ENTEGRIS INC
Form 10-K
February 11, 2019
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UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
WASHINGTON, D.C. 20549

FORM 10-K

(Mark One)
x ANNUAL REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934
For the fiscal year ended December 31, 2018
or
o TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934
For the transition period from to
Commission file number: 001-32598

Entegris, Inc.
(Exact name of registrant as specified in its charter)

Delaware	41-1941551
(State or Other Jurisdiction of Incorporation or Organization)	(I.R.S. Employer Identification No.)

129 Concord Road, Billerica, Massachusetts 01821
(Address of principal executive offices and zip code)
(978) 436-6500
(Registrant's telephone number, including area code)
Securities registered pursuant to Section 12(b) of the Act:

Title of Class	Name of Exchange on which Registered
Common Stock, $0.01 Par Value	The Nasdaq Global Select Market

Securities registered pursuant to Section 12(g) of the Act: None

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Indicate by check mark if the registrant is a well known seasoned issuer, as defined in Rule 405 of the Securities Act. x Yes o No
Indicate by check mark if the registrant is not required to file reports pursuant to Section 13 or 15(d) of the Act. o Yes x No
Indicate by check mark whether the registrant: (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days. Yes x No o
Indicate by check mark whether the registrant has submitted electronically and posted on its corporate Web site, if any, every Interactive Data File required to be submitted and posted pursuant to Rule 405 of Regulation S-T (§232.405 of this chapter) during the preceding 12 months (or for such shorter period that the registrant was required to submit and post such files). Yes x No o
Indicate by check mark if disclosure of delinquent filers pursuant to Item 405 of Regulation S-K (§229.405) is not contained herein and will not be contained, to the best of registrant's knowledge, in definitive proxy or information

statements incorporated by reference in Part III of Form 10-K or any amendment to this Form 10-K. o
Indicate by check mark whether the registrant is a large accelerated filer, an accelerated filer, a non-accelerated filer, smaller reporting company, or an emerging growth company. See the definitions of “large accelerated filer,” “accelerate filer,” “smaller reporting company,” and “emerging growth company” in Rule 12-b-2 of the Exchange Act.

Large Accelerated Filer	x	Accelerated Filer	o
Non-Accelerated Filer	o (Do not check if a smaller reporting company)	Smaller reporting company	o
		Emerging growth company	o

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If an emerging growth company, indicate by check mark if registrant has elected not to use the extended transition period for complying with any new or revised financial accounting standards provided pursuant to Section 13(a) of the Exchange Act. ¨

Indicate by check mark whether the registrant is a shell company (as defined in Rule 12b-2 of the Exchange Act).   Yes ¨   No ý

The aggregate market value of voting stock held by non-affiliates of the registrant, based on the last sale price of the Common Stock on June 30, 2018, the last business day of registrant’s most recently completed second fiscal quarter, was $4,768,870,172. Shares held by each officer and director of the registrant and by each person who owned 10 percent or more of the outstanding Common Stock have been excluded from this computation in that such persons may be deemed to be affiliates of the registrant. This determination of affiliate status for this purpose is not necessarily a conclusive determination for other purposes.

As of February 4, 2019, 134,942,439 shares of the registrant’s Common Stock were outstanding.

DOCUMENTS INCORPORATED BY REFERENCE

Portions of the registrant’s Definitive Proxy Statement for its 2019 Annual Meeting of Stockholders scheduled to be held on April 30, 2019, or the 2019 Proxy Statement, which will be filed with the Securities and Exchange Commission, or SEC, not later than 120 days after December 31, 2018, are incorporated by reference into Part III of this Annual Report on Form 10-K. With the exception of the portions of the 2019 Proxy Statement expressly incorporated into this Annual Report on Form 10-K by reference, such document shall not be deemed filed as part of this Annual Report on Form 10-K.

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PART I

Item 1. Business.

OUR COMPANY

Entegris, Inc. (“Entegris”, “the Company”, “us”, “we”, or “our”) is a leading global developer, manufacturer and supplier of microcontamination control products, specialty chemicals and advanced materials handling solutions for manufacturing processes in the semiconductor and other high-technology industries. Our mission is to leverage our unique breadth of capabilities to create value for our customers by developing mission-critical solutions to maximize manufacturing yields, reduce manufacturing costs and enable higher device performance.

Semiconductors, or integrated circuits, are key components in modern electronic devices. Smartphones, cloud computing, the Internet of Things, artificial intelligence and other applications require faster, more powerful and more energy efficient semiconductors. In response to these requirements and the growing demand from these applications, semiconductor makers have been adding more capacity and semiconductor manufacturing technology has rapidly been moving to smaller dimensions, adopting new device architectures, such as FinFET transistors and 3D-NAND, and utilizing new and innovative manufacturing materials to increase transistor and bit density. As the technology node becomes increasingly complex, to enable improvements and to maximize yields, manufacturers require the effective development and application of new materials, a reliable and consistent supply of high-value materials, and contamination-free transportation, storage and delivery of these materials, seamlessly integrated into the semiconductor manufacturing process, at ever-increasing levels of purity and contaminant control. Additionally, the effective management and maintenance of the entire materials handling system, from initial production of process chemistry, to transportation and dispensing onto the wafer, has grown in importance to enhanced device yield.

Entegris is uniquely positioned to rapidly respond to these challenges and to help our customers solve problems throughout their advanced manufacturing processes. We deliver advanced materials and high-purity chemistries, free from contamination, with optimized packaging and delivery solutions and in-process filtration and purification solutions that ensure high-value liquid chemistries and gases are free from contaminants before reaching the wafer. Our technology portfolio includes approximately 21,000 standard and customized products and solutions to achieve the highest levels of purity and performance that are essential to the manufacture of semiconductors, flat panel displays, light emitting diodes, or LEDs, high-purity chemicals, solar cells, gas lasers, optical and magnetic storage devices, and critical components for aerospace, glass manufacturing and biomedical applications. The majority of our products are consumed at various times throughout the manufacturing process, with demand driven in part by the level of semiconductor and other manufacturing activity.

Our business is organized and operated in three operating segments, which align with the key elements of the advanced semiconductor manufacturing ecosystem. The Specialty Chemicals and Engineered Materials, or SCEM, segment provides high-performance and high-purity process chemistries, gases, and materials, and safe and efficient delivery systems to support semiconductor and other advanced manufacturing processes. The Microcontamination Control, or MC, segment offers solutions to filter and purify critical liquid chemistries and gases used in semiconductor manufacturing processes and other high-technology industries. The Advanced Materials Handling, or AMH, segment develops solutions to monitor, protect, transport, and deliver critical liquid chemistries, wafers and other substrates for a broad set of applications in the semiconductor industry and other high-technology industries. While these segments have separate products and technical know-how, they share a global generalist sales force, common business systems and processes, technology centers, and strategic and technology roadmaps. We leverage our expertise from these three segments to create new and increasingly integrated solutions for our customers.

PROPOSED MERGER

On January 27, 2019, we entered into a definitive Agreement and Plan of Merger (“Merger Agreement”) with Versum Materials, Inc., a Delaware corporation (“Versum”), a leading specialty materials supplier to the semiconductor industry. Pursuant to and subject to the terms and conditions of the Merger Agreement, upon completion of the transaction, Versum will merge with and into Entegris (the “Proposed Merger”), with Entegris surviving and continuing as the surviving corporation, and retaining its name and headquarters. At the effective time of the Proposed Merger, each outstanding share of common stock of Versum (with certain exceptions set forth in the Merger Agreement) will be converted into the right to receive 1.120 shares of common stock of Entegris. The transaction is subject to certain

conditions, including a majority of the outstanding shares of common stock of both Entegris and Versum approving the Merger Agreement and the receipt of approvals under U.S. and certain foreign antitrust and competition laws. We have agreed to operate our business in the ordinary course during the period between the execution of the Merger Agreement and the effective time of the Proposed Merger, subject to specific exceptions set forth in the Merger Agreement, and have agreed to certain other customary restrictions on operations, as set forth in the Merger Agreement.

THE SEMICONDUCTOR ECOSYSTEM

The manufacture of semiconductors requires hundreds of highly complex and sensitive manufacturing steps, during which a variety of materials are repeatedly applied to a silicon wafer to build integrated circuits on the wafer surface. We serve the semiconductor ecosystem by providing specialty materials and chemicals utilized in many process steps, offering a broad range of products to monitor, protect, transport, and deliver these critical process materials during the manufacturing process and providing systems to purify liquid chemistry and gases throughout the manufacturing process. The areas of the semiconductor ecosystem that rely most heavily on our products and solutions are described below.

Deposition. Deposition processes include physical vapor deposition (PVD), where a thin film is deposited on a wafer surface in a low-pressure gas environment, chemical vapor deposition (CVD), where a thin film is deposited on a wafer surface by exposing it to one or more volatile precursors which react with the wafer surface, atomic-layer deposition (ALD), where a thin film is deposited on a wafer surface by exposing it to one or more precursors which react through a series of sequential, self-limiting reactions, and electro-plating, where a metal layer, such as copper, is deposited using chemical baths. Our advanced precursor materials and electro-plating chemicals are utilized to meet the semiconductor industry’s composition, uniformity and thickness needs of deposited films. Our filtration and purification products are used to remove contaminants during the deposition process, consequently reducing defects on wafers. These products are critical to ensuring device performance and the manufacturing yields of semiconductor manufacturers.

Chemical Mechanical Planarization (CMP). CMP is a polishing process used by semiconductor manufacturers to planarize, or flatten, many of the layers of material that have been deposited upon silicon wafers. We offer a broad range of products used by semiconductor manufacturers during and immediately following the CMP process. Our formulated cleaning chemistries remove residue from wafer surfaces after the CMP process, and prevent subsequent corrosion. Our filtration and purification systems are used to filter liquid slurries and cleaning chemistries in order to remove select particles and contaminants that can cause defects on a wafer’s surface. Our roller brushes are used in conjunction with our cleans chemistries to clean the wafer after completion of the CMP process in order to prepare the wafer for subsequent operations and our pad conditioners are used to prepare the surface of the CMP polishing pad prior to every polishing cycle.

Photolithography. Photolithography is a process repeated many times throughout the semiconductor manufacturing process that uses light to print complex circuit patterns onto the wafer. To print the projected optical pattern, the wafer is coated with a thin film of light-sensitive material, called photoresist. Light is projected to expose the photoresist, which is then developed (somewhat like photographic film) to create a stenciled image pattern. Our liquid filtration and liquid packaging and dispense systems play a vital role in assuring the pure, accurate and uniform dispense of photoresists onto the wafer so that manufacturers can achieve acceptable yields in the manufacturing process, and our gas microcontamination control systems eliminate airborne contaminants that can disrupt effective photolithography processes.

Etch and Resist Strip. During the etch process, specific areas of the thin film that have been deposited on the surface of a wafer are removed to leave a desired circuit pattern. After the etch process, the hardened resist needs to be completely removed. Our formulated chemical solutions remove photo resists and post-etch residues and our gas filters and purifiers help assure the purity of the process gas streams used in the etch process. Our precision-engineered coatings provide barriers to corrosive chemistries in the etch environment, protect surfaces from erosion and minimize particle generation.

Ion Implant. Ion implantation is a key technology for forming transistors and is used many times during semiconductor fabrication. During ion implantation, wafers are bombarded by a beam of electrically-charged ions, called dopants, which change the electrical properties of the exposed surface films. Our Safe Delivery Source® (SDS®) and VAC® (Vacuum Actuated Cylinders) gas delivery systems assure the safe, effective and efficient delivery of the toxic gases necessary for the implant process. In addition, our proprietary low temperature plasma coating processes for core components are critical elements of ion implantation equipment.

Wet Cleaning. Ultra-high purity chemicals of precise composition are used to clean the wafers before and after several of the processes described above, to pattern circuit images and to remove photoresists after etch. The cleaning chemicals must be maintained at very high purity levels without the presence of foreign material such as particles,

ions or organic contaminants in order to maintain manufacturing yields and avoid defective products. Our proprietary formulated cleaning chemistries are used in these wet cleaning processes and our liquid filters and purifiers ensure the purity of these chemicals.

Wafer Solutions. Our wafer and reticle carriers are high-purity “micro-environments” that carry wafers between manufacturing process steps. These products protect wafers from damage or abrasion and minimize contamination during transportation and automated processing. Front-end wafer processing can involve hundreds of steps and take several weeks. Protection of the processed wafer is essential, as a batch of fully processed 200 mm or 300 mm wafers transported in one of our products can be worth over a million dollars.

Chemical Containers. Semiconductor manufacturing and other high-technology processes utilize large volumes of high-purity, corrosive and hazardous chemicals. Our ultrahigh purity chemical container products, such as drums, flexible packaging and

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associated coded connection systems, maintain chemical purity, maximize utilization and ensure safe transport, containment and dispense of valuable, ultraclean process fluids, from storage by the chemical manufacturer to point-of-use. Our FluoroPure® containers and NOWPak® liner-based systems maximize chemical retrieval and minimize chemical waste, which lowers our semiconductor manufacturer customers' costs. Our portfolio of bottles, canisters, closures and accessories enhance tool productivity, increase yields and reduce operating costs. Relatedly, our ultrapure valves, fitting, tubings, and sensing and control products are used to distribute these chemicals around the fab and in wet process tools.

Other Markets. Many of the processes used to manufacture semiconductors are also used to manufacture photovoltaic cells, LEDs, flat panel displays and magnetic storage devices resulting in the need for similar filtration, purification, control and measurement capabilities. We seek to leverage our products, technologies and expertise to address these important market opportunities.

INDUSTRY TRENDS

Emerging Applications. The market for semiconductors has grown significantly over the past few decades and we expect this trend to continue. We believe that the smartphone, Internet of Things and emerging applications in cloud computing, machine learning and artificial intelligence, autonomous vehicles, and virtual reality will drive growth in the demand for semiconductors, drive wafer starts and create significant opportunities for our products. Existing applications in data processing, wireless communications, broadband infrastructure, personal computers, handheld electronic devices and other consumer electronics, are also expected to drive demand for semiconductors, and in turn, our products.

Manufacturing Complexity and Architecture. The emerging applications described above require more powerful, faster and more energy efficient semiconductors. Semiconductor architectures are changing, with transistor design increasing in complexity, the use of multilayered patterning, vertical structures such as FinFET and 3D-NAND, and shrinking dimensions. These advanced architectures require an increase in the number of process steps required to manufacture these semiconductors. We believe that demand for our materials and consumable products will be driven by the increase in process steps and the associated lithography, deposition, CMP, and etch and clean required to manufacture leading edge semiconductors. Additionally, new materials have played a significant role in enabling improved devices performance and we expect this trend to continue. As dimensions get smaller, new materials will be required for transistor connectivity. For example, leading edge semiconductor manufacturers are moving towards atomic layer scale, where the precision of the manufacturing process and purity of the materials is extremely important to maintain the device integrity. These materials need to be supplied and delivered at ever-increasing levels of purity and control, from point-of-production to point-of-use and dispense on the wafer. We expect the trend for new materials supplied at high levels of purity to drive the demand for our advanced materials and our products and solutions designed to purify, monitor, protect, transport, and deliver critical materials. To address the challenges of the advanced technology nodes, we collaborate with our customers to develop new materials, to enhance our filtration and purification capabilities and to introduce advanced materials packaging and monitoring capabilities.

Material Handling Solutions. Our semiconductor customers have become increasingly focused on materials handling solutions that enable them to safely store, handle, process and transport critical materials throughout the manufacturing process to minimize the potential for damage or degradation to their materials and to protect their investment in processed wafers. We believe that these trends provide opportunities for us to utilize our unique breadth of capabilities to provide innovative materials, materials management, purification, wafer transport, and process solutions to semiconductor customers to enable them to successfully manage this growing complexity.

Reliance on Trusted Suppliers. Our customers require that their key materials suppliers demonstrate greater capabilities, such as sustainability, scalability, flexible manufacturing, quality control, supply chain management, and the ability to effectively collaborate on solutions to problems. We have responded to these demands by deploying resources to enable us to align with their requirements and drive operational excellence. For example, in 2016 and 2017, we expanded our technology centers in South Korea and Taiwan and we are currently building a technology center in Shanghai, China, adding to our research and development capabilities to enhance local development and collaboration and to strengthen relationships with our key customers. We believe these trends will allow us to leverage our manufacturing, operational and technical capabilities, along with our broad technology portfolio, to become an

increasingly important strategic supplier to our customers.

Continued Consolidation. Our customer base within the semiconductor industry has consolidated through mergers and acquisitions. As a result, the importance of maintaining and developing strong and close relationships with our customers becomes even more essential. While continuing to strengthen these relationships, we also seek to further broaden our customer base by leveraging our products, technologies and expertise in serving semiconductor applications to address adjacent market opportunities, including in manufacturing processes for flat panel displays, high-purity chemicals, solar cells, optical magnetic storage devices and products for life sciences.

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Manufacturing in China. An additional factor that could spur future industry growth is sustained semiconductor industry development in China, which has experienced recent growth in semiconductor production. Construction on an historic number of fabs has been commenced in recent years, and we expect that heavy investment in the semiconductor sector in China will continue, with more than 10 new fab projects expected to ramp in the next several years by local and multinational companies. As a result, we expect that China will remain one of the fastest growing regions in semiconductor industry. Additionally, existing fabs in China are working to rapidly enhance their capabilities to manufacture the latest generation advanced node products, targeting both leading-edge and mainstream applications. However, as Chinese fabs have been facing difficulty in obtaining the necessary technology and products, we expect some uncertainty on the time of some these fab ramps. Expansion and growth of the semiconductor industry in China could increase the need and demand for our products.

OUR COMPETITIVE STRENGTHS

Technology Leadership. We are committed to being able to provide our customers with innovative solutions for their manufacturing needs. For example, we have introduced sub-10 nanometer and 7 nanometer filtration products, advanced deposition materials for next generation transistor and interconnect technologies, advanced reticle pods for extreme ultra-violet, or EUV, photolithography applications, advanced 300 mm wafer carriers and advanced coatings to meet the rigorous demands of the advanced technology nodes faced by our customers. As described in further detail below in “Engineering, Research and Development”, this commitment to technology leadership is demonstrated by our ER&D expenditures in 2018, 2017 and 2016 of $118.5 million, $107.0 million and $107.0 million, respectively.

Comprehensive and Diverse Product Offerings. As semiconductor manufacturers are driving towards more advanced technology nodes, our customers are seeking suppliers who can provide a broad range of reliable, flexible and cost-effective products and materials, as well as the technological and application design expertise necessary to enhancing their productivity, quality, and yield. We believe our comprehensive offering of materials and products creates a competitive advantage as it enables us to meet a broad range of customer needs and provide a single source of product offerings for semiconductor device and equipment manufacturers as they seek to consolidate their supplier relationships and pursue advanced technology nodes. Additionally, our broad product and solution portfolio allows us to serve many aspects of the semiconductor manufacturing ecosystem and to create synergies among certain of our products. For example, our microenvironment and fluidics products are utilized when a fab is being built to move wafers and materials throughout the fab, our chemistries and gas products are consumed during operation of the fab, and our contamination control products ensure the purity of chemistries and gases throughout the fab and its supply chain.

Global Presence. We have established a global infrastructure of design, manufacturing, distribution, service and technical support facilities to meet the needs of our global customers. We have, for example, expanded our manufacturing operations and increased our investment in advanced technology centers in Taiwan and South Korea to support our important customers in these regions, established new sales and service offices in China and are currently building a technology center in Shanghai, China to serve a growing semiconductor manufacturing base in that country, and expanded our presence in Singapore to enhance our global and regional management of supply chain and manufacturing processes. We service our customer relationships in Asia, North America, Europe and the Middle East predominantly via direct sales and support personnel and to a lesser extent through selected independent sales representatives and distributors.

Advanced Manufacturing. We have established leading-edge manufacturing plants located in the United States, Malaysia, Japan, South Korea and Taiwan that possess the advanced manufacturing capabilities described under “Manufacturing” below.

Strong Relationships with Broad Customer Base. We have strong relationships with our customers, which include leading semiconductor manufacturers, original equipment manufacturers, or OEMs, and semiconductor materials suppliers. These relationships provide us with significant collaboration opportunities at the product design stage, which facilitate our ability to introduce new products and applications. For example, we work with our key customers in the development of advanced manufacturing processes to identify and respond to their requests for current and future generations of products for emerging applications requiring cleaner materials, as well as systems that maintain the integrity and stability of materials during transport through the manufacturing process. We believe that our

customer base will continue to be an important source of new product development opportunities. Due to the specialized nature of our products, manufacturing complexity, qualification requirements in customers' fabrication processes, high customer re-formulation and qualification change costs, and extensive proprietary products, we believe our supply position with our customers is strong.

Strong Financial Performance and Cash Flow Generation. We have a strong financial profile with net income of $240.8 million, operating margin of 18.9% and Adjusted EBITDA margin of 28.1% for the fiscal year ended December 31, 2018. In addition to servicing our debt obligations and effecting our capital allocation strategy, we expect that our financial profile will allow us to invest in the research and development and advanced manufacturing capabilities necessary to maintain and expand our technology leadership and to drive organic growth. Additionally, as we have done in the past, we expect that our cash flow generation will enable us to grow inorganically through smaller acquisitions of product lines or technology that expand upon

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our product portfolio or through larger acquisitions where we act as a consolidator in the industry and increase our scale and strengthen our position as a leading supplier to our customers. For an explanation of Adjusted EBITDA and Adjusted EBITDA Margin and a reconciliation to GAAP net income, see "Non-GAAP Information" in Management's Discussion and Analysis of Financial Condition and Results of Operations in Part II, Item 7 of this Annual Report on Form 10-K.

OUR BUSINESS STRATEGY

We intend to build upon our position as a leading worldwide developer, manufacturer and supplier of advanced specialty materials, filtration and purification solutions, delivery systems, and materials packaging solutions to expand our core business and to grow in other high value-added manufacturing process markets. Our strategy includes the following key elements:

Commitment to Technology Leadership. We continuously improve our products and develop new products as our customers' needs evolve. As semiconductor devices become smaller and more powerful, and new materials and processes are deployed to produce them, we seek to expand our technological capabilities by developing advanced products that address the requirements for greater purification, protection and transport of high value-added materials and by developing advanced chemical materials for use in critical fabrication processes.

Leveraging our Expertise. We leverage our broad expertise across our portfolio of advanced materials, materials handling and purification capabilities to create innovative new solutions to address unmet customer needs. For example, our industry-leading post-CMP cleaning chemistry is developed and manufactured by our SCEM segment, with collaboration from our MC segment, packaged with our ultra clean container and connector system made by our AMH segment, and delivered to the process tools through fluid handling systems also made by our AMH segment. Furthermore, in the process tool, these chemistries may go through one or several purification systems made by our MC segment to eliminate particles and contaminants. Another example of the results of this strategy is our advanced deposition materials business, where we leverage our ability to synthesize unique molecules, our knowledge of how to purify these materials, and our capability to safely transport these materials and deliver them onto the wafer at the highest throughput. We seek to utilize our diverse and unique expertise in areas of increasing importance to semiconductor manufacturers, such as developing advanced materials and ensuring the purity of high-value materials, and our ability to work collaboratively across our three segments, which enables us to quickly and effectively develop optimized and complimentary solutions for our customers.

Operational Excellence. Our strategy is to continue to develop our advanced manufacturing capabilities into a competitive advantage with our customers by focusing on the following priorities:

- use of manufacturing equipment and facilities incorporating leading-edge technology including advanced cleanroom and cleaning procedures;
- implementation of standardized manufacturing systems stressing optimization of equipment effectiveness, predictive maintenance, and direct labor productivity;
- implementation of automated quality systems that provide both process monitoring and process control throughout the manufacturing process as well as predictive quality data to mitigate against potential quality excursions;
- implementation of supply chain management systems that assure a reliable and responsive supply of high-quality raw materials;
- conduct of manufacturing operations to assure the safety of our employees and of the individuals using our products; and
- maintaining an agile manufacturing organization that is capable of rapid design and development of prototypes of new and derivative products, as well as promptly responding to customer feedback concerning prototypes so that we quickly commercialize and ramp production acceptable to our customers.

Continued Focus on Customers. We view the strong relationships we have with our customers, which include leading semiconductor manufacturers, OEMs, and semiconductor materials suppliers, as critical to our long term success. We intend to reinforce and further strengthen these relationships, through, among other things, collaborations and joint development. Customer intimacy enables us to respond rapidly and thoroughly to their manufacturing challenges and enables us to bring forth new products that serve an existing need.

Adjacent Markets. We leverage our expertise in the semiconductor industry by developing products for other industries that employ similar technologies and production processes and that utilize materials integrity management, high-purity fluids and integrated dispense systems. For example, outside of the semiconductor industry, our products are used in manufacturing processes for flat panel displays, high-purity chemicals, solar cells, optical magnetic storage devices and products for life sciences. We plan to continue to identify and develop products that address needs in adjacent markets. We believe that by utilizing our technology to provide manufacturing solutions across multiple industries, we are able to increase the total available market for our products and reduce, to an extent, our exposure to the cyclicality of the semiconductor industry.

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Strategic Acquisitions, Partnerships and Related Transactions. We will continue to pursue strategic acquisitions and business partnerships that enable us to address gaps in our product offerings, secure new customers, diversify into complementary product markets, broaden our technological capabilities and product offerings, access local or regional markets and achieve benefits of increased scale. For example, in June 2018, we acquired from SAES Getters S.p.A. the SAES Pure Gas business, a leading provider of high-capacity gas purification systems used in semiconductor manufacturing and adjacent markets, which now reports into our Microcontamination Control division, enabling us to offer a complete portfolio of gas purifications solutions for both bulk and specialty gases to our customers. In January 2018, we acquired Particle Sizing Systems, LLC, a company focused on particle sizing instrumentation for liquid applications in both semiconductor and life science industries, which enables customers to perform particle size analysis online and in real time, directly in fluid stream process, preventing costly yield excursions. In April 2017, we acquired the water and chemical filtration product line for microelectronics applications from W. L. Gore & Associates, Inc., or Gore, where we acquired a synergistic product line that leverages our existing platform and expands our served markets. Our 2014 acquisition of ATMI, Inc., or ATMI, brought a whole new portfolio of technologies and materials products to serve our semiconductor customers. Further, as the dynamics of the markets that we serve shift, we will reevaluate our existing businesses and in the event that we conclude that a business is not able to provide value-added solutions to its markets in a manner that contributes to achieving our financial objectives, we expect to restructure or replace that business, such as the sale of our small cleaning business in France. Finally, we are continuously evaluating opportunities for strategic alliances, such as our strategic alliance with Enthone, joint development programs and collaborative marketing efforts with key customers and other industry leaders. For example, in connection with our strategic commitment to support the growing semiconductor and related microelectronics industries in China, in 2017, we entered into agreements with local partners to expand our capability to manufacture our specialty chemical and deposition products locally and shorten our supply chain for our customers in China.

OUR SEGMENTS

As discussed, our business is organized and operated in three operating segments which align with the key elements of the advanced semiconductor manufacturing ecosystem: Specialty Chemicals and Engineered Materials, or SCEM; Microcontamination Control, or MC; and Advanced Materials Handling, or AMH. We leverage our expertise from these three segments to create new and increasingly integrated solutions for our customers. The following is a detailed description of our three segments:

SPECIALTY CHEMICALS AND ENGINEERED MATERIALS SEGMENT

The SCEM segment provides high-performance and high-purity process chemistries, gases, and materials that enable enhanced device performance. These materials are utilized in critical semiconductor manufacturing processes such as deposition, cleaning, and integration of complex materials. Advanced materials, delivered at high purity, are critical to enabling the performance of leading-edge logic and memory applications. We believe the growing demand in the 3D-NAND market, challenges with metallization schemes and the need for specialized cleaning solutions will drive consumption for materials in our SCEM segment. In conjunction with products from our MC and AMH segments, the materials in our SCEM segment provide unique solutions to safely and efficiently deliver critical materials to support semiconductor and other advanced manufacturing processes.

Specialty Gas Products. Our specialty gas solutions provide advanced safety and process capabilities to semiconductor, display and solar panel manufacturers. Our SDS cylinders store and deliver hazardous gases, such as arsine, phosphine, germanium tetrafluoride and boron trifluoride, at sub-atmospheric pressure through the use of our proprietary carbon-based adsorbent materials. These products minimize potential leaks during transportation and use and allow more gas to be stored in the cylinder, features which provide significant safety, environmental and productivity benefits over traditional high-pressure cylinders. New generations of SDS products further increase the gas storage capacity, reducing tool down time, therefore, resulting in significant cost savings for our customers. We also offer VAC, a complementary technology to SDS, where select implant gases and gas mixtures are stored under high pressure but delivered sub-atmospherically.

Specialty Materials Products. Our specialty materials include specialized graphite, silicon carbide, thermally conductive foam and a variety of unique, high purity coatings for dry or plasma etch, chemical vapor deposition and

ion implant applications. Our POCO® premium graphite is used to make precision consumable electrodes for electrical discharge machining, hot glass contact materials for glass product manufacturing and forming, and other consumable products for various industrial applications, including aerospace, optical, medical devices, air bearings and printing. Our high-performance specialty coatings, such as our Pegasus™ and our latest development Cearus™ coatings, provide erosion resistance, minimize particle generation and prevent contamination on critical components in semiconductor environments and other high-technology manufacturing operations. Our specialty materials provide customized solutions for applications challenged with unique temperature, corrosive, chemical or process environments, such as electrostatic chucks used to hold wafers during processing, plasma etch chamber components, aircraft bearings, and ultrasonic transducers.

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Advanced Deposition Materials Products. Our advanced deposition materials include advanced liquid, gaseous and solid precursors which are incorporated in chemical vapor deposition (CVD) and atomic layer deposition (ALD) processes by the semiconductor industry, including organometallic precursors for the deposition of tungsten, titanium, cobalt and aluminum containing films and organosilane precursors for the deposition of silicon oxide and silicon nitride films. These precursors are designed in close collaboration with OEM process tool manufacturers as well as device makers to produce application specific solutions that are compatible with complex integrations of material solutions used to build the semiconductor device. We offer containers that allow for reliable storage and delivery of low volatility solid and liquid precursors required in ALD processes. When combined with our proprietary corrosion resistant coatings and filtration solutions from our MC segment, our advanced deposition materials enable the industry’s highest purity levels, resulting in improved device performance.

Surface Preparation and Integration Products. We offer a range of materials used to prepare the surface of a semiconductor wafer during the manufacturing process and to integrate with materials being used on the wafer. We also provide advanced plating solutions, such as our Viaform® product (a trademark of and exclusively licensed from Enthone Inc., or Enthone, a subsidiary of Platform Specialty Products Corporation), which includes inorganic and proprietary organic molecules that provide the wiring for copper interconnects. We also offer CMP cleaning solutions for applications such as semiconductor post-etch residue removal, wafer etching, organics removal, negative resist removal, edge bead removal, and corrosion prevention. Our wet chemistries solutions, combined with filtration solutions from our MC segment and fluid handling solutions from our AMH segment, provide enhanced purity, which results in improvements in our customers’ processes. Our consumable PVA roller brush products are used to clean the wafer following the CMP process and our pad conditioners, based on our silicon carbide capabilities, lengthen CMP pad life.

MICROCONTAMINATION CONTROL SEGMENT

The MC segment offers solutions to purify critical liquid chemistries and gases used in semiconductor manufacturing processes and other high-technology industries. The design and performance of our liquid and gas filtration and purification products are important to the semiconductor manufacturing process because they remove contamination and directly reduce defects and improve manufacturing yield. Our proprietary filters remove organic and inorganic nanometer-sized contaminants from the different fluids and gases used in the manufacturing process, including photolithography, deposition, planarization and surface etching and cleaning. As our customers leverage leading edge lithography tools and multi-patterning technology to enable each subsequent generation of products, our filtration and purification products are utilized to achieve necessary levels of purity and contamination control. We believe demand for purification and filtration products is being driven by the continuous node shrink in logic semiconductors and the ramp in the 3D-NAND market, as the risk of yield loss grows with the incremental manufacturing steps needed for the production of these devices. We utilize expertise from the AMH segment in polymer science and from the SCEM segment in chemical manufacturing to develop differentiated filtration and purification solutions for our customers.

Liquid Microcontamination Control Products. We offer a variety of unique products that are optimized to control contaminants in our customers’ liquid processes. For example, our Torrento® series of filters is used for the filtration of aggressive acid and base chemistries for both semiconductor fabs as well as specialty chemical manufacturers including our SCEM segment. Manufacturers of high purity chemicals as well as semiconductor fabs use our Trinzik® products for the filtration of chemicals as well as ultra-pure water. Our Impact® series of filters are used in point-of-use photochemical dispense applications, including those provided by our AMH segment, where the delivery of superior flow rate performance and reduced microbubble formation is critical.

Gas Microcontamination Control Products. We offer a complete portfolio of products designed to remove particulate and molecular contaminates from gas streams from the point of creation on the gas pads to the point of use at the wafer in semiconductor, flat panel display and LED fabs. In addition, we provide products used to eliminate airborne molecular contamination from critical process tool areas or cleanrooms in the fab. Our Waferguard® gas filters reduce outgassing and remove particle contamination. Our GateKeeper® gas purifiers and large facility wide gas purification systems provide continuous purified gas supply to customer fabs by chemically reacting and absorbing contaminants, effectively removing gaseous contaminants down to part-per-trillion levels. Our Chambergard™ gas diffusers provide semiconductor equipment manufacturers with the capability to rapidly vent their tools to atmosphere to dramatically

reduce process cycle times without adding particles to the wafers. These products are used in, or alongside, critical processing tools to improve yield and reduce tool downtime. In addition, we provide filters used to eliminate airborne molecular contamination from critical process tool areas or cleanrooms in the fab, improving process yield.

ADVANCED MATERIALS HANDLING SEGMENT

The AMH segment develops solutions to monitor, protect, transport, and deliver critical liquid chemistries, wafers and substrates for a broad set of applications in the semiconductor industry and other high-technology industries. These systems and products improve our customers' yields by protecting wafers from abrasion, degradation and contamination during

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manufacturing and transportation and by assuring the consistent, clean and safe delivery of advanced chemicals from the chemical manufacturer to the point-of-use in the semiconductor fab. As advanced semiconductor fabs are built, demand is driven for our wafer handling and fluid handling products. As those fabs move into production, we see demand for wafer carrying and fluid containment solutions offered by this segment. The AMH segment collaborates closely with the semiconductor chemical manufacturers segment in developing products that are compatible with advanced chemistries to enhance yield, and integrates liquid filtration technology from our MC segment to deliver consistent and pure chemistry.

Wafer Solutions. We lead the market with our high-volume line of Ultrapak® and Crystalpak® products for wafers ranging from 100 to 200 mm, which ensure the clean and secure transport of wafers from the wafer manufacturers to the semiconductor fab. We also offer a front-opening shipping box, or FOSB, for the transportation and automated interface of 300 mm wafers. We lead the market for 300mm front opening unified pods, or FOUPs, wafer transport and process carriers, and standard mechanical interface pods, or SMIF pods, for 200mm wafer applications. These microenvironment products safely and accurately deliver wafers within the semiconductor fab environment to the various process fabrication steps. We are a leader in reticle protection products for photolithography. This includes products that protect the high-value EUV (extreme ultraviolet) lithography masks during both the mask manufacturing process and their use in the semiconductor fab.

Chemical Containers. We have a broad portfolio of flexible and rigid polymer packaging and container products, from low-volume containers to transport high-value photoresist chemistries, such as our NOWPak® products, to large intermediate bulk containers (IBCs) to safely and efficiently transport chemicals in bulk, such as our FluoroPure® products. Our connection systems provide for safe and efficient chemical dispense from the container in the fab. Chemical companies utilize our packaging products to ensure the purity of chemistries shipped to semiconductor fabs, resulting in enhance yields.

Fluidics. We are a leader in high-purity fluid transfer products such as valves, measurement, fittings, tubing, pipe, custom fabricated products and associated connection systems, such as our PrimeLock® connections, for high-purity chemical applications and our proprietary digital flow control technology improves the uniformity of chemicals applied on wafers. Our IntelliGen® integrated high-precision liquid dispense systems enable the uniform application of advanced chemistries during the wafer fabrication process, integrating our valve control expertise with filter device technologies from our MC segment, so that filtering and dispensing of photochemicals can occur at different rates, conserving high-value chemistry and reducing defects on wafers. Our comprehensive product lines provide our semiconductor manufacturers, process tool makers and chemical customers with a single-source provider for their high-purity chemical management needs throughout the manufacturing process.

OUR CUSTOMERS AND MARKETS

Our most significant customers include semiconductor device manufacturers, semiconductor equipment makers, gas and chemical manufacturing companies, leading wafer grower companies and manufacturers of high-precision electronics. We also sell our products to flat panel display equipment makers, materials suppliers and panel manufacturers, and manufacturers of hard disk drive components and devices.

Our other high-technology markets include manufacturers and suppliers in the solar and life science industries, electrical discharge machining customers, glass and glass container manufacturers, aerospace manufacturers and manufacturers of biomedical implantation devices.

In 2018, 2017 and 2016, net sales to our top ten customers accounted for 44%, 47% and 45%, respectively, of combined net sales. In 2018, 2017 and 2016, Taiwan Semiconductor Manufacturing Company Limited, accounted for $154 million, $168 million and $162 million of net sales, respectively, or approximately 10%, 13% and 14% of our net sales, respectively, including sales from each of our three reporting segments. In addition, in 2018 and 2017, Samsung Electronics Co. accounted for $164 million and $141 million of net sales, respectively, or approximately 11% and 10% of our net sales, respectively, including sales from all of the Company's segments, respectively. International net sales represented 78%, 79% and 78%, respectively, of net sales in 2018, 2017 and 2016. Approximately 3,100 customers purchased products from us during 2018. For the fiscal year ended December 31, 2018, our revenue breakdown by customer segment was as follows: semiconductor manufacturers 46%; OEMs 13%; electronic materials customers 14%; other semiconductor customers 15%; and non-semiconductor customers 12%.

We may enter into supply agreements with our customers. These agreements generally have a term of one to three years, but do not contain any long-term purchase commitments. Instead, we work closely with our customers to develop non-binding forecasts of the future volume of orders. However, customers may cancel their orders, change production quantities from forecasted volumes or delay production for a number of reasons beyond our control.

SALES, MARKETING AND SUPPORT

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We sell our products worldwide, primarily through our direct sales force and strategic independent distributors located in all major semiconductor markets. Independent distributors are also used in other semiconductor market territories and for specific market segments. As of December 31, 2018, our sales and marketing force consisted of approximately 560 employees worldwide.

Our unique capabilities and long-standing industry relationships have provided us with the opportunity for significant collaboration with our customers at the product design stage, which has facilitated our ability to introduce new materials and new solutions that meet our customers' needs. We are constantly identifying for our customers a variety of materials, purification and process control challenges that may be addressed by our product solutions. Our sales representatives provide our customers with worldwide technical support and information about our products and materials.

We believe that our technical support services are important to our sales and marketing efforts. These services include assisting in defining a customer's needs, evaluating alternative products and materials, designing a specific system to perform the desired operation, training users and assisting customers in compliance with relevant government regulations. Additionally, our field applications engineers, located in all of the major markets we serve, work directly with our customers on product qualification and process improvements in their facilities. We maintain a network of service centers, applications laboratories and technology centers located in all key markets internationally and in the United States to support our products and our customers with their advanced development needs, provide local technical service and ensure fast turnaround time.

COMPETITION

The market for our products is highly competitive. While price is an important factor, we compete primarily on the basis of the following factors:

- technical expertise;
- product quality and performance;
- advanced manufacturing capabilities;
- total cost of ownership;
- historical customer relationships;
- breadth of product line;
- breadth of geographic presence;
- customer service and support; and
- after-sales service.

We believe that we compete favorably with respect to all of the factors listed above. We believe that our key competitive strengths include our broad product line, our strong research and development infrastructure and investment, our manufacturing excellence, our advanced quality control systems, the low total cost of ownership of our products, our ability to provide our customers with quick order fulfillment and our applications expertise in semiconductor manufacturing processes. However, our competitive position varies depending on the market segment and specific product areas within these segments. While we have longstanding relationships with a number of semiconductor and other electronic device manufacturers, we also face significant competition from companies that also have longstanding relationships with other semiconductor and electronic device manufacturers and, as a result, have been able to have their products specified by those customers for use in manufacturers' fabrication facilities. The competitive landscape is varied, from multinational companies to small regional or regionally-focused companies. While product quality and technology remain critical, overall, industry trends are indicating a shift to localized, cost-competitive and consolidated supply chains.

Because of the unique breadth of our capabilities, we believe that there are no global competitors that compete with us across the full range of our product offerings. Many of our competitors are local companies that participate in only a few products or in specific geographies. While there are other larger, broad-based materials suppliers, many are concentrated in specific product areas, such as filtration, specialty chemicals or materials handling. Notable competitors with respect to certain specific product areas include Pall Corporation (part of Danaher Corporation), Shin-Etsu Polymer Co., Ltd., Gemu Valves, Inc., Tokyo Keiso Co., Ltd., Mersen, Versum Materials, Inc., E. I. du Pont de Nemours and Company and The Dow Chemical Company (each a subsidiary of DowDupont Inc.), Air Liquide, Praxair, Inc. (a subsidiary of Linde plc.), Donaldson Company, Inc. and Parker Hannifin Corp.

ENGINEERING, RESEARCH AND DEVELOPMENT

We believe that technology is important to the success of our businesses, and we plan to continue to devote significant resources to engineering, research and development (R&D), balancing efforts between shorter-term market needs and

longer-term investments. Our aggregate engineering, research and development expenses in 2018, 2017 and 2016 were $118.5 million, $107.0 million and $107.0 million, respectively. As of December 31, 2018, we had approximately 500 employees in engineering, research and development. We have supplemented and may continue to supplement our internal research and development efforts by licensing technology from unaffiliated third parties and/or acquiring rights with respect to products

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incorporating externally owned technologies. Our R&D expenses consist of personnel and other direct and indirect costs for internally funded project development, including the use of outside service providers.

We believe we have a rich pipeline of development projects. For example, our engineering, research and development efforts have been focusing on growth opportunities in areas such as bulk photochemical filtration, new boron mixtures for ion implant, new precursors for deposition, specialty coatings for key applications and new cleans chemistries. Our engineering, research and development efforts are directed toward developing and improving our technology platforms for semiconductor and advanced processing applications and identifying and developing products for new applications, often working directly with our customers to address their particular needs.

We have engineering, research and development capabilities in California, Colorado, Connecticut, Massachusetts, Minnesota, Texas, Japan, South Korea, Taiwan, Singapore and Malaysia to meet the global needs of our customers. We use sophisticated methodologies to research, develop and characterize our materials and products. Our capabilities to test and characterize our materials and products are focused on continuously reducing risks and threats to the integrity of the critical materials that our customers use in their manufacturing processes.

We participate in Semiconductor Equipment and Materials International (SEMI®), an association of semiconductor equipment suppliers, as well as collaborate with leading universities and industry consortia, such as the University of California and the Interuniversity Microelectronics Centre (imec®). We undertake this work to extend the reach of our internal R&D and to gain access to leadership ideas and concepts beyond the time horizon of our internal development activities.

PATENTS AND OTHER INTELLECTUAL PROPERTY RIGHTS

As of December 31, 2018, we own approximately 2,284 active patents worldwide, of which about 644 are United States patents. Additionally, Entegris owns about 1,098 that are pending patent applications globally. In addition, we license certain patents owned by third parties. We rely on a combination of patent, copyright, trademark and trade secret laws and license agreements to establish and protect our proprietary rights. We refresh our intellectual property on an ongoing basis through continued innovation. While we license and will continue to license technology used in the manufacture and distribution of products from third parties, we do not consider any particular patent or license to be material to our business.

We vigorously protect and defend our intellectual property. We require each of our employees, including our executive officers, to enter into standard agreements pursuant to which the employee agrees to keep confidential all of our proprietary information and to assign to us all inventions made while employed by us. We also require all outside scientific collaborators, sponsored researchers, and other advisors and consultants who are provided confidential information to execute confidentiality agreements upon the commencement of the consulting or collaboration relationship in question. These agreements generally provide that all confidential information developed or made known to the entity or individual during the course of the entity's or individual's relationship with the Company is to be kept confidential and not disclosed to third parties except in specific limited circumstances.

MANUFACTURING

Our customers rely on our products and materials to assure the integrity of the critical materials used in their manufacturing processes by providing purity, cleanliness, consistent performance, dimensional precision and stability. Our ability to meet our customers' expectations, combined with our substantial investments in worldwide manufacturing capacity, position us to respond to the increasing demands from our customers for yield-enhancing materials and solutions.

To meet our customers' needs worldwide, we have established an extensive global manufacturing network with facilities in the United States, Japan, Taiwan, Malaysia and South Korea. Because we work in an industry where contamination control is paramount, we maintain Class 100 to Class 10,000 cleanrooms for manufacturing and assembly. We believe that our worldwide advanced manufacturing capabilities are important competitive advantages. These include:

- engineered polymer conversion and processing;
- advanced membrane modification and cleaning;
- chemical distillation, synthesis and purification;
- gas delivery systems;
- specialty coating capabilities;
- solids and powders compounding and handling;
- graphite synthesis;
- blow molding;

- high-purity gas handling and transfilling;
- high-purity materials packaging;
- membrane casting;
- cartridge manufacturing and assembly;
- rotational molding;
- machining; and
- assembly.

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We have made significant investments in systems and equipment to create innovative products and tool designs, including metrology and 3D printing capabilities for rapid analysis and production prototype of products. In addition, we use contract manufacturers for certain of our gas purification systems and certain electronic materials products both in the U.S. and Asia.

RAW MATERIALS

Our products are made from a wide variety of raw materials that are generally available from multiple sources of supply. However, while we seek to have several sources of supply for all of these materials, certain materials included in our products, such as certain filtration membranes in our MC segment, petroleum coke and specialty and commodity chemicals in our SCEM segment and polymer resins in our AMH segment, are obtained from a single source or a limited group of suppliers or from suppliers in a single country. We have entered into multi-year supply agreements with a number of suppliers for the purchase of raw materials in the interest of supply assurance and to control costs.

GOVERNMENTAL REGULATION

Our operations are subject to federal, state and local regulatory requirements relating to environmental, waste management and health and safety matters, including measures relating to the release, use, storage, treatment, transportation, discharge, disposal and remediation of contaminants, hazardous substances and wastes, as well as practices and procedures applicable to the construction and operation of our plants. Although some risk of costs and liabilities related to these matters is inherent in our business, as with many similar businesses, we believe that our business is operated in substantial compliance with applicable regulations. However, new, modified or more stringent requirements or enforcement policies could be adopted, which could adversely affect us. While we expect that capital expenditures will be necessary to assure that any new manufacturing facility is in compliance with environmental and health and safety laws, we do not expect these expenditures to be material.

EMPLOYEES

As of December 31, 2018, we had approximately 4,900 employees. Given the variability of business cycles in the semiconductor industry and the quick response time required by our customers, it is critical that we be able to quickly adjust the size of our production staff to maximize efficiency. Therefore, we use skilled temporary labor as required. None of our employees are represented by a labor union or covered by a collective bargaining agreement other than statutorily mandated programs in certain European countries.

FINANCIAL INFORMATION ABOUT OUR OPERATING SEGMENTS

For a discussion of revenue and segment profitability with respect to each of our reporting segments, see Item 7. Management’s Discussion and Analysis of Financial Condition and Results of Operations - Segment Analysis below, which is incorporated herein by reference. See also note 16 to our consolidated financial statements. Approximately 78%, 79% and 78% of our net sales were made to customers outside North America in 2018, 2017 and 2016, respectively. Industry and geographic segment information is also discussed in note 16 to the Entegris, Inc. consolidated financial statements included in response to Item 8 below, which is incorporated herein by reference.

OUR HISTORY

The Company was incorporated in Delaware on March 17, 2005 in connection with a merger between Entegris, Inc., a Minnesota corporation, and Mykrolis Corporation, a Delaware corporation. On April 30, 2014, the Company acquired ATMI, based in Danbury, CT. Entegris has been helping its customers solve their critical materials challenges and enhance their manufacturing yields for over 50 years, tracing its corporate origins back to Fluoroware, Inc., which began operating in 1966.

AVAILABLE INFORMATION

Our Internet address is www.entegris.com. On this web site, under the “Investors-Financial Information-SEC Filings” section, we post the following filings as soon as reasonably practicable after they are electronically filed with, or furnished to, the U.S. Securities and Exchange Commission (SEC): our annual, quarterly, and current reports on Forms 10-K, 10-Q, and 8-K; our proxy statements; any amendments to those reports or statements, and Form SD. All such filings are available on our web site free of charge. The SEC also maintains a web site (www.sec.gov) that contains reports, proxy and information statements, and other information regarding issuers that file electronically with the SEC. The content on our website, and any other website, as referred to in this Form 10-K is not incorporated

by reference into this Form 10-K unless expressly noted.

Item 1A. Risk Factors.

In addition to the other information in this Annual Report on Form 10-K, the following risk factors should be carefully considered in evaluating us and our common stock. Any of the following risks, many of which are beyond our control, could

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materially and adversely affect our financial condition, results of operations or cash flows, or cause our actual results to differ materially from those projected in any forward-looking statements. While we believe that the following list identifies our most significant risk factors, there may be additional risks and uncertainties that are not presently known, are not currently believed to be material, or are not identified below because they are common to all businesses. Past financial performance may not be a reliable indicator of future performance and historical trends should not be used to anticipate results or trends in future periods. For more information, see "Cautionary Statement" in Item 7 of this Annual Report on Form 10-K.

Risks Related to Our Business and Industry

WORLDWIDE ECONOMIC AND INDUSTRY CONDITIONS MAY CAUSE DEMAND FOR OUR PRODUCTS TO DECREASE AND MAY ADVERSELY AFFECT OUR BUSINESS.

Worldwide economic and industry conditions may adversely affect our business. Our revenue is primarily dependent upon demand from semiconductor manufacturers, which is largely driven by the current and anticipated business and consumer demand for electronic products that utilize semiconductors. Despite the broadening of semiconductor demand drivers to including applications such as smartphones, cloud computing, the Internet of Things, and artificial intelligence, amongst others, the semiconductor industry has historically been, and may in the future be, highly cyclical with periodic significant downturns, resulting in significantly decreased expenditures by semiconductor manufacturers. We are unable to predict the ultimate duration or severity of any future downturns for the semiconductor industry. We have in the past experienced significant revenue deterioration and operating losses due to a severe downturn in the semiconductor industry. During downturns, our revenue is reduced and there is likely to be an increase in pricing pressure and shifts in product and customer mix, all of which may affect gross margin and net income. Additionally, the semiconductor industry is affected by seasonal shifts in demand. Even moderate cyclicality or seasonality can cause our operating results to fluctuate significantly from one period to the next.

Uncertain and volatile economic conditions and other factors can exacerbate negative trends in business and consumer spending, causing our customers to push out, cancel, or refrain from purchasing our products and solutions, which may have an adverse impact on our revenues, results of operations and financial condition. Changes in order patterns have an immediate impact on our revenues because we typically do not have significant backlog. Uncertain economic and industry conditions make it more challenging for us to forecast our operating results, make business decisions, and identify and prioritize business risks. If we do not appropriately respond to changing economic and industry conditions, it could have a significant negative impact on its business performance and financial condition. We may be required to implement additional cost reduction efforts, including restructuring activities, which may adversely affect our ability to capitalize on opportunities. Furthermore, since we must continue to maintain a satisfactory level of engineering, research and development expenditures, continue to invest in our infrastructure and maintain the ability to respond to any significant increases in demand, if they occur, lower sales volume in periods of reduced demand can have a large impact on our profitability.

OUR DEPENDENCE ON SINGLE AND LIMITED SOURCE SUPPLIERS OR AN INTERRUPTION IN OUR ORDINARY SOURCES OF SUPPLY COULD AFFECT OUR ABILITY TO MANUFACTURE OUR PRODUCTS AND HAVE AN ADVERSE EFFECT ON OUR RESULTS OF OPERATIONS.

We rely on single or limited source suppliers for raw materials, such as plastic polymers, filtration membranes, petroleum coke and other materials, which are critical to the manufacturing of our products. If we lost one of these sources, it may be difficult for us to find an alternative supplier and we would need to qualify this new source through our customers' rigorous qualification processes. Although we seek to reduce dependence on these sole and limited source suppliers, the partial or complete loss of these sources could interrupt our manufacturing operations and result in an adverse effect on our results of operations.

At times, we have experienced a limited supply of certain raw materials and have had to substitute raw materials, which have resulted in delays, increased costs and risks associated with qualifying products made from such new raw materials with our customers. Events such as an industry-wide increase in demand for, or the discontinuation of, raw materials used in our products could affect our ability to acquire sufficient quantities and our manufacturing operations may be interrupted. For example, global demand for fluoropolymers increased unexpectedly in 2017 due to greater requirements from certain markets. While we were able to maintain our supply of this raw material and

prevent delays in customer shipments by holding forecast reviews with our key suppliers and securing higher levels of fluoropolymers inventory, future raw materials shortages may adversely affect our operations. Additionally, our suppliers may not have the capacity to meet increases in our demand for raw materials, in turn, making it difficult for us to meet demand from our customers. Furthermore, prices for our raw materials can vary widely. While we have long-term arrangements with certain key suppliers that fix our price for the purchase of certain raw materials, if the cost of our raw materials increases and we are unable to correspondingly increase the sales price of our products or find other cost savings, our profit margins will decline.

WE ARE EXPOSED TO THE RISKS OF OPERATING A GLOBAL BUSINESS AS A SIGNIFICANT AMOUNT OF OUR SALES AND MANUFACTURING ACTIVITY OCCUR OUTSIDE THE UNITED STATES.

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Sales to customers outside the United States accounted for approximately 78%, 79% and 78% of our net sales in 2018, 2017 and 2016, respectively. We anticipate that international sales will continue to account for a majority of our net sales. In addition, a number of our key domestic customers derive a significant portion of their revenues from sales in international markets. We also manufacture a significant portion of our products outside the United States and are dependent on international suppliers for many of our parts and raw materials. We intend to continue to pursue opportunities in both sales and manufacturing internationally. Our international operations are subject to a number of risks and potential costs that could adversely affect our revenue and profitability, including:

- unanticipated government actions, laws, rules, regulations and policies, such as “trade wars” or changes in international trade requirements and sanctions and/or tariffs that affect our business and that of our customers and suppliers, that could impose additional costs on our operations, or that could limit our ability to operate our business;
- challenges in hiring and integrating workers in different countries;
- management of a diverse workforce with different experience levels, languages, cultures, customs, business practices and worker expectations, along with differing employment practices and labor issues;
- maintenance of appropriate business processes, procedures and internal controls, and compliance with legal, environmental, health and safety, anti-corruption and other regulatory requirements;
- development of relationships with local customers, suppliers and governments;
- fluctuating pricing and availability of raw materials and supply chain interruptions;
- expense and complexity of complying with U.S. and foreign import and export regulations, including the ability to obtain required import and export licenses;
- fluctuations in interest rates and currency exchange rates, including the relative strength or weakness of the U.S. dollar against foreign currency including Japanese yen, euro, Taiwanese dollar, Korean won, Chinese yuan or Singapore dollar, which could cause our sales and profitability to decline;
- liability for foreign taxes assessed at rates higher than those applicable to our domestic operations;
- customer or government efforts to encourage operations and sourcing in a particular country, such as Korea and China or that favor domestic companies over nondomestic companies, including efforts to provide for the development and growth of local competitors; and
- political and economic instability and uncertainty.

In the past, we have incurred costs or experienced disruptions due to the factors described above and we expect to do so in the future. For example, effective October 30, 2018, the U.S. Department of Commerce restricted exports to a Chinese semiconductor manufacturing company and may in the future impose further restrictions on this or other semiconductor manufacturers or industry participants. While this particular event is not expected to have an adverse effect on our revenue, other restrictions could impact our ability to serve customers in China and in other countries. In addition, the import of gas canisters and chemicals viewed as dangerous have come under increased regulatory scrutiny by governmental officials in China. As a result, we have established partnerships with local suppliers. However, this increased regulation may impair the ability of our SCEM segment to import those products into China and may cause us to lose sales. Also, in the past, our operations in Asia, and particularly South Korea, Taiwan and Japan, have been negatively impacted as a result of regional economic instability. There have historically been strained relations between China and Taiwan and there are continuing tensions between North Korea and other countries, including South Korea and the United States. Any adverse developments in those relations could significantly disrupt the worldwide production of semiconductors, which may lead to reduced sales of our products.

A SIGNIFICANT AMOUNT OF OUR SALES IS CONCENTRATED ON A LIMITED NUMBER OF KEY CUSTOMERS AND, THEREFORE, OUR NET SALES AND PROFITABILITY MAY MATERIALLY DECLINE IF WE LOST ONE OR MORE OF THESE CUSTOMERS.

Sales to a limited number of large customers constitute a significant portion of our overall revenue, shipments, cash flows, collections, and profitability. Our top ten customers accounted for 44%, 47% and 45% of our net sales in 2018, 2017 and 2016, respectively. Our customers could stop using our products in their manufacturing processes with limited advance notice to us and suffer little or no penalty for doing so. The cancellation, reduction or deferral of purchases of our products by even a single customer could significantly reduce our revenues in any particular quarter.

If we were to lose any of our significant customers, if our products are not specified for these customers' products or production processes, or if we suffer a material reduction in their purchase orders, our revenue could decline and our business, financial condition and results of operations could be materially and adversely affected. Due to the long design and development cycle and lengthy customer product qualification periods required for most of our new products, we may be unable to quickly replace these customers, if at all.

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Furthermore, the semiconductor industry has been undergoing, and is expected to continue to undergo, consolidation. If any of our customers merge or are acquired, we may experience lower overall sales from the merged or surviving companies. In addition, our principal customers also hold considerable purchasing power and may be able to negotiate requirements that result in decreased pricing, increased costs, and/or lower margins for us, and limitations on our ability to share jointly developed technology with others.

We could also lose our key customers or significant sales to our key customers because of factors beyond our control, such as a significant disruption in our customers' businesses generally or in a specific product line, a change in the manufacturing sourcing policies or practices of these customers or the timing of customer inventory adjustments. For example, our customers' aggressive management of inventory has adversely affected revenue in our SCEM segment in the past and may adversely affect future results of operations.

IF WE ARE UNABLE TO RESPOND TO RAPID TECHNOLOGICAL CHANGE BY CONTINUING TO INNOVATE AND INTRODUCE NEW AND ENHANCED PRODUCTS AND SOLUTIONS, OUR BUSINESS COULD BE SERIOUSLY HARMED.

The semiconductor industry is subject to rapid technological change, changing customer requirements and frequent new product introductions. As a result, the life cycle of our products is difficult to determine. We believe that our future success will depend upon our ability to continue to develop mission-critical solutions to maximize our customers' manufacturing yields and enable higher performance of end-market materials or devices. This requires that we successfully anticipate and respond to technological changes in manufacturing processes in a cost-effective and timely manner. A failure to develop new products or enhancements to our existing products or the inability to timely manufacture and ship these products or enhancements in sufficient volume could harm our business prospects and significantly reduce our sales. In addition, if new products have reliability or quality problems, we may experience reduced orders, higher manufacturing costs, delays in acceptance and payment, additional service and warranty expense, and damage to our reputation.

COMPETITION FROM NEW OR EXISTING COMPANIES COULD HARM OUR FINANCIAL CONDITION, RESULTS OF OPERATIONS AND CASH FLOW.

We operate in a highly competitive industry. Our competitors include many domestic and foreign companies, some of which have substantially greater manufacturing, financial, research and development, and marketing resources than we do. In addition, some of our competitors may have better-established customer relationships than we do, which may enable them to have their products specified for use more frequently and more quickly by these customers. We also face competition from smaller, regional companies, which focus on serving those customers in their same region. Another source of competition is from the manufacturing engineering teams of our customers, who continually evaluate the benefits of internal manufacturing versus outsourcing. If we are unable to maintain our competitive position, we could experience downward pressure on prices, fewer customer orders, reduced margins, the inability to take advantage of new business opportunities and a loss of market share, which could have a material adverse effect on our results of operations. Further, we expect that existing and new competitors will improve the design of their existing products and will introduce new products with enhanced performance characteristics. The introduction of new products or more efficient production of existing products by our competitors could diminish our market share and increase pricing pressure on our products.

IF OUR NEW PRODUCT INITIATIVES AND RELATED INVESTMENTS DO NOT RESULT IN FUTURE BUSINESS OPPORTUNITIES, OUR REVENUE AND PROFITABILITY MAY DECLINE.

In the semiconductor market, while the development period for a product can be very long, the first company to introduce an innovative product meeting an identified customer need will often have a significant advantage over offerings of competitive products. For this reason, we may make significant cash expenditures to research, develop, engineer and market new products and make significant capital investments in technology and manufacturing capacity in advance of future business developing and without any purchase commitment from our customers. For example, to support new product and technology development, we incurred $118.5 million, $107.0 million and $107.0 million for engineering, research and development expense in 2018, 2017 and 2016, respectively.

Following development, it may take a number of years for sales of a new product to reach a substantial level, if ever. A product concept may never progress beyond the development stage or may only achieve limited acceptance in the

marketplace. If this occurs, we do not receive a direct return on our expenditures, we may not realize any indirect benefits, we may lose market share and our revenue and profitability may decline. For example, from 2011 to 2014, our capital expenditures relating to developing the capability to manufacture shippers and FOUPs for 450 mm wafers were approximately $16.5 million. However, major semiconductor manufacturers have announced that they would not initiate 450 mm manufacturing in the foreseeable future. As a result, we incurred significant impairment charges in fiscal year 2017. We cannot assure you that the new products and technology we choose to develop and market in the ordinary course of our business will be successful.

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TARIFFS, TRADE RESTRICTIONS AND PROTECTIONIST MEASURES RESULTING FROM INTERNATIONAL TRADE DISPUTES COULD HAVE AN ADVERSE IMPACT ON OUR OPERATIONS.

We have significant sales to customers outside of the United States and we purchase a significant amount of raw materials from suppliers outside of the United States. The United States and other countries have levied tariffs and taxes on certain goods. While there is uncertainty as to the duration of these tariffs and scope of future tariffs, tariffs may increase the costs of certain raw materials that we import into the United States and may negatively impact our margins as we may not be able to increase the prices of our products. Retaliatory tariffs on goods manufactured in the United Stated could make the products we sell from the United States more expensive to customers outside the United States, reducing the competitiveness of our products, harming sales and inhibiting our ability to do business in these foreign countries. As a result of these ongoing trade disputes, our business, financial condition, results of operations and cash flow could be negatively impacted.

WE MAY ACQUIRE OTHER BUSINESSES, FORM JOINT VENTURES OR DIVEST BUSINESSES, WHICH COULD NEGATIVELY AFFECT OUR FINANCIAL PERFORMANCE.

As part of our business strategy, and as we have done in the past, we expect to address gaps in our product offerings, adjust our portfolio of businesses to meet our ongoing strategic objectives, diversify into complementary markets and increase our scale through acquisitions, joint ventures or other types of collaborations, including the Proposed Merger. As a result, we may enter markets in which we have no or limited prior experience and may encounter difficulties in divesting businesses that no longer meet our objectives. Competition for acquiring attractive businesses in our industry is substantial. We may experience difficulty in identifying suitable acquisition candidates or in completing selected transactions at appropriate valuations, in a timely manner, on a cost-effective basis or at all, and we may not realize the anticipated benefits of any such transaction. In addition, new legislation or regulations may increase the difficulty or impair our ability to invest or consummate transactions in certain countries or require us to obtain regulatory approvals to do so. Specifically, the Proposed Merger is subject to a number of closing conditions, many of which are outside of our control, including the receipt of approvals from our and Versum’s shareholders, the receipt of approvals under U.S. and certain foreign antitrust and competition laws, and other conditions set forth in the Merger Agreement, and there can be no assurance that the Proposed Merger will be completed.

Alternatively, we may be required to undertake multiple transactions at the same time in order to take advantage of acquisition opportunities that do arise. This could strain our ability to effectively execute and integrate these transactions. In addition, the integration of certain operations following a transaction, including the Proposed Merger, requires the dedication of significant management resources, which may temporarily distract management’s attention from our day-to-day business. Employee uncertainty and lack of focus during integration process may also disrupt our business. Further, we may not be able to successfully integrate any acquisitions that we do make into our existing business operations, including the Proposed Merger. For example, if we fail to successfully integrate and operate the gas purification business we acquired from SAES Getters S.p.A. in June 2018, we may not meet our revenue and bottom line objectives for the MC division or for the Company, and if we fail to successfully integrate the operations of Versum, we may not be able to achieve the anticipated operating and cost synergies or long-term strategic benefits of the Proposed Merger. An inability to realize the full extent of, or any of, the anticipated benefits of the Proposed Merger, as well as any delays encountered in the integration process, could have an adverse effect on our business and results of operations, which may affect the value of the shares of our common stock after the completion of the Proposed Merger. Additionally, we could assume unknown or contingent liabilities or experience negative effects on our reported results of operations from dilutive results from operations and/or from future potential impairment of acquired assets, including goodwill, related to future acquisitions. For example, despite our due diligence review, an acquired company may have inadequate or ineffective an internal financial controls, disclosure controls and procedures, cybersecurity, privacy policies and procedures, or environmental, health and safety, anti-corruption, human resource, or other policies or practices. We may experience difficulties in retaining key employees or customers of an acquired business, and our management’s attention could be diverted from other business issues.

MANUFACTURING INTERRUPTIONS OR DELAYS, FAILURE TO RESPOND TO SHIFTS IN DEMAND, AND RISKS ASSOCIATED WITH THE USE AND MANUFACTURE OF HAZARDOUS MATERIALS COULD ADVERSELY AFFECT OUR BUSINESS, FINANCIAL CONDITION AND RESULTS OF OPERATIONS.

Our manufacturing processes are complex and require the use of expensive and technologically sophisticated equipment and materials. These processes are frequently modified to improve manufacturing yields and product quality. We have, on occasion, experienced manufacturing difficulties, such as occasional critical equipment breakdowns or the introduction of impurities in the manufacturing process, which could cause lower manufacturing yields, make our products unmarketable and/or delay deliveries to customers. In addition, modification to the manufacturing process of our products may require that the affected product be re-qualified by our customers, which can increase our costs and delay our ability to sell this product to our customers. These and other manufacturing difficulties may result in the loss of sales and exposure to warranty and product liability claims.

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A number of our product lines are manufactured at only one or two facilities in different countries. A disruption at these facilities could impact our sales until another facility could commence or expand production of such products. We have in the past moved, and we may in the future move, the manufacture of certain product lines from one of our plants to another, usually to enhance efficiency and cost effectiveness of our manufacturing operations and to better serve customers located in various countries. If we fail to efficiently and effectively transfer and re-establish the manufacturing processes in the destination plant, we may not be able to meet customer order, we may lose credibility with our customers and our business may be harmed. Even if we successfully move our manufacturing processes, there is no assurance that we will achieve anticipated cost savings and efficiencies.

Our ability to increase sales of our products, particularly our capital equipment products, depends in part upon our ability to timely ramp up our manufacturing capacity for such products, often in as little as a few months, and to quickly mobilize our supply chain. If we are unable to accurately foresee or anticipate rapid shifts in demand, expand our manufacturing capacity on a timely basis, manage such expansion effectively and obtain an increase in required raw materials from our supply chain, our customers could seek such products from our competitors, and our market share could be reduced. Additionally, we typically operate our business on a just-in-time shipment basis with a modest level of backlog, ordering supplies and planning production based on internal demand forecasts. The failure to accurately forecast demand for our products, in terms of both volume and product type, has in the past led to, and may in the future lead to, delays in product shipments, disappointment of customer expectations, and, alternatively, an increased risk of excess and obsolescence of our inventory. If we fail to accurately forecast demand for our products, our business, financial condition and operating results could be materially and adversely affected.

Our operations involve, and we are exposed to the risks associated with, the use and the manufacture of hazardous materials, in particular, specialty chemical manufacturing, and the related storage and transportation of raw materials, products and waste in our manufacturing facilities or distribution centers. In addition, a failure of one of our products at a customer site could interrupt the business operations of the customer. For example, while we believe that our SDS and VAC delivery systems are the safest available in the industry, as with any products involved in the transport, storage and delivery of toxic gases, if a leak were to occur during transport, during storage or during delivery at our customers' location, serious damage could result including injury or death to any person exposed to those toxic gases creating significant product liability for us. There can be no assurance that our insurance will be adequate to satisfy any such liabilities and our financial results or financial condition could be adversely affected.

LOSS OF OUR KEY PERSONNEL, WHO HAVE SIGNIFICANT EXPERIENCE IN THE SEMICONDUCTOR INDUSTRY AND TECHNOLOGICAL EXPERTISE, COULD HARM OUR BUSINESS, WHILE OUR INABILITY TO ATTRACT AND RETAIN NEW QUALIFIED PERSONNEL COULD INHIBIT OUR ABILITY TO OPERATE AND GROW OUR BUSINESS SUCCESSFULLY.

Many of our key personnel have significant experience in the semiconductor industry and deep technical expertise. The loss of the services of one or several of our key employees or an inability to attract, train and retain qualified and skilled employees, specifically research and development and engineering personnel, could inhibit our ability to operate and grow our business successfully. As the semiconductor industry has experienced growth in recent years, the competition between industry participants for qualified talent, particularly those with significant experience in the semiconductor industry, has intensified. As a result, the difficulty and costs associated with attracting and retaining key employees has risen and may rise further in the future rise.

IF WE FAIL TO OBTAIN, PROTECT AND ENFORCE INTELLECTUAL PROPERTY RIGHTS, OUR BUSINESS AND PROSPECTS COULD BE HARMED.

Our future success and competitive position depend in part upon our ability to obtain, maintain and enforce intellectual property rights. We rely on patent, trade secret and trademark law to protect many of our major product platforms. We have obtained a number of patents relating to our products and solution. While we have filed applications for additional patents, we cannot assure you that any of our pending patent applications will be approved, that we will develop additional patentable proprietary technology, that any patents owned by or issued to us will provide us with competitive advantages or that these patents will not be challenged, invalidated, circumvented, rendered unenforceable or otherwise compromised by third parties. In addition, if we do not obtain intellectual property protection in the international jurisdictions we serve, our competitiveness in these markets could be

significantly impaired, which could limit our growth and future revenue. While we routinely enter into confidentiality agreements with our employees and with third parties to protect our proprietary information and technology, these agreements may be breached by such employees or third parties, and we may not have adequate remedies for such breaches. Furthermore, our confidential and proprietary information and technology could be independently developed by or become otherwise known to third parties and third parties could design around our patents. Competitors may misappropriate our intellectual property rights, and disputes as to ownership of intellectual property rights may arise. We may institute litigation in order to enforce our patents, copyrights or other intellectual property rights, to protect our trade secrets, to determine the validity and scope of the proprietary rights of others or to defend against claims of

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infringement. Such litigation could result in substantial costs and diversion of resources and could negatively affect our sales, profitability and prospects regardless of whether we are able to successfully enforce our rights. For example, in January 2011, we settled multiple patent litigations with Pall Corporation (which was acquired by Danaher Corporation in 2015). We prosecuted and defended these cases vigorously and incurred substantial costs in pursuing them. It may become necessary for us to initiate other costly patent litigation against our competitors in order to protect and/or perfect our intellectual property rights. We cannot predict how any existing or future litigation will be resolved or what its impact will be on us.

Our commercial success depends, in part, on our ability to avoid infringing or misappropriating any patents or other proprietary rights owned by third parties. If we are found to infringe or misappropriate a third party's patent or other proprietary rights, we could be required to pay damages to such third party, alter our products or processes, obtain a license from the third party or cease activities utilizing such proprietary rights, including making or selling products utilizing such proprietary rights. If we are required to obtain a license from a third party, there can be no assurance that we will be able to do so on commercially favorable terms or at all.

OUR RESULTS OF OPERATIONS COULD BE ADVERSELY AFFECTED BY CLIMATE CHANGE OR NATURAL CATASTROPHES IN THE LOCATIONS IN WHICH WE, OUR CUSTOMERS OR OUR SUPPLIERS OPERATE, SUCH AS THE MARCH 2011 EARTHQUAKE AND TSUNAMI IN JAPAN, HURRICANE HARVEY IN EAST TEXAS, HURRICANE IRMA IN FLORIDA IN 2017 AND THE WILDFIRES IN COLORADO SPRINGS, COLORADO AND CALIFORNIA IN 2012, 2017 AND 2018.

We have manufacturing and other operations in locations subject to severe weather and natural catastrophes which could disrupt operations, such as typhoons in Taiwan and China, earthquakes and tsunamis in Japan in 2011, hurricanes in east Texas (Hurricane Harvey) and in Florida (Hurricane Irma), each in 2017, and wildfires in Colorado Springs, Colorado in 2012 and in California in 2017 and 2018. In addition, our suppliers and customers also have operations in such locations. A natural disaster that results in a prolonged disruption to our operations, or our customers' or suppliers' operations, may adversely affect our results of operations and financial condition. Also, climate change poses both regulatory and physical risks that could harm our results of operations or affect the way we conduct our businesses. While our business continuity plans enabled us to mitigate the impact to our operations of the events described above, there can be no assurance that such plans will be effective in the future or that such catastrophes will not disrupt our ability to manufacture and deliver products to our customers, resulting in an adverse impact on our business and results of operations.

WE MAY BE SUBJECT TO INFORMATION TECHNOLOGY SYSTEM FAILURES, NETWORK DISRUPTIONS AND BREACHES IN DATA SECURITY, WHICH COULD DAMAGE OUR REPUTATION AND ADVERSELY AFFECT OUR FINANCIAL CONDITION, RESULTS OF OPERATIONS AND CASH FLOWS.

In the ordinary course of our business, we collect and store sensitive data, including our financial information, intellectual property, confidential information, proprietary business information and that of our customers, suppliers and business partners and personally identifiable information of our employees in our data centers and on our networks. The secure processing, maintenance and transmission of this information is critical to our operations. Information technology system failures, network disruptions and breaches of data security from cyber-attacks, employee error or social media use on our computers, through failure of our internet service providers and other cloud computing service providers to successfully secure their own systems or from other causes could disrupt our operations, cause customer communication and order management issues, cause the unintentional disclosure of customer, employee and proprietary information, cause disruption in our transaction processing or lead to issues with maintaining our controls over our financial reporting, which could affect our reputation and reporting of financial results.

All information systems are subject to disruption, breach or failure. While our management has implemented network security procedures, virus protection software, intrusion prevention systems, access control, emergency recovery processes and internal control measures, we have experienced, and expect to continue to be subject to, cybersecurity threats and incidents ranging from employee error or misuse, to individual attempts to gain unauthorized access to our systems, to sophisticated and targeted measures known as advanced persistent threats, none of which have been material to the Company to date. Furthermore, there can be no assurance that a system failure or data security breach

will not occur and have a material adverse effect on our financial condition results of operations and cash flows. Relatedly, new laws and regulations, such as the European Union General Data Protection Regulation 2016 that became effective May 2018, add to the complexity of our compliance obligations, which may increase compliance costs, and a failure to comply with such laws and regulations could result in significant penalties.

WE ARE SUBJECT TO A VARIETY OF ENVIRONMENTAL LAWS AND REGULATIONS THAT COULD CAUSE US TO INCUR SIGNIFICANT LIABILITIES AND EXPENSES.

Failure to comply with the wide variety of federal, state, local and non-U.S. regulatory requirements relating to the release, use, storage, treatment, transportation, discharge, disposal and remediation, of, and human exposure to, hazardous chemicals, which

have tended to become stricter over time, could result in future liabilities or the suspension of production or shipment. For example, the Frank R. Lautenberg Chemical Safety for the 21st Century Act modified the Toxic Control Substances Act, or TSCA, by requiring the Environmental Protection Agency, or the EPA, to prioritize and evaluate the environmental and health risks of existing chemicals and provides EPA with greater authority to regulate chemicals posing unreasonable risks. According to this statute, the EPA is required to make an affirmative finding that a new chemical will not pose an unreasonable risk before such chemical can go into production. As a result, TSCA has been updated so that it operates in a similar fashion to the Registration, Evaluation, and Authorization of Chemicals, or REACH, legislation in Europe. Regulations similar to REACH have been enacted in South Korea and Taiwan. These laws and regulations, among others, increase the complexity and costs of transporting our products from the country in which they are manufactured, to the location of our customer. Any further changes to these and similar regulations in the countries in which we operate or sell into could restrict our ability to expand our facilities or to build or acquire new facilities, require us to acquire costly control equipment, cause us to incur expenses associated with remediation of contamination, modify our manufacture or shipping processes, or otherwise increase our cost of doing business and have a negative impact on our financial condition, results of operations and cash flows.

The nature of our business exposes us to risk of liability for environmental contamination if hazardous materials are released into the environment, which could result in substantial losses, reputational harm, increase in our insurance cost or otherwise adversely impact our results of operations.

CHANGES IN TAXATION OR ADVERSE TAX RULINGS COULD ADVERSELY AFFECT OUR RESULTS OF OPERATIONS.

We have facilities in many foreign countries and, as a result, are subject to taxation at various rates and audit by a number of taxing authorities. Our results of operations could be affected by changes in applicable tax rates or audits by the taxing authorities in countries in which we operate or in the countries from which we purchase raw materials, changes in laws and regulations governing calculation and location of earned profit and taxation thereof, changes in laws and regulations affecting our ability to realize deferred tax assets on our balance sheet and changes in laws and regulations relating to the repatriation of cash into the United States. Each quarter we forecast our tax liability based on our forecast of our performance for the year. If that performance forecast changes, our forecasted tax liability may change.

We have undertaken a number of complex internal reorganizations of our foreign subsidiaries in order to rationalize and streamline our foreign operations, focus our management efforts on certain local opportunities and take advantage of favorable business conditions in certain localities. While we have exercised diligence in undertaking these internal reorganizations, there can be no assurance that these reorganizations, or any future internal reorganization, will not result in adverse tax consequences in the United States or in foreign countries in which we have operations. This could adversely impact our profitability from foreign operations and result in a material reduction in our results of operations.

The U.S. Tax Cuts and Jobs Act of 2017 (the “Tax Cuts and Jobs Act”) significantly changed how the U.S. taxes corporations, including limitations on the deductibility of interest expense and executive compensation, and the imposition or acceleration of taxation on certain foreign income, each of which may increase our tax expense. Both the Tax Cuts and Jobs Act and subsequent regulations and interpretations require complex computations to be performed that were not previously required in U.S. tax law, significant judgments to be made in interpretation of the provisions of the Tax Cuts and Jobs Act, significant estimates in calculations, and the preparation and analysis of information not previously relevant or regularly produced. The U.S. Treasury Department, the IRS, and other standard-setting bodies could interpret or issue guidance on how provisions of the Tax Cuts and Jobs Act will be applied or otherwise administered that is different from our interpretation. As additional clarification and guidance is issued regarding the Tax Cuts and Jobs Act, we may make adjustments to amounts that we have recorded, which may materially impact our provision for income taxes in the period in which the adjustments are made.

Various other jurisdictions, including members of the Organization for Economic Cooperation and Development, are considering changes to their tax laws, including provisions intended to address base erosion and profit shifting by taxpayers. Any tax reform adopted in these or other countries may exacerbate the risks described above.

UNCERTAINTY AND VOLATILITY IN THE GLOBAL ECONOMY COULD ADVERSELY AFFECT OUR RESULTS.

Financial markets in the United States, Europe and Asia have experienced extreme disruption in the recent past. Such disruption included, among other things, volatility in securities prices, severely diminished liquidity and credit availability, rating downgrades of sovereign debt, declining valuation of certain investments, declines in consumer confidence, declines in economic growth, volatility in unemployment rates, and uncertainty about economic stability. Such conditions have had a significant adverse impact on our industry, our financial condition and results of operations. There may be further changes in the global economy, which could lead to further challenges in our business and negatively impact our financial results. For example, the U.K. vote in favor of leaving the European Union may cause instability and uncertainty in European economies and may negatively impact the outlook for the global economy. Tightness of credit in financial markets could adversely affect the ability of our customers and suppliers to obtain financing for significant purchases and operations and could result in a

decrease in orders and spending for our products and services. We are unable to predict the likely duration and severity of any disruption in regional or global financial markets and adverse economic conditions and the effects they may have on our business and financial condition. If uncertain economic conditions return or deteriorate, our business and results of operations could be further materially and adversely affected.

Risks Related to Our Indebtedness

WE HAVE A SUBSTANTIAL AMOUNT OF INDEBTEDNESS, WHICH COULD ADVERSELY AFFECT OUR FINANCIAL HEALTH AND OUR ABILITY TO OBTAIN FINANCING IN THE FUTURE AND REACT TO CHANGES IN OUR BUSINESS.

As of December 31, 2018, we have approximately an aggregate principal amount of $950.0 million of indebtedness outstanding, including our 4.625% senior unsecured notes due April 1, 2026 (the "Notes", and the indenture that governs the Notes, the "Indenture") and our senior secured term loan facility due 2025 (the "Term Loan Facility"). In addition, we have approximately $300 million of unutilized capacity under our senior secured revolving credit facility due 2023 (the "Revolving Facility", and together with the Term Loan Facility, the "Credit Facilities", and the credit agreement that governs the Credit Facilities, the "Credit Agreement").

Our debt could have important consequences, including:

- making it more difficult for us to satisfy our obligations with respect to the Notes and the Credit Facilities;
- limiting our ability to obtain additional financing to fund future working capital, capital expenditures, acquisitions or other general corporate purposes;
- requiring a substantial portion of our cash flow to be dedicated to debt service payments instead of other purposes, thereby reducing the amount of cash flow available for working capital, capital expenditures, acquisitions and other general corporate purposes;
- increasing our vulnerability to adverse changes in general economic, industry and competitive conditions;
- exposing us to the risk of increased interest expense as certain of our borrowings, including borrowings under the Credit Facilities, include variable interest rates;
- limiting our flexibility in planning for and reacting to changes in the industry in which we compete;
- preventing us from raising funds necessary to repurchase all Notes tendered to us upon the occurrence of certain change of control repurchase events, which could constitute a default under the Indenture;
- placing us at a disadvantage compared to other, less leveraged competitors or competitors with comparable debt at more favorable interest rates; and
- increasing our cost of borrowing.

In addition, the Indenture and the Credit Agreement contain restrictive covenants that will limit our ability to engage in activities that may be in our long-term best interest. Our failure to comply with those covenants could result in an event of default which, if not cured or waived, could result in the acceleration of substantially all of our debt.

DESPITE OUR CURRENT LEVEL OF INDEBTEDNESS, WE MAY STILL BE ABLE TO INCUR SUBSTANTIALLY MORE DEBT, WHICH COULD FURTHER EXACERBATE THE RISKS TO OUR FINANCIAL CONDITION DESCRIBED ABOVE.

We may incur significant additional indebtedness in the future. Although the Indenture and the Credit Agreement restrict our ability to incur additional indebtedness, the restrictions are subject to a number of significant qualifications and exceptions, such as indebtedness to finance working capital, capital expenditures, investments and acquisitions, or other purposes, and the additional indebtedness that we may incur while remaining in compliance with these restrictions could be substantial. For example, the Credit Agreement provides that we have the right to request additional loans and commitments in an aggregate amount not to exceed the greater of $400 million and 100% of EBITDA and additional amounts if our secured net leverage ratio is less than a specified ratio or, in the case of unsecured loans or other unsecured debt, or loans or other debt secured by junior liens, if our total net leverage ratio is less than a specified ratio. The Indenture does not limit the Company's ability to incur unsecured indebtedness. Moreover, the restrictions in the Indenture on our ability to incur additional secured indebtedness are subject to a number of significant exceptions and qualifications that may permit us to incur a substantial amount of additional secured indebtedness. Further, although the Indenture limits the ability of a non-guarantor subsidiary to incur indebtedness unless it also guarantees the Notes, this limitation is subject to a number of significant exceptions and

qualifications, and the amount of indebtedness incurred in compliance with the Indenture could be substantial. These restrictions do not prevent us from incurring monetary obligations that do not constitute indebtedness. If we add new indebtedness and other monetary obligations to our current debt levels, the related risks that we now face could intensify.

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WE MAY NOT BE ABLE TO GENERATE SUFFICIENT CASH TO SERVICE OUR INDEBTEDNESS AND MAY BE FORCED TO TAKE OTHER ACTIONS, WHICH MAY NOT BE SUCCESSFUL, TO SATISFY OUR OBLIGATIONS UNDER OUR INDEBTEDNESS.

We may be unable to maintain a level of cash flow from operating activities sufficient to permit us to pay the principal of, premium, if any, and interest on our indebtedness. Our ability to make scheduled payments on or to refinance our debt obligations depends on our financial condition and operating performance and the condition of the capital markets, which are subject to prevailing economic, industry and competitive conditions, as well as certain financial, business, legislative, political, regulatory and other factors beyond our control. If our cash flow and capital resources are insufficient to fund our debt service obligations, we could face substantial liquidity problems, be forced to reduce or delay investments and capital expenditures, dispose of material assets or operations, seek additional debt or equity capital or restructure or refinance our indebtedness, and our financial position and results of operations could be materially and adversely affected.

Any refinancing of our debt could be at higher interest rates and may require us to comply with more onerous covenants, which could further restrict our business operations. We may not be able to effect any such alternative measures on commercially reasonable terms or at all and, even if successful, those alternative actions may not allow us to meet our scheduled debt service obligations. Our ability to dispose of assets and use the proceeds from those dispositions is restricted by the agreements governing our indebtedness, and we may not be able to consummate those dispositions or to obtain proceeds in an amount sufficient to meet any debt service obligations then due.

If we cannot make scheduled payments on our debt, we will be in default, and holders of the Notes and lenders under the Credit Facilities could declare all outstanding principal and interest to be due and payable, the lenders under the Revolving Facility could terminate their commitments to advance further loans, our secured lenders could foreclose against the assets securing their borrowings, and we could be forced into bankruptcy or liquidation.

THE TERMS OF THE CREDIT AGREEMENT RESTRICT OUR CURRENT AND FUTURE OPERATIONS, PARTICULARLY OUR ABILITY TO RESPOND TO CHANGES OR TO CONDUCT OUR BUSINESS OR RAISE ADDITIONAL FUNDS.

The Credit Agreement contains a number of restrictive covenants that impose significant operating and financial restrictions on us and may limit our ability to take action that may be in our long-term best interest, including restrictions on our ability to:

- incur certain liens;
- incur additional indebtedness and guarantee indebtedness;
- pay dividends or make other distributions in respect of, or repurchase or redeem, capital stock;
- prepay, redeem or repurchase certain debt;
- make investments, loans, advances and acquisitions;
- sell or otherwise dispose of assets, including capital stock of our subsidiaries;
- enter into transactions with affiliates;
- alter the businesses we conduct;
- enter into agreements restricting our subsidiaries’ ability to pay dividends; and
- merge or sell all or substantially all of our assets or incur a change of control in our capital stock ownership.

In addition, the restrictive covenants in the Credit Agreement may, at certain times based on the outstanding amount of revolving borrowings, unreimbursed letter of credit drawings and undrawn letters of credit, require us to maintain a secured net leverage ratio. Our ability to meet this financial ratio can be affected by events beyond our control.

Our failure to comply with these covenants could result in an event of default that, if not cured or waived, could result in the acceleration of some or all of our indebtedness, which could lead to bankruptcy, reorganization or insolvency.

These restrictions may affect our ability to grow in accordance with our plans and could adversely affect our ability to:

- finance our operations;
- make needed capital expenditures;
- make strategic acquisitions or investments or enter into joint ventures;
- withstand a future downturn in our business, the industry or the economy in general;

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- compete effectively and engage in business activities, including future opportunities, that may be in our best interest; and
- plan for or react to market conditions or otherwise execute our business strategies.

Risks Related to Owning our Common Stock

THE PRICE OF OUR COMMON STOCK HAS BEEN VOLATILE IN THE PAST AND MAY BE VOLATILE IN THE FUTURE.

The price of our common stock has been volatile in the past and may be volatile in the future. In 2018, the closing price of our stock on The NASDAQ Global Select Market, or NASDAQ, ranged from a low of $24.44 to a high of $38.85, and, as in past years, the price of our common stock may show greater volatility.

The trading price of our common stock is subject to significant volatility in response to various factors, some of which are beyond our control or may be unrelated to our operating results, and which may adversely affect the market price of our common stock, including the following: the failure to meet the published expectations of securities analysts; changes in financial estimates by securities analysts; press releases or announcements by, or changes in market values of, comparable companies; volatility in the markets for high-technology stocks, general stock market price and volume fluctuations, which are particularly common among securities of high-technology companies; stock market price and volume fluctuations attributable to inconsistent trading volume levels; the public perception of equity values of publicly traded companies and the other risks and uncertainties described in this Annual Report on Form 10-K and in our other filings with the SEC. Such fluctuations in our results could cause our stock price to decline significantly. We believe that period-to-period comparisons of our results of operations may not be meaningful, and you should not rely upon them as indicators of our future performance. Future decreases in our stock price may adversely impact our ability to raise sufficient additional capital in the future, if needed.

THERE CAN BE NO ASSURANCE THAT WE WILL CONTINUE TO DECLARE CASH DIVIDENDS OR REPURCHASE OUR SHARES AT ALL OR IN ANY PARTICULAR AMOUNTS

Our Board of Directors initiated a quarterly dividend in November 2017. Our intent to continue to pay quarterly dividends and to repurchase our shares is subject to capital availability and periodic determinations by our Board of Directors that such actions are in the best interest of our stockholders and are in compliance with all laws and applicable agreements. Future dividends and share repurchases may also be affected by, among other factors, our views on potential future capital requirements for investments in acquisitions and the funding of our research and development; legal risks; changes in federal and state income tax laws or corporate laws; contractual restrictions, such as financial or operating covenants in our debt arrangements; availability of onshore cash flow; and changes to our business model. Our dividend payments and share repurchases may change from time to time, and we cannot provide assurance that we will continue to declare dividends or repurchase shares at all or in any particular amounts. A reduction or suspension in our dividend payments could have a negative effect on the price of our common stock.

PROVISIONS IN OUR CHARTER DOCUMENTS AND DELAWARE LAW MAY DELAY OR PREVENT AN ACQUISITION OF US, WHICH COULD DECREASE THE VALUE OF YOUR SHARES.

Our restated certificate of incorporation and by-laws and Delaware law contain provisions that could make it harder for a third party to acquire us without the consent of our board of directors. These provisions include limitations on actions by our stockholders by written consent.

Our restated certificate of incorporation makes us subject to the anti-takeover provisions of Section 203 of the Delaware General Corporation Law. In general, Section 203 prohibits publicly held Delaware corporations to which it applies from engaging in a “business combination” with an “interested stockholder” for a period of three years after the date of the transaction in which the person became an interested stockholder, unless the business combination is approved in a prescribed manner. This provision could discourage others from bidding for our shares of common stock and could, as a result, reduce the likelihood of an increase in the price of our common stock that would otherwise occur if a bidder sought to buy our common stock.

Our restated certificate of incorporation provides that our board of directors is authorized to issue from time to time, without further stockholder approval, up to 5,000,000 shares of preferred stock in one or more series and to fix and designate the rights, preferences, privileges and restrictions of the preferred stock, including dividend rights, conversion rights, voting rights, redemption rights and terms of redemption and liquidation preferences. Such shares

of preferred stock could have preferences over our common stock with respect to dividends and liquidation rights. Our issuance of preferred stock may have the effect of delaying or preventing a change in control. Our issuance of preferred stock could decrease the amount of earnings and assets available for distribution to the holders of common stock or could adversely affect the rights and powers, including voting rights, of the holders of common stock. The issuance of preferred stock could have the effect of decreasing the market price of our common stock.

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YOUR PERCENTAGE OWNERSHIP IN US MAY BE DILUTED BY FUTURE ISSUANCES OF CAPITAL STOCK, WHICH COULD REDUCE YOUR INFLUENCE OVER MATTERS ON WHICH STOCKHOLDERS VOTE.

Subject to applicable NASDAQ standards, our board of directors has the authority, without action or vote of our stockholders, to issue all or any part of our authorized but unissued shares. Issuances of common stock or the exercise of employee stock options would dilute your percentage ownership interest, which will have the effect of reducing your influence over matters on which our stockholders vote. In addition, we may issue substantial quantities of our common stock in order to effect acquisitions which would also dilute your ownership interest. If the issuances are made at prices that reflect a discount from the then current trading price of our common stock, your interest in the book value of our common stock might be diluted.

Risks Related to Our Pending Merger with Versum Materials, Inc.

FAILURE TO COMPLETE OUR PENDING MERGER WITH VERSUM MATERIALS, INC. (VERSUM) COULD HAVE A MATERIALLY ADVERSE EFFECT ON OUR FINANCIAL CONDITION AND RESULTS AND COULD NEGATIVELY IMPACT OUR STOCK PRICE.

On January 27, 2019, we entered into an agreement and plan of merger pursuant to which Versum will merge with and into Entegris. We will incur significant transaction costs relating to the merger, including legal, accounting, financial advisory, regulatory and other expenses. In general, these expenses are payable by us whether or not the merger is completed. If the merger is not completed under specific circumstances provided in the agreement and plan of merger, we may be required to pay Versum a termination fee of $155 million. The payment of such transaction costs or termination fees could have an adverse effect on our financial condition, results of operations or cash flows. In addition, we could be subject to litigation in the event the merger is not consummated, which could subject us to significant liability for damages and result in the incurrence of substantial legal fees. The current market price of our stock may reflect an assumption that the pending merger will occur and failure to complete the merger could result in a decline in our stock price.

Item 1B. Unresolved Staff Comments.

Not Applicable.

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Item 2. Properties.

Our principal executive offices are located in Billerica, Massachusetts. We also have manufacturing, research and development facilities in the United States, Japan, France, Taiwan, South Korea, Singapore, China and Malaysia. Information about our principal facilities is set forth below:

Location	Principal Function	Approximate Square Feet	Leased/ Owned	Reporting Segment
Bedford, Massachusetts	Research & Manufacturing	80,000	Owned	MC & SCEM
Billerica, Massachusetts[1]	Executive Offices, Research & Manufacturing	175,000	Leased	MC & SCEM
Bloomington, MN	Research & Manufacturing	68,000	Leased	AMH
Burnet, TX	Research & Manufacturing	77,000	Owned	SCEM
Chaska, Minnesota	Executive Offices, Research & Manufacturing	186,000	Owned	AMH
Colorado Springs, CO	Manufacturing	82,000	Owned	AMH
Danbury, CT	Research & Manufacturing	73,000	Leased	SCEM
Decatur, Texas	Manufacturing	359,000	Owned	SCEM
Hsin-chu, Taiwan	Executive Offices, Sales Research & Manufacturing	146,330	Leased	MC, SCEM & AMH
Yangmei City, Taiwan	Manufacturing	40,000	Leased	AMH
JangAn, South Korea	Manufacturing	127,000	Owned	SCEM & AMH
Kulim, Malaysia	Manufacturing	195,000	Owned	SCEM & AMH
Russellville, Arkansas	Manufacturing	113,127	Leased	SCEM
San Luis Obispo, CA	Manufacturing	37,000	Owned	MC
San Luis Obispo, CA	Manufacturing	34,000	Leased	MC
Shanghai, China	Executive Offices & Research	24,000	Leased	MC, SCEM & AMH
Suwon, South Korea	Executive Offices & Research	42,000	Leased	MC & SCEM
Tokyo, Japan	Executive Offices, Sales & Research	28,623	Leased	MC, SCEM & AMH
Wonju City, South Korea	Manufacturing	39,000	Owned	AMH
Yonezawa, Japan	Manufacturing	185,000	Owned	MC & AMH

[1] This lease has been extended through September 30, 2026 and is subject to one five-year renewal option.

We lease approximately 13,000 square feet of research and development and manufacturing office space located in San Diego, CA, approximately 31,000 square feet of manufacturing space located in Franklin, MA, approximately 10,000 square feet of office space in Round Rock, TX, approximately 3,300 square feet of office space in Tempe, AZ, approximately 10,000 square feet of manufacturing space in Goleta, CA, approximately 4,000 square feet of manufacturing space in Logan, Utah, approximately 5,200 square feet of office and manufacturing space in Port Richey, FL, approximately 15,000 square feet of manufacturing space in Anseong, South Korea, approximately 9,000 square feet of office space in Moirans, France and approximately 10,000 square feet of office space in Dresden, Germany.

We lease approximately 12,000 square feet for our Asia manufacturing management offices in Singapore. In addition, we maintain a worldwide network of sales, service, repair or cleaning centers in the United States, Germany, France, Israel, Japan, Malaysia, Taiwan, Singapore, China and South Korea. Leases for our facilities expire through September 2026. We currently expect to be able to extend the terms of expiring leases or to find suitable replacement facilities on reasonable terms.

We believe that our facilities are well-maintained and suitable for their respective operations. All of our facilities are generally utilized within a normal range of production volume.

Item 3. Legal Proceedings.

As of December 31, 2018, we were not involved in any legal proceedings that we believe will have a material impact on our consolidated financial position, results of operations or cash flows. From time to time the Company may be a

party to litigation involving claims against the Company arising in the ordinary course of our business. We are not aware of any material potential litigation or claims against us which would have a material adverse effect upon our financial statements.

Item 4. Mine Safety Disclosures.

Not applicable.

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EXECUTIVE OFFICERS OF THE REGISTRANT

The following is a list of our Executive Officers and their ages, as of the date of this this Annual Report on Form 10-K.

Name	Age	Office	First Appointed To Office*
Bertrand Loy	53	President & Chief Executive Officer	2001
Gregory B. Graves	58	Executive Vice President, Chief Financial Officer & Treasurer	2002
Todd Edlund	56	Executive Vice President & Chief Operating Officer	2007
Sue Rice	60	Senior Vice President, Human Resources	2017
Corey Rucci	59	Senior Vice President, Business Development	2014
Gregory Marshall	61	Senior Vice President, Quality, EH&S and Entegris Business Support	2011
Stuart Tison	55	Senior Vice President & General Manager, Specialty Chemicals and Engineered Materials	2016
Clint Haris	46	Senior Vice President & General Manager, Microcontamination Control	2016
William Shaner	51	Senior Vice President & General Manager, Advanced Materials Handling	2007
Bruce W. Beckman	51	Senior Vice President, Finance	2018
Michael D. Sauer	53	Vice President, Controller & Chief Accounting Officer	2011

* With either the Company or a predecessor company

Bertrand Loy has been our Chief Executive Officer, President and a director since November 2012. Mr. Loy served as our Executive Vice President and Chief Operating Officer since 2008. From August 2005 until July 2008, he served as our Executive Vice President and Chief Administrative Officer in charge of our global supply chain and manufacturing operations. He served as the Vice President and Chief Financial Officer of Mykrolis from January 2001 until August 2005. Prior to that, Mr. Loy served as the Chief Information Officer of Millipore Corporation during 1999 and 2000. From 1995 until 1999, he served as the Division Controller and Head of Manufacturing for Millipore's Laboratory Water Division. From 1989 until 1995, Mr. Loy served Sandoz Pharmaceuticals (now Novartis) in a variety of financial, audit and controller positions located in Europe, Central America and Japan. Mr. Loy served as a director of BTU International, Inc. (supplier of advanced thermal processing equipment) until its acquisition in January 2015. He also serves as a director of Harvard Bioscience, Inc. (scientific equipment) since November 2014 and has been a director for SEMI (Semiconductor Equipment and Materials International) (global high-technology manufacturing trade association) since July 2013.

Gregory B. Graves has served as our Executive Vice President and Chief Financial Officer since July 2008. Prior to that he served as Senior Vice President and Chief Financial Officer since April 2007. Prior to April 2007, he served as Senior Vice President, Strategic Planning & Business Development since the effectiveness of the merger with Mykrolis. Mr. Graves served as the Chief Business Development Officer of Entegris Minnesota since September 2002 and from September 2003 until August 2004 he also served as Senior Vice President of Finance. Prior to joining Entegris Minnesota, Mr. Graves held positions in investment banking and corporate development, including at U.S. Bancorp Piper Jaffray from June 1998 to August 2002 and at Dain Rauscher from October 1996 to May 1998. Since May 2017, Mr. Graves has served as a director of Power Plug Inc. (energy solutions provider).

Todd Edlund has been our Executive Vice President and Chief Operating Officer since July 2016. Prior to that he was our Senior Vice President and Chief Operating Officer since November 2014. After the merger with ATMI, Mr. Edlund served as Senior Vice President and General Manager of our Critical Materials Handling business and prior to the merger with ATMI, he was the Vice President and General Manager of our Contamination Control Solutions division since December 2007. He served as the Vice President and General Manager of our Liquid Systems business unit from 2005 to 2007, and prior to that as Entegris Minnesota's Vice President of Sales for semiconductor markets from 2003 to 2005. Prior to 2003, Mr. Edlund held a variety of positions with our predecessor companies since 1995.

Sue Rice joined us as our Senior Vice President of Human Resources in September 2017. Prior to that, Ms. Rice served as Senior Vice President and Chief Human Resources Officer for Thermo Fisher Scientific from 2013 to

2017, Region Vice President HR Asia Pacific & Emerging Markets from 2009 to 2013 and Group Vice President, HR Analytical Technologies Group from 2006 to 2009. Prior to that, Ms. Rice held senior human resource positions with Fidelity Human Resources Services Company and Sherbrooke Associates.

Gregory Marshall has been our Senior Vice President, Quality, EH&S and Entegris Business Support since August 2016. Prior to that Mr. Marshall served as our Vice President, Quality and EH&S since March 2010 and our Global Director of Quality since

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the merger with Mykrolis Corporation, prior to which he served as the Director of Quality for Mykrolis. Prior to joining Mykrolis, Mr. Marshall served as the Director of US Quality for Kokusai Semiconductor Equipment Corporation.

Corey Rucci has served as our Senior Vice President, Business Development since January 2018, having served as Vice President, Business Development since February 2014. Prior to that he served as Vice President and General Manager of our Specialty Materials Division since 2011 and as General Manager of Poco Graphite, Inc. (POCO) since 2008 when we acquired POCO. Prior to joining Entegris, Mr. Rucci served POCO as the President and Chief Operating Officer since 2007, Chief Operating Officer since 2005, Chief Financial Officer since 2001 and Vice President of Business Development since 1998. Prior to that he worked at UNOCAL Corp. for 17 years in a variety of accounting, marketing and business development roles.

Stuart Tison has been our Senior Vice President, Specialty Chemicals and Engineered Materials since July 2016. Prior to that, Mr. Tison served as Vice President, Specialty Gas Solutions since February 2015, as Vice President, Business Development since January 2010 and as Vice President, Corporate Development since July 2007. Prior to that he served Celerity, Inc. as Vice President, Engineering and served Entegris predecessor companies Mykrolis and Millipore in a variety of sales, marketing, business development and engineering roles.

Clint Haris has been our Senior Vice President, Microcontamination Control since July 2016. Prior to that, Mr. Haris served as our Vice President, Liquid Microcontamination Control since August 2014. Prior to joining Entegris, Mr. Haris served in a variety of executive roles at Brooks Automation Inc. including Senior Vice President, Life Science Systems from 2010 to 2014 and Senior Vice President and General Manager, Systems Solutions from 2009 to 2010.

William Shaner has been our Senior Vice President, Advanced Materials Handling since July 2016. Prior to that, Mr. Shaner served as our Senior Vice President, Global Operations since February 2014 and as our Vice President and General Manager, Microenvironments division since 2007. He has served in a variety of sales, marketing, business development and engineering roles since joining Entegris in 1995.

Bruce W. Beckman has been our Senior Vice President, Finance since February 2018. Prior to that, Mr. Beckman served as Vice President, Finance since joining Entegris in 2015. From 1990 to 2015, Mr. Beckman worked in numerous capacities for General Mills, Inc., including Vice President, Finance, Meals Division, Director of Corporate Planning & Analysis and Director of Internal Controls.

Michael D. Sauer has been our Vice President, Controller and Chief Accounting Officer since June 2012. Prior to that, he served as the Corporate Controller since 2008. From the time of the merger with Mykrolis until April 2008, Mr. Sauer served as Director of Treasury and Risk Management. Mr. Sauer joined Fluoroware, Inc., a predecessor to Entegris Minnesota in 1988 and held a variety of finance and accounting positions until 2001 when he became the Director of Business Development for Entegris Minnesota, the successor to Fluoroware, serving in that position until the merger with Mykrolis.

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PART II

Item 5. Market for Registrant’s Common Equity, Related Stockholder Matters and Issuer Purchases of Equity Securities.

Market Information and Holders:

Entegris’ Common Stock, $0.01 par value, trades on the NASDAQ Global Select Market under the symbol “ENTG”. As of February 4, 2018, there were 1,057 shareholders of record. On February 4, 2018, the last sale price reported on the Nasdaq Global Select Market for our common stock was $33.64 per share.

Dividend Policy:

Holders of the Company’s common stock are entitled to receive dividends when and if they are declared by the Company’s Board of Directors. The Company’s Board of Directors declared a cash dividend of $0.07 per share during the first, second, third and fourth quarters of 2018, which totaled $39.7 million.

On January 16, 2019, the Company’s Board of Directors declared a quarterly cash dividend of $0.07 per share to be paid on February 20, 2019 to shareholders of record as of January 30, 2019.

Future dividend declarations, if any, as well as the record and payment dates for such dividends, are subject to the final determination of our board of directors. Furthermore, the credit agreements governing the New Credit Facilities contain restrictions that may limit our ability to pay dividends.

Issuer Sales of Unregistered Securities During the Past Three Years:

None

Comparative Stock Performance

The following graph compares the cumulative total shareholder return on the common stock of Entegris, Inc. from December 31, 2013 through December 31, 2018 with the cumulative total return of (1) The NASDAQ Composite Index, and (2) The Philadelphia Semiconductor Index, assuming $100 was invested at the close of trading December 31, 2013 in Entegris, Inc. common stock, the NASDAQ Composite Index and the Philadelphia Semiconductor Index and that all dividends are reinvested.

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	December 31, 2013	December 31, 2014	December 31, 2015	December 31, 2016	December 31, 2017	December 31, 2018
Entegris, Inc.	$100.00	$113.98	$114.50	$154.44	$263.30	$243.34
NASDAQ Composite	100.00	114.75	122.74	133.62	173.22	168.30
Philadelphia Semiconductor Index	100.00	131.40	129.29	167.18	234.97	220.76

Issuer Purchases of Equity Securities:

On February 13, 2018, the Company's Board of Directors authorized a repurchase program covering up to an aggregate of $100 million of the Company's common stock in open market transactions and in accordance with one or more pre-arranged stock trading plans to be established in accordance with Rule 10b5-1 under the Securities Exchange Act of 1934, as amended, over a period of twenty-four months. This repurchase program represents a further renewal of the repurchase program originally authorized by the Board of Directors on February 5, 2016, which had been subsequently renewed on February 15, 2017. On November 19, 2018, the Company's Board of Directors authorized the repurchase of up to an additional $250 million in aggregate principal amount of the Company's common stock. The authorization is in addition to the amount remaining under the share repurchase program previously authorized in February 2018.

The following table provides information concerning shares of the Company's Common Stock $0.01 par value purchased during the three months ended December 31, 2018:

Period	(a) Total Number of Shares Purchased	(b) Average Price Paid per Share	(c) Total Number of Shares Purchased as Part of Publicly Announced Plans or Programs	(d) Maximum Number (or Approximate Dollar Value) of Shares that May Yet Be Purchased Under the Plans or Programs
September 29 through November 3, 2018	1,110,600	$26.95	1,110,600	$45,508,371
November 4 through December 1, 2018	2,045,271	$27.31	2,045,271	$239,657,590
December 2 through December 31, 2018	2,394,518	$26.53	2,394,518	$176,127,662
Total	5,550,389		5,550,389	

The Company issues restricted stock unit awards (RSUs) under its equity incentive plans. In the consolidated financial statements, the Company treats shares of common stock withheld for tax purposes on behalf of its employees in connection with the vesting of RSUs as common stock repurchases because they reduce the number of shares that would have been issued upon vesting. These withheld shares of common stock are not considered common stock repurchases under the Company's authorized common stock repurchase plan and accordingly are not included in the common stock repurchase totals in the preceding table.

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Item 6. Selected Financial Data.

The table that follows presents selected financial data for each of the last five years from the Company's consolidated financial statements and should be read in conjunction with the Company's Consolidated Financial Statements and the related Notes and with "Management's Discussion and Analysis of Financial Condition and Results of Operations" included elsewhere in this Annual Report on Form 10-K. The selected financial data set forth below as of December 31, 2018 and 2017 and for the years ended December 31, 2018, 2017 and 2016 are derived from our audited financial statements included in this Annual Report on Form 10-K. All other selected financial data set forth below is derived from our audited financial statements not included in this Annual Report on Form 10-K. The selected financial data set forth below as of December 31, 2018 and for the year ended December 31, 2018 includes the results of operations of our 2018 acquisitions, see footnote 3 for additional discussion. Our historical results are not necessarily indicative of our results of operations to be expected in the future.

(In thousands, except per share amounts)	Year ended December 31, 2018	Year ended December 31, 2017	Year ended December 31, 2016	Year ended December 31, 2015	Year ended December 31, 2014
Operating Results					
Net sales	$1,550,497	$1,342,532	$1,175,270	$1,081,121	$962,069
Gross profit	719,831	608,985	508,691	470,231	376,683
Selling, general and administrative expenses	246,534	216,194	201,901	198,914	231,833
Engineering, research and development expenses	118,456	106,951	106,991	105,900	87,711
Amortization of intangible assets	62,152	44,023	44,263	47,349	37,067
Contingent consideration fair value adjustment	—	—	—	—	(1,282)
Operating income	292,689	241,817	155,536	118,068	21,354
Income (loss) before income taxes and equity in net loss of affiliate	254,432	184,731	119,999	92,185	(13,392)
Income tax expense (benefit)	13,677	99,665	22,852	10,202	(21,572)
Net income	240,755	85,066	97,147	80,296	7,887
Earnings Per Share Data					
Diluted earnings per share	$1.69	$0.59	$0.68	$0.57	$0.06
Weighted average shares outstanding – diluted	142,610	143,518	142,050	141,121	140,062
Operating Ratios – % of net sales					
Gross profit	46.4 %	45.4 %	43.3 %	43.5 %	39.2 %
Selling, general and administrative expenses	15.9	16.1	17.2	18.4	24.1
Engineering, research and development expenses	7.6	8.0	9.1	9.8	9.1
Amortization of intangible assets	4.0	3.3	3.8	4.4	3.9
Contingent consideration fair value adjustment	—	—	—	—	(0.1)
Operating income	18.9	18.0	13.2	10.9	2.2
Income (loss) before income taxes and equity in net loss of affiliate	16.4	13.8	10.2	8.5	(1.4)
Effective tax rate	5.4	54.0	19.0	11.1	161.1
Net income	15.5	6.3	8.3	7.4	0.8
Cash Flow Statement Data					
Depreciation and amortization	$127,268	$102,231	$99,886	$101,654	$83,704
Capital expenditures	110,153	93,597	65,260	71,977	57,733
Net cash provided by operating activities	312,576	293,373	207,555	120,918	126,423
Net cash used in investing activities	(485,944)	(112,455)	(66,686)	(63,638)	(860,295)
Net cash provided by (used in) financing activities	34,411	27,251	(81,747)	(92,787)	747,648

Balance Sheet and Other Data					
Current assets	$1,029,338	$1,057,608	$800,131	$708,787	$763,604
Current liabilities	269,668	290,971	261,571	175,550	262,520
Working capital	759,670	766,637	538,560	533,237	501,084
Current ratio	3.82	3.63	3.06	4.04	2.91
Long-term debt, including current maturities	938,863	674,380	584,677	656,044	753,012
Shareholders’ equity	1,012,025	993,018	899,218	802,883	748,441
Total assets	2,317,641	1,976,172	1,699,532	1,646,697	1,748,307
Return on average shareholders’ equity – %	24.0 %	9.0 %	11.4 %	10.4 %	1.0 %
Shares outstanding at end of year	135,977	141,283	141,320	140,716	139,793

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Item 7. Management's Discussion and Analysis of Financial Condition and Results of Operations.

The following discussion and analysis of the Company's consolidated financial condition and results of operations should be read along with the consolidated financial statements and the accompanying notes to the consolidated financial information included elsewhere in this Annual Report on Form 10-K. This discussion contains forward-looking statements that involve numerous risks and uncertainties, including, but not limited to, those described in the "Cautionary Statements" sections of this Item 7 below. The Company's actual results may differ materially from those contained in any forward-looking statements. You should review the Item 1A "Risk Factors" of this Annual Report on Form 10-K for a discussion of important factors that could cause actual results to differ materially from the results described in or implied by the forward-looking statements contained in the following discussion and analysis.

Cautionary Statements

This Annual Report on Form 10-K and the documents incorporated by reference in this Annual Report on Form 10-K contain "forward-looking statements" within the meaning of the Private Securities Litigation Reform Act of 1995. The words "believe," "expect," "anticipate," "intends," "estimate," "forecast," "project," "should," "may," "will," "would" or the n and similar expressions are intended to identify such forward-looking statements. These forward-looking statements include those about future period guidance; projected sales, net income, net income per diluted share, non-GAAP EPS, non-GAAP net income and other financial metrics; our performance relative to our markets; market and technology trends, including the duration and drivers of any growth trends; the development of new products and the success of their introductions; the focus of our engineering, research and development projects; our ability to execute on our business strategies; our capital allocation strategy, which may be modified at any time for any reason, including share repurchases, dividends, debt repayments and potential acquisitions; the effect of the Tax Cuts and Jobs Act; future capital and other expenditures; the Company's expected tax rate; the impact of accounting pronouncements; and other matters. These forward-looking statements are based on current management expectations and assumptions only as of the date of this Annual Report on Form 10-K, are not guarantees of future performance and involve substantial risks and uncertainties that are difficult to predict and that could cause actual results to differ materially from the results expressed in, or implied by, these forward-looking statements. These risks and uncertainties include, but are not limited to, the risk factors and additional information described in this Annual Report on Form 10-K under the caption "Risk Factors," elsewhere in this Annual Report on Form 10-K and in our other periodic filings. Except as required under the federal securities laws and the rules and regulations of the SEC, we undertake no obligation to update publicly any forward-looking statements contained herein.

Overview

This overview is not a complete discussion of the Company's financial condition, changes in financial condition and results of operations; it is intended merely to facilitate an understanding of the most salient aspects of its financial condition and operating performance and to provide a context for the detailed discussion and analysis that follows, and must be read in its entirety in order to fully understand the Company's financial condition and results of operations.

The Company is a leading global developer, manufacturer and supplier of microcontamination control products, specialty chemicals and advanced materials handling solutions for manufacturing processes in the semiconductor and other high-technology industries. Our mission is to leverage our unique breadth of capabilities to create value for our customers by developing mission-critical solutions to maximize manufacturing yields, reduce manufacturing costs and enable higher device performance.

Our technology portfolio includes approximately 21,000 standard and customized products and solutions to achieve the highest levels of purity and performance that are essential to the manufacture of semiconductors, flat panel displays, light emitting diodes, or LEDs, high-purity chemicals, solar cells, gas lasers, optical and magnetic storage devices, and critical components for aerospace, glass manufacturing and biomedical applications. The majority of our products are consumed at various times throughout the manufacturing process, with demand driven in part by the level of semiconductor and other manufacturing activity. The Company's customers consist primarily of semiconductor manufacturers, semiconductor equipment and materials suppliers as well as thin film transistor-liquid crystal display (TFT-LCD) and hard disk manufacturers, which are served through direct sales efforts, as well as sales and

distribution relationships, in the United States, Asia, Europe and the Middle East.
Our business is organized and operated in three operating segments which align with the key elements of the advanced semiconductor manufacturing ecosystem. The Specialty Chemicals and Engineered Materials, or SCEM, segment provides high-performance and high-purity process chemistries, gases, and materials, and safe and efficient delivery systems to support semiconductor and other advanced manufacturing processes. The Microcontamination Control, or MC, segment offers solutions to filter and purify critical liquid chemistries and gases used in semiconductor manufacturing processes and other high-technology industries. The Advanced Materials Handling, or AMH, segment develops solutions to monitor, protect, transport, and deliver critical liquid chemistries, wafers and other substrates for a broad set of applications in the semiconductor

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industry and other high-technology industries. While these segments have separate products and technical know-how, they share a global generalist sales force, common business systems and processes, technology centers, and strategic and technology roadmaps. We leverage our expertise from these three segments to create new and increasingly integrated solutions for our customers. See note 16 to the consolidated financial statements for additional information on the Company's three segments.

Key operating factors Key factors, which management believes have the largest impact on the overall results of operations of the Company, include:

- Level of sales Since a significant portion of the Company's product costs (except for raw materials, purchased components and direct labor) are largely fixed in the short-to-medium term, an increase or decrease in sales affects gross profits and overall profitability significantly. Also, increases or decreases in sales and operating profitability affect certain costs such as incentive compensation and commissions, which are highly variable in nature. The Company's sales are subject to the effects of industry cyclicality, technological change, substantial competition, pricing pressures and foreign currency fluctuation.
- Variable margin on sales The Company's variable margin on sales is determined by selling prices and the costs of manufacturing and raw materials. This is affected by a number of factors, which include the Company's sales mix, purchase prices of raw material (especially polymers, membranes, stainless steel and purchased components), domestic and international competition, direct labor costs, and the efficiency of the Company's production operations, among others.
- Fixed cost structure The Company's operations include a number of large fixed or semi-fixed cost components, which include salaries, indirect labor and benefits, facility costs, lease expenses, and depreciation and amortization. It is not possible to vary these costs easily in the short-term as volumes fluctuate. Accordingly, increases or decreases in sales volume can have a large effect on the usage and productivity of these cost components, resulting in a large impact on the Company's profitability.

Overall Summary of Financial Results for the Year Ended December 31, 2018

Total net sales for the year ended December 31, 2018 were $1,550.5 million, up $208.0 million, or 15%, from sales of $1,342.5 million for the year ended December 31, 2017.

Exclusive of sales associated with acquisitions of $80.0 million and favorable foreign currency translation effects of $8.2 million, the Company's sales increased 9%, reflecting an increase in overall demand for the Company's products from semiconductor industry customers, particularly in the sale of fluid handling products, liquid chemistry filtration solutions and certain specialty materials products. The sales increase in 2018 was driven primarily by higher volume and the effect of selling price erosion was nominal. Semiconductor industry demand in 2018 was driven by improved demand from device makers, as wafer starts and semiconductor unit production increased, higher industry fab utilization rates, and node transitions. The Company believes sales of its products in 2018 exceeded the overall semiconductor industry growth rate.

The Company's gross profit rose by $110.8 million for the year ended December 31, 2018, to $719.8 million, up from $609.0 million for the year ended December 31, 2017. Accordingly, the Company reported a 46.4% gross margin rate compared to 45.4% in 2017. The gross profit and gross margin figures for 2018 include an incremental cost of sales charge of $6.9 million associated with the sale of inventory acquired in the SAES Pure Gas business (SPG) and $0.4 million severance related to organization realignment charges. In addition, the gross profit and gross margin figures for 2017 included impairment charges of $6.1 million related to certain equipment-related impairment and severance related to organizational realignment charges. Excluding those charges, the Company's gross margin for 2018 was 46.9% and for 2017 was 45.8%.

The Company's selling, general and administrative (SG&A) and engineering, research and development (ER&D) expenses increased moderately in 2018, mainly reflecting higher compensation costs and the inclusion in SG&A and ER&D expenses of SPG's infrastructure, deal costs and the cost of integration activities.

The Company's income tax expense decreased significantly in 2018, primarily due to the reduction of the U.S. corporate tax rate from 35% in 2017 to 21% in 2018, a $34.5 million tax benefit associated with legal entity restructuring and the absence of a one-time charge of $66.7 million related to the impact of the Tax Cuts and Jobs Act incurred in 2017.

As a result of the aforementioned and other factors discussed below, net income for 2018 was $240.8 million, or $1.69 per diluted share, compared to net income of $85.1 million, or $0.59 per diluted share, in 2017.

On January 22, 2018, the Company acquired Particle Sizing Systems, LLC, or PSS, which provides particle sizing instrumentation for liquid applications to the semiconductor and life science industries. The total purchase price of the acquisition was approximately $37.3 million in cash. The acquisition of PSS does not constitute a material business combination.

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On June 25, 2018, the Company acquired the SAES Pure Gas business, or SPG, a leading provider of high-capacity gas purification systems used in semiconductor manufacturing and adjacent markets. The total purchase price of the acquisition was approximately $352.7 million in cash, or $341.5 million net of cash acquired, subject to revision for customary working capital adjustments. The acquisition of SPG does not constitute a material business combination.
During 2018, the Company's operating activities provided cash flow of $312.6 million. Cash and cash equivalents, and short-term investments were $482.1 million at December 31, 2018 compared with $625.4 million at December 31, 2017. The Company had long-term borrowings, including current maturities, of $938.9 million at December 31, 2018 compared with $674.4 million at December 31, 2017.
On November 6, 2018, the Company obtained a new senior secured credit facility consisting of a term loan facility of $400.0 million and a revolving credit facility of $300.0 million. The term loans were fully drawn at closing. The Company used approximately $109 million of the proceeds of the new term loans to repay and terminate its previous senior secured revolving and term loan credit facilities.

Subsequent Event

On January 28, 2019, the Company and Versum Materials, Inc., a leading specialty materials supplier to the semiconductor industry, announced that they had entered into an Agreement and Plan of Merger, dated as of January 27, 2019, pursuant to which they agreed to combine in a merger of equals. Under the terms of the agreement, Versum will merge with and into Entegris, with Entegris surviving and continuing as the surviving corporation, and Versum stockholders will receive 1.120 shares of Company common stock for each existing Versum share. The transaction is subject to certain conditions, including a majority of the outstanding shares of common stock of both Entegris and Versum approving the Merger Agreement and the receipt of approvals under U.S. and certain foreign antitrust and competition laws. We have agreed to operate our business in the ordinary course during the period between the execution of the Merger Agreement and the effective time of the Proposed Merger, subject to specific exceptions set forth in the Merger Agreement, and have agreed to certain other customary restrictions on operations, as set forth in the Merger Agreement.

Critical Accounting Policies

Management's discussion and analysis of financial condition and results of operations are based upon the Company's consolidated financial statements, which have been prepared in accordance with accounting principles generally accepted in the United States. The preparation of these consolidated financial statements requires the Company to make estimates, assumptions and judgments that affect the reported amounts of assets, liabilities, revenues and expenses and related disclosure of contingent assets and liabilities. At each balance sheet date, management evaluates its estimates, including, but not limited to, those related to long-lived assets (property, plant and equipment, and identified intangibles), goodwill, income taxes and business combinations. The Company bases its estimates on historical experience and various other assumptions that are believed to be reasonable under the circumstances. If management made different judgments or utilized different estimates, this could result in material differences in the amount and timing of the Company's results of operations for any period. In addition, actual results could be different from the Company's current estimates, possibly resulting in increased future charges to earnings.
The critical accounting policies affected most significantly by estimates, assumptions and judgments used in the preparation of the Company's consolidated financial statements are discussed below.
Impairment of Long-Lived Assets As of December 31, 2018, the Company had $419.5 million of net property, plant and equipment and $295.7 million of net intangible assets. The Company routinely considers whether indicators of impairment of the value of its long-lived assets, particularly its manufacturing equipment, and its intangible assets, are present. A long-lived asset (asset group) shall be tested for recoverability whenever events or changes in circumstances (triggering events) indicate that its carrying amount may not be recoverable. The following are examples of such events or changes in circumstances:

a. A significant decrease in the market price of a long-lived asset (asset group);
b. A significant adverse change in the extent or manner in which a long-lived asset (asset group) is being used or in its physical condition;
c. A significant adverse change in legal factors or in the business climate that could affect the value of a long-lived asset (asset group), including an adverse action or assessment by a regulator;

d. An accumulation of costs significantly in excess of the amount originally expected for the acquisition or construction of a long-lived asset (asset group);

e. A current-period operating or cash flow loss combined with a history of operating or cash flow losses or a projection or forecast that demonstrates continuing losses associated with the use of a long-lived asset (asset group); and

f. A current expectation that, more likely than not, a long-lived asset (asset group) will be sold or otherwise disposed of significantly before the end of its previously estimated useful life.

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If such indicators are present, it is determined whether the sum of the estimated undiscounted cash flows attributable to the asset group in question is less than its carrying value. If less, an impairment loss is recognized based on the excess of the carrying amount of the assets in the group over its respective fair value. Fair value is determined by discounting estimated future cash flows, appraisals or other methods deemed appropriate. If the asset groups determined to be impaired are to be held and used, the Company recognizes an impairment charge to the extent the fair value attributable to the asset group is less than the assets' carrying value. The fair value of the assets then becomes the assets' new carrying value, which is depreciated or amortized over the remaining estimated useful life of the assets.

The Company's long-lived assets are grouped with other assets and liabilities at the lowest level (asset groups) for which the identifiable cash flows are largely independent of the cash flows of other assets and liabilities. As described above, the evaluation of the recoverability of long-lived assets requires the Company to make significant estimates and assumptions. These estimates and assumptions primarily include, but are not limited to, the identification of the asset group at the lowest level of independent cash flows, the primary asset of the group and long-range forecasts of revenue and costs, reflecting management's assessment of general economic and industry conditions, operating income, depreciation and amortization and working capital requirements.

Due to the inherent uncertainty involved in making estimates, actual results could differ from those estimates. In addition, changes in the underlying assumptions would have a significant impact on the conclusion that an asset group's carrying value is recoverable, or the determination of any impairment charge if it was determined that the asset values were indeed impaired. The Company continually monitors circumstances and events to determine whether asset impairment testing is warranted. It is possible that in the future the Company may conclude that there is impairment of certain of its long-lived assets, and that significant impairment charges of long-lived assets may occur in future periods.

Goodwill Goodwill is not subject to amortization and is tested for impairment annually and whenever events or changes in circumstances indicate that impairment may have occurred. The Company performs its annual impairment test as of August 31. The Company first assesses qualitative factors to determine whether it is more likely than not (that is, a likelihood of more than 50%) that the fair value of a reporting unit is less than its carrying amount, including goodwill. If, after assessing qualitative factors, the Company determines that it is more likely than not that the fair value of a reporting unit is less than its carrying amount, then a two-step impairment test is performed to identify potential goodwill impairment and measure the amount of goodwill impairment loss to be recognized, if any.

As of August 31, 2018, the Company's assessment of qualitative factors informed its conclusion that it was more likely than not that a goodwill impairment did not occur. The significant qualitative factors considered include a significant increase in the Company's share price, increasing revenues and operating cash flow for each of the Company's reporting units combined with solid demand in the semiconductor industry driven by the Internet of Things, virtual reality, autonomous car and artificial intelligence/machine learning applications. The Company noted that a significant number of its very largest customers purchase from all of the Company's reporting units. For example, approximately 25 customers, accounting for approximately 59% of net sales, purchase from all of the Company's reporting units.

Income Taxes In the preparation of the Company's consolidated financial statements, the income tax expense, deferred tax assets and liabilities, and reserves for unrecognized tax benefits reflect management's best assessment of estimated current and future taxes to be paid. The Company is subject to income taxes in both the United States and numerous foreign jurisdictions. Significant judgments and estimates are required in determining consolidated income tax expense.

Deferred income taxes arise from temporary differences between the tax basis of assets and liabilities and their reported amounts in the consolidated financial statements, which will result in taxable or deductible amounts in the future. In evaluating the Company's ability to recover its deferred tax assets within the jurisdiction from which they arise, management considers all available positive and negative evidence, including scheduled reversals of deferred tax liabilities, projected future taxable income, tax-planning strategies, and results of recent operations. In projecting future taxable income, the Company begins with historical results adjusted for the results of discontinued operations and incorporates assumptions about the amount of future state, federal and foreign pretax operating income adjusted for items that do not have tax consequences. The assumptions about future taxable income require significant

judgment and are consistent with the plans and estimates management is using to manage the underlying business. In evaluating the objective evidence that historical results provide, the Company considers three years of cumulative operating income.

The Company has deferred tax assets related to certain federal and state credit carryforwards, and foreign net operating loss carryforwards of $18.8 million and $18.0 million as of December 31, 2018 and 2017, respectively. Management believes it is more likely than not that the benefit from a portion of these carryforwards will not be realized. In recognition of this risk, the Company provided a valuation allowance of $18.1 million and $17.5 million as of December 31, 2018 and 2017, respectively, relating to these carryforwards. If the Company's assumptions change and it determines it will be able to realize these carryforwards, the tax benefits relating to any reversal of the valuation allowance on the deferred tax assets will be recognized as a reduction of income tax expense.

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The calculation of tax liabilities involves dealing with uncertainties in the application of complex tax laws and regulations in a multitude of jurisdictions across our global operations. A tax benefit from an uncertain tax position may be recognized when it is more likely than not that the position will be sustained upon examination, including resolutions of any related appeals or litigation processes, on the basis of the technical merits. Resolution of these uncertainties in a manner inconsistent with management’s expectations could have a material impact on the Company’s financial condition and operating results.

U.S. Tax Reform

On December 22, 2017, the Tax Cuts and Jobs Act of 2017 (the “Tax Cuts and Jobs Act”) was signed into law making significant changes to the Internal Revenue Code. Changes include, but are not limited to, a corporate tax rate decrease from 35 percent to 21 percent effective for tax years beginning after December 31, 2017, the transition of U.S international taxation from a worldwide tax system to a territorial system, and a one-time transition tax on the mandatory deemed repatriation of cumulative foreign earnings as of December 31, 2017. The Company recognized the income tax effects of the Tax Cuts and Jobs Act in the financial statements included in its 2017 Annual Report on Form 10-K in accordance with Staff Accounting Bulletin No. 118, which provides SEC staff guidance for the application of ASC Topic 740, Income Taxes, in the reporting period in which the 2017 Tax Cuts and Jobs Act was signed into law. During the period ended December 31, 2018, the company finalized its accounting for the income tax effects of the Tax Cuts and Jobs Act in accordance with management's understanding of the Tax Cuts and Jobs Act and guidance available as of the date of this filing. The Company recognized an additional measurement period adjustment increase to income tax expense of $0.7 million, an increase to income tax payable of $0.8 million and a decrease to deferred tax liability of $0.1 million, in the fourth quarter of 2018, the period in which the SAB 118 measurement period ceased.

Business Acquisitions

The Company accounts for acquired businesses using the acquisition method of accounting which requires that the assets acquired and liabilities assumed be recorded at the date of acquisition at their respective fair values. The judgments made in determining the estimated fair value assigned to each class of assets acquired and liabilities assumed, as well as asset lives, can materially impact net income. Accordingly, for significant items, the Company typically obtains assistance from a third-party valuation firm.

There are several methods that can be used to determine the fair value of assets acquired and liabilities assumed in a business combination. For intangible assets, the Company normally utilizes the “income method.” This method starts with a forecast of all of the expected future net cash flows attributable to the subject intangible asset. These cash flows are then adjusted to present value by applying an appropriate discount rate that reflects the risk factors associated with the cash flow streams. Some of the more significant estimates and assumptions inherent in the income method (or other methods) include the projected future cash flows (including timing) and the discount rate reflecting the risks inherent in the future cash flows.

Estimating the useful life of an intangible asset also requires judgment. For example, different types of intangible assets will have different useful lives, influenced by the nature of the asset, competitive environment, and rate of change in the industry. Certain assets may even be considered to have indefinite useful lives. All of these judgments and estimates can significantly impact the determination of the amortization period of the intangible asset, and thus net income.

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Results of Operations

Year ended December 31, 2018 compared to year ended December 31, 2017

The following table sets forth the results of operations and the relationship between various components of operations, stated as a percent of net sales, for the years ended December 31, 2018 and 2017. The Company's historical financial data was derived from its consolidated financial statements and related notes included elsewhere in this annual report.

(Dollars in thousands)	2018	% of net sales	2017	% of net sales
Net sales	$1,550,497	100.0 %	$1,342,532	100.0 %
Cost of sales	830,666	53.6	733,547	54.6
Gross profit	719,831	46.4	608,985	45.4
Selling, general and administrative expenses	246,534	15.9	216,194	16.1
Engineering, research and development expenses	118,456	7.6	106,951	8.0
Amortization of intangible assets	62,152	4.0	44,023	3.3
Operating income	292,689	18.9	241,817	18.0
Interest expense	34,094	2.2	32,343	2.4
Interest income	(3,839)	(0.2)	(715)	(0.1)
Other expense, net	8,002	0.5	25,458	1.9
Income before income taxes	254,432	16.4	184,731	13.8
Income tax expense	13,677	0.9	99,665	7.4
Net income	$240,755	15.5	$85,066	6.3

Net sales For the year ended December 31, 2018, net sales were $1,550.5 million, up $208.0 million, or 15%, from sales for the year ended December 31, 2017. An analysis of the factors underlying the increase in net sales is presented in the following table:

(In thousands)	
Net sales in 2017	$1,342,532
Organic growth associated with volume and pricing	119,820
Increase associated with acquired businesses	79,980
Increase associated with effect of foreign currency translation	8,165
Net sales in 2018	$1,550,497

The Company's sales increase was due to strong across-the-board demand for the Company's products from semiconductor industry customers, reflecting both higher industry fab utilization and semiconductor industry capital spending compared to the year-ago period. This sales increase reflected improved sales of fluid handling products, liquid chemistry filtration solutions and certain specialty materials products. Exclusive of the sales of the acquired businesses of $80.0 million of revenue for 2018 and the favorable currency translation effects of $8.2 million for the year, mainly due to the strengthening of the Japanese yen, Korean won and Euro relative to the U.S. dollar, the Company's sales grew 9% in 2018 when compared to 2017.

On a geographic basis, in 2018, total sales to Taiwan were 19%, to North America were 22%, to South Korea were 16%, to Japan were 14%, to China were 13%, to Europe were 9% and to Southeast Asia were 7%. In 2017, total sales to Taiwan were 22%, to North America were 21%, to South Korea were 16%, to Japan were 13%, to China were 11%, to Europe were 9%, and to Southeast Asia were 8%. From 2017 to 2018, net sales to customers in South Korea, China, Europe, North America, Japan and Southeast Asia increased 12%, 37%, 15%, 21%, 24%, and 7%, respectively, while net sales to customers in Taiwan were flat.

Demand drivers for the Company's business primarily consist of semiconductor fab utilization and production (unit-driven) as well as capital spending for new or upgraded semiconductor fabrication equipment and facilities (capital-driven). The Company analyzes sales of its products by these two key drivers. Sales of unit-driven products represented 70% of total sales and sales of capital-driven products represented 30% of total sales in 2018. This compares to a unit-driven to capital-driven ratio of 74%:26% for 2017 as a result of the Pure Gas business.

Gross profit Gross profit for 2018 increased by $110.8 million, to $719.8 million, an increase of 18% from $609.0 million for 2017. The gross margin rate for 2018 was 46.4% versus 45.4% for 2017. The gross profit and gross margin

improvements reflect the improved factory utilization associated with strong sales levels and a slightly favorable sales mix. These factors were partly offset by an incremental cost of sales charge of $6.9 million associated with the sale of inventory acquired in the SAES

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Pure Gas business acquisition and price erosion for certain products in response to normal competitive pressures. In addition, the gross profit and gross margin figures include impairment charges of $0.4 million and $6.1 million for the year ended December 31, 2018 and 2017, respectively, related to equipment-related and severance related to organization realignment charges.

Selling, general and administrative expenses

Selling, general and administrative expense (SG&A) consists primarily of payroll and related expenses for the sales and administrative staff, professional fees (including accounting, legal and technology costs and expenses), and sales and marketing costs. SG&A expenses for 2018 increased $30.3 million, or 14%, to $246.5 million from $216.2 million in 2017. SG&A expenses, as a percent of net sales, decreased to 15.9% from 16.1% a year earlier, reflecting the increase in net sales.

An analysis of the factors underlying the increase in SG&A is presented in the following table:

(In thousands)	
Selling, general and administrative expenses in 2017	$216,194
Deal costs	5,121
Integration costs	3,237
Employee costs	15,181
Professional fees	2,842
Travel costs	2,164
Impairment charge related to acquired intangible assets recorded in prior year	(3,866)
Other increases, net	5,661
Selling, general and administrative expenses in 2018	$246,534

Engineering, research and development expenses

Engineering, research and development (ER&D) expenses related to the support of current product lines and the development of new products and manufacturing technologies was $118.5 million and $107.0 million in 2018 and 2017, respectively. ER&D expenses as a percent of net sales were 7.6% compared to 8.0% a year ago, reflecting the increase in net sales, offset by the increase in ER&D expenditures levels, primarily due to higher employee costs of $7.8 million and project costs of $3.5 million.

The Company's overall ER&D efforts will continue to focus on the support or extension of current product lines, the development of its technologies to create differentiated and high-value products for the most advanced and demanding semiconductor applications and leveraging its unique and diverse technology portfolio to develop innovative, integrated solutions for unmet customer needs. The Company expects ER&D costs to stay relatively stable as a percentage of net sales.

Amortization of intangible assets Amortization of intangible assets was $62.2 million in 2018 compared to $44.0 million for 2017. The increase reflects the the additional amortization expense associated with the PSS acquisition completed in the first quarter of 2018 and the SPG acquisition completed in the second quarter of 2018.

Interest expense Interest expense was $34.1 million and $32.3 million in the years ended December 31, 2018 and 2017, respectively. Interest expense includes interest associated with debt outstanding and the amortization of debt issuance costs associated with such borrowings. The increase in 2018 reflects higher average debt levels.

Interest income Interest income was $3.8 million and $0.7 million in the years ended December 31, 2018 and 2017, respectively. The increase reflects higher average U.S. cash levels earning a higher rate of interest.

Other expense, net Other expense, net, was $8.0 million in 2018 compared to other expense, net, of $25.5 million in 2017.

In 2018, other expense, net, included a loss of extinguishment of debt of $2.3 million associated with the redemption of the Company's senior secured term loan facility due 2021 and asset-based revolving credit facility (see note 8 to the Company's consolidated financial statements), foreign currency transaction losses of $4.4 million and penalty charges of $1.1 million.

In 2017, other expense, net, included an impairment charge of $2.8 million, a loss of extinguishment of debt of $20.7 million associated with the redemption of the Company's 2022 Notes (see note 8 to the Company's consolidated financial statements), and foreign currency transaction losses of $2.3 million.

Income tax expense The Company recorded income tax expense of $13.7 million in 2018 compared to income tax expense of $99.7 million in 2017. The Company's effective tax expense rate was 5.4% in 2018, compared to an effective tax rate of 54.0% in 2017.

The decrease in the effective tax rate in 2018 from 2017 reflects several factors. The decrease in the effective rate is primarily due to the reduction in the U.S. corporate tax rate from 35% in 2017 to 21% in 2018. Additionally, in 2018, the Company recorded a $25.1 million benefit related to foreign tax credit generation and a $9.4 million benefit related to a dividend received

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deduction based on a restructuring to simplify its legal entity structure. In 2017, the effective tax rate increased due to the recognition of the one-time mandatory repatriation transition tax of $73.0 million on the net accumulated earnings and profits of the Company's foreign subsidiaries and $4.0 million of incremental tax related to no longer asserting that a significant portion of the Company's undistributed earnings are considered indefinitely invested overseas. The increase was partially offset by the remeasurement of the U.S. deferred taxes of $10.3 million to reflect the lower U.S. federal tax rate.

The $9.4 million tax benefit for the dividends received deduction was based on the Company's assessment of the treatment under the provisions of the Tax Cuts and Jobs Act. Congress or the Department of Treasury may provide legislative or regulatory updates which would change the Company's assessment. If legislative or regulatory updates are issued related to this item, the timing of which is uncertain, the Company may be required to recognize additional tax expense up to the full amount of the $9.4 million in the period such updates are issued.

Net income Net income was $240.8 million, or $1.69 per diluted share, in 2018 compared to net income of $85.1 million, or $0.59 per diluted share, in 2017. The decrease reflects the Company's aforementioned operating results described in greater detail above.

Non-GAAP Measures Information The Company's consolidated financial statements are prepared in conformity with accounting principles generally accepted in the United States (GAAP). The Company also utilizes certain non-GAAP financial measures as a complement to financial measures provided in accordance with GAAP in order to better assess and reflect trends affecting the Company's business and results of operations. See "Non-GAAP Information" included below in this section for additional detail, including the reconciliation of GAAP measures to the Company's non-GAAP measures.

The Company's non-GAAP financial measures are Adjusted EBITDA and Adjusted Operating Income, together with related measures thereof, and non-GAAP Earnings Per Share (EPS).

Adjusted EBITDA increased 22% to $436.1 million in 2018, compared to $357.1 million in 2017. Adjusted EBITDA, as a percent of net sales, was 28.1% in 2018 compared to 26.6% in 2017. Adjusted Operating Income increased 24% to $371.0 million in 2018, compared to $298.9 million in 2017. Adjusted Operating Income, as a percent of net sales, was 23.9% in 2018 compared to 22.3% in 2017. Non-GAAP Earnings Per Share increased 31% to $1.89 in 2018, compared to $1.44 in 2017. The improvement in the Adjusted EBITDA and Adjusted Operating Income reflect the increase in net sales and related increase in gross profit. In addition, Non-GAAP Earnings Per Share was positively affected by a lower adjusted effective tax rate.

Segment Analysis

The Company reports its financial performance based on three reporting segments. See note 16 to the consolidated financial statements for additional information on the Company's three segments.

The following table and discussion concern the results of operations of the Company's three reportable segments for the years ended December 31, 2018 and 2017.

(In thousands)	2018	2017
Specialty Chemicals and Engineered Materials		
Net sales	$530,241	$485,470
Segment profit	129,754	111,802
Microcontamination Control		
Net sales	$552,844	$436,225
Segment profit	173,964	141,413
Advanced Materials Handling		
Net sales	$467,412	$420,837
Segment profit	82,541	59,838

Specialty Chemicals and Engineered Materials (SCEM)

For the year ended December 31, 2018, SCEM net sales increased to $530.2 million, up 9%, from $485.5 million in the comparable period last year. The sales increase primarily reflects strong product sales for specialty gases and specialty materials.

SCEM reported a segment profit of $129.8 million for the year ended December 31, 2018, up 16%, compared to a $111.8 million segment profit in the year-ago period. The increase in the SCEM's profit in 2018 was primarily due to increased sales, partially offset by higher operating expenses of 8% mainly due to higher employee costs and R&D spending.

Microcontamination Control (MC)

For the year ended December 31, 2018, MC net sales increased to $552.8 million, up 27%, from $436.2 million in the comparable period last year. The sales increase primarily reflects strength in photolithography applications, liquid chemistry

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filters for wet, etch and clean driven by strong industry tool shipments, and the acquisition of SPG in the second quarter of 2018, which contributed $62.4 million of sales.

MC reported a segment profit of $174.0 million for the year ended December 31, 2018, up 23%, compared to a $141.4 million segment profit in the year-ago period. The increase in MC's profit in 2018 reflects increased sales, partially offset by higher operating expenses of 21%, primarily due to higher employee costs, increased R&D spending and SPG operating infrastructure.

Advanced Materials Handling (AMH)

For the year ended December 31, 2018, AMH net sales increased 11% to $467.4 million, from $420.8 million in 2017. The increase primarily reflects strong sales of fluid handling products and liquid packaging and dispense products, and the acquisition of PSS in the first quarter of 2018, which contributed $16.0 million of sales.

AMH reported a segment profit of $82.5 million for the year ended December 31, 2018, up 38% compared to a $59.8 million segment profit in the year-ago period. The increase in the AMH's profit in 2018 was due to higher sales, partially offset by a 9% increase in operating expenses primarily related to higher employee costs and the absence of $7.1 million of impairment and severance related to organizational realignment from 2017.

Unallocated general and administrative expenses

Unallocated general and administrative expenses for the year ended December 31, 2018 totaled $31.4 million compared to $27.2 million for the year ended December 31, 2017. The $4.2 million increase mainly reflects the deal and integration costs of $8.4 million in the discussion of SG&A above, partially offset by $3.9 million impairment charges related to certain acquired intangible assets recorded in 2017.

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Results of Operations

Year ended December 31, 2017 compared to year ended December 31, 2016

The following table sets forth the results of operations and the relationship between various components of operations, stated as a percent of net sales, for the years ended December 31, 2017 and 2016. The Company's historical financial data was derived from its consolidated financial statements and related notes included elsewhere in this annual report.

(Dollars in thousands)	2017	% of net sales	2016	% of net sales
Net sales	$1,342,532	100.0 %	$1,175,270	100.0 %
Cost of sales	733,547	54.6	666,579	56.7
Gross profit	608,985	45.4	508,691	43.3
Selling, general and administrative expenses	216,194	16.1	201,901	17.2
Engineering, research and development expenses	106,951	8.0	106,991	9.1
Amortization of intangible assets	44,023	3.3	44,263	3.8
Operating income	241,817	18.0	155,536	13.2
Interest expense	32,343	2.4	36,846	3.1
Interest income	(715)	(0.1)	(318)	—
Other expense (income), net	25,458	1.9	(991)	(0.1)
Income before income taxes and equity in net loss of affiliate	184,731	13.8	119,999	10.2
Income tax expense	99,665	7.4	22,852	1.9
Net income	$85,066	6.3	$97,147	8.3

Net sales For the year ended December 31, 2017, net sales were $1,342.5 million, up $167.3 million, or 14%, from sales for the year ended December 31, 2016. An analysis of the factors underlying the increase in net sales is presented in the following table:

(In thousands)	
Net sales in 2016	$1,175,270
Organic growth associated with volume and pricing	164,505
Increase associated with liquid filtration product line acquisition	3,643
Decrease associated with effect of foreign currency translation	(886)
Net sales in 2017	$1,342,532

The Company's sales increase was due to strong across-the-board demand for the Company's products from semiconductor industry customers, reflecting both higher industry fab utilization and semiconductor industry capital spending compared to the year-ago period. This sales increase reflected improved sales of gas microcontamination filters, liquid chemistry filtration solutions and certain specialty materials products. Exclusive of the sales of the acquired liquid filtration product line of $3.6 million of revenue for 2017 and the unfavorable currency translation effects of $0.9 million for the year, mainly due to the weakening of the Japanese yen relative to the U.S. dollar, the Company's sales grew 14% in 2017 when compared to 2016.

On a geographic basis, in 2017, total sales to Taiwan were 22%, to North America were 21%, to South Korea were 16%, to Japan were 13%, to China were 11%, to Europe were 9% and to Southeast Asia were 8%. In 2016, total sales to Taiwan were 25%, to North America were 22%, to Japan were 13%, to South Korea were 12%, to China were 10%, to Europe were 9%, and to Southeast Asia were 9%. From 2016 to 2017, net sales to customers in South Korea, China, Europe, North America, Japan and Southeast Asia increased 49%, 26%, 14%, 13%, 9%, and 6%, respectively, while net sales to customers in Taiwan were down 1%.

Demand drivers for the Company's business primarily consist of semiconductor fab utilization and production (unit-driven) as well as capital spending for new or upgraded semiconductor fabrication equipment and facilities (capital-driven). The Company analyzes sales of its products by these two key drivers. Sales of unit-driven products represented 74% of total sales and sales of capital-driven products represented 26% of total sales in 2017. This compares to a unit-driven to capital-driven ratio of 76%:24% for 2016.

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Gross profit Gross profit for 2017 increased by $100.3 million, to $609.0 million, an increase of 20% from $508.7 million for 2016. The gross margin rate for 2017 was 45.4% versus 43.3% for 2016. The gross profit and gross margin improvements reflect the improved factory utilization associated with strong sales levels, a slightly favorable sales mix and the absence of the qualification and start-up costs incurred at the Company's i2M center in the prior year period. These factors were partly offset by modest price erosion for certain products in response to normal competitive pressures. In addition, the gross profit and gross margin figures include impairment charges of $6.1 million and $6.3 million for the years ended December 31, 2017 and 2016, respectively, related to equipment-related and severance charges.

Selling, general and administrative expenses

Selling, general and administrative expense (SG&A) consists primarily of payroll and related expenses for the sales and administrative staff, professional fees (including accounting, legal and technology costs and expenses), and sales and marketing costs. SG&A expenses for 2017 increased $14.3 million, or 7%, to $216.2 million from $201.9 million in 2016. SG&A expenses, as a percent of net sales, decreased to 16.1% from 17.2% a year earlier, reflecting the increase in net sales.

An analysis of the factors underlying the increase in SG&A is presented in the following table:

(In thousands)	
Selling, general and administrative expenses in 2016	$201,901
Employee costs	7,455
Impairment charge related to acquired intangible assets	3,866
Other increases, net	2,972
Selling, general and administrative expenses in 2017	$216,194

Engineering, research and development expenses

Engineering, research and development (ER&D) expenses related to the support of current product lines and the development of new products and manufacturing technologies was $107.0 million in both 2017 and 2016. ER&D expenses as a percent of net sales were 8.0% compared to 9.1% a year ago, reflecting the increase in net sales.

The Company's overall ER&D efforts will continue to focus on the support or extension of current product lines, the development of its technologies to create differentiated and high-value products for the most advanced and demanding semiconductor applications and leveraging its unique and diverse technology portfolio to develop innovative, integrated solutions for unmet customer needs. The Company expects ER&D costs to stay relatively stable as a percentage of net sales.

Amortization of intangible assets Amortization of intangible assets was $44.0 million in 2017 compared to $44.3 million for 2016. The decline reflects the absence of amortization expense for certain identifiable trademark intangible assets acquired in the ATMI merger that became fully amortized in early 2017, offset by additional amortization expense from the liquid filtration product line acquisition in 2017.

Interest expense Interest expense was $32.3 million and $36.8 million in the years ended December 31, 2017 and 2016, respectively. Interest expense includes interest associated with debt outstanding and the amortization of debt issuance costs associated with such borrowings. The decrease in 2017 reflects lower average outstanding borrowings due to the Company's payments on the Term Loan in 2017.

Other expense (income), net Other expense, net, was $25.5 million in 2017 compared to other income, net, of $1.0 million in 2016.

In 2017, other expense, net, included an impairment charge of $2.8 million, a loss of extinguishment of debt of $20.7 million associated with the redemption of the Company's 2022 Notes (see note 7 to the Company's consolidated financial statements), and foreign currency transaction losses of $2.3 million.

In 2016, other income, net, included foreign currency transaction gains of $0.6 million and other gains of $0.4 million.

Income tax expense The Company recorded income tax expense of $99.7 million in 2017 compared to income tax expense of $22.9 million in 2016. The Company's effective tax expense rate was 54.0% in 2017, compared to an effective tax rate of 19.0% in 2016.

The increase in the effective tax rate in 2017 from 2016 and the variance in both years from the U.S. statutory rate of 35% reflects several factors. The increase in the effective rate is primarily due to the recognition of the one-time

mandatory repatriation transition tax of $73.0 million on the net accumulated earnings and profits of the Company's foreign subsidiaries and $4.0 million of incremental tax related to no longer asserting that a significant portion of the Company's undistributed earnings are considered indefinitely invested overseas. This increase was partially offset by the remeasurement of the U.S. deferred taxes for $10.2 million to reflect the lower U.S. federal tax rate and an increase in the federal research and

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development tax credit. The effective tax rates in both years reflect a greater concentration in the Company’s geographic composition of income toward jurisdictions with lower tax rates than in the U.S.

Net income Net income was $85.1 million, or $0.59 per diluted share, in 2017 compared to net income of $97.1 million, or $0.68 per diluted share, in 2016. The decrease reflects the Company’s aforementioned operating results described in greater detail above.

Non-GAAP Measures Information The Company’s consolidated financial statements are prepared in conformity with accounting principles generally accepted in the United States (GAAP). The Company also utilizes certain non-GAAP financial measures as a complement to financial measures provided in accordance with GAAP in order to better assess and reflect trends affecting the Company’s business and results of operations. See “Non-GAAP Information” included below in this section for additional detail, including the reconciliation of GAAP measures to the Company’s non-GAAP measures.

The Company’s non-GAAP financial measures are Adjusted EBITDA and Adjusted Operating Income, together with related measures thereof, and non-GAAP Earnings Per Share (EPS).

Adjusted EBITDA increased 35% to $357.1 million in 2017, compared to $263.7 million in 2016. Adjusted EBITDA, as a percent of net sales, was 26.6% in 2017 compared to 22.4% in 2016. Adjusted Operating Income increased 44% to $298.9 million in 2017, compared to $208.0 million in 2016. Adjusted Operating Income, as a percent of net sales, was 22.3% in 2017 compared to 17.7% in 2016. Non-GAAP Earnings Per Share increased 53% to $1.44 in 2017, compared to $0.94 in 2016. The improvement in the Adjusted EBITDA and Adjusted Operating Income reflect the increase in net sales and related increase in gross profit. In addition, Non-GAAP Earnings Per Share was positively affected by a lower adjusted effective tax rate.

Segment Analysis

The following table and discussion concern the results of operations of the Company’s three reportable segments for the years ended December 31, 2017 and 2016.

(In thousands)	2017	2016
Specialty Chemicals and Engineered Materials		
Net sales	$485,470	$428,328
Segment profit	111,802	77,328
Microcontamination Control		
Net sales	$436,225	$362,658
Segment profit	141,413	93,911
Advanced Materials Handling		
Net sales	$420,837	$384,284
Segment profit	59,838	56,282

Specialty Chemicals and Engineered Materials (SCEM)

For the year ended December 31, 2017, SCEM net sales increased to $485.5 million, up 13%, from $428.3 million in the comparable period last year. The sales increase primarily reflects strong product sales for specialty gases, glass forming products and advanced deposition materials.

SCEM reported a segment profit of $111.8 million for the year ended December 31, 2017 compared to a $77.3 million segment profit in the year-ago period. The increase in the SCEM’s profit in 2017 was primarily due to increased sales, partially offset by higher operating expenses of 5%.

Microcontamination Control (MC)

For the year ended December 31, 2017, MC net sales increased to $436.2 million, up 20%, from $362.7 million in the comparable period last year. The sales increase primarily reflects strength in photolithography applications, gas filter products, and liquid chemistry filters for wet, etch and clean driven by strong industry tool shipments.

MC reported a segment profit of $141.4 million for the year ended December 31, 2017 compared to a $93.9 million segment profit in the year-ago period. The increase in the MC’s profit in 2017 reflects increased sales and the absence of the qualification and start-up costs incurred at the Company’s i2M center in the year-ago period, partially offset by higher operating expenses of 5%.

Advanced Materials Handling (AMH)

For the year ended December 31, 2017, AMH net sales increased 10% to $420.8 million, from $384.3 million in 2016. The increase primarily reflects strong sales of wafer and reticle handling, wafter shipping and fluid handling products.

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AMH reported a segment profit of $59.8 million in 2017, up 6% from $56.2 million in 2016. The increase in the AMH's profit in 2017 was due to higher sales, partially offset by a 6% increase in operating expenses. Results in 2017 include impairment and severance charges of $7.5 million compared to $6.8 million a year ago.

Unallocated general and administrative expenses

Unallocated general and administrative expenses for the year ended December 31, 2017 totaled $27.2 million compared to $27.7 million for the year ended December 31, 2016. Results in 2017 include a $3.9 million impairment charge related to certain acquired intangible assets.

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Quarterly Results of Operations

The following table presents selected data from the Company’s consolidated statements of operations for the eight quarters ended December 31, 2018. This unaudited information has been prepared on the same basis as the audited consolidated financial statements appearing elsewhere in this annual report. All adjustments that management considers necessary for the fair presentation of the unaudited information have been included in the quarters presented.

QUARTERLY STATEMENTS OF OPERATIONS DATA

	2017				2018			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
(In thousands)								
Net sales	$317,377	$329,002	$345,591	$350,562	$367,199	$383,059	$398,597	$401,642
Gross profit	139,596	150,303	155,407	163,679	175,997	182,378	181,716	179,740
Selling, general and administrative expenses	50,492	52,985	57,699	55,018	58,269	65,200	62,358	60,707
Engineering, research and development expenses	27,239	27,221	26,002	26,489	27,586	30,231	29,964	30,675
Amortization of intangible assets	10,945	11,007	11,051	11,020	11,669	12,014	21,419	17,050
Operating income	50,920	59,090	60,655	71,152	78,473	74,933	67,975	71,308
Net income (loss)	32,514	39,991	40,902	(28,341)	57,562	54,349	48,060	80,784

	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
(Percent of net sales)								
Net sales	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %
Gross profit	44.0	45.7	45.0	46.7	47.9	47.6	45.6	44.8
Selling, general and administrative expenses	15.9	16.1	16.7	15.7	15.9	17.0	15.6	15.1
Engineering, research and development expenses	8.6	8.3	7.5	7.6	7.5	7.9	7.5	7.6
Amortization of intangibles	3.4	3.3	3.2	3.1	3.2	3.1	5.4	4.2
Operating income	16.0	18.0	17.6	20.3	21.4	19.6	17.1	17.8
Net income (loss)	10.2	12.2	11.8	(8.1)	15.7	14.2	12.1	20.1

The Company’s quarterly results of operations have been, and will likely continue to be, subject to significant fluctuations due to a myriad of factors, many of which are beyond the Company’s control. The variability in sales, and

its corresponding effect on gross profit, are generally the most important factors underlying the changes in the Company's operating income and net income over the past eight quarters.

Liquidity and Capital Resources

The Company has historically financed its operations and capital requirements through cash flow from its operating activities, long-term loans, lease financing and borrowings under domestic and international short-term lines of credit. In fiscal 2000 and 2009, the Company raised capital via public offerings of its common stock.

Operating activities

Net cash flow provided by operating activities totaled $312.6 million for the year ended December 31, 2018. Cash generated by the Company's operations included net income of $240.8 million, as adjusted for the impact of various non-cash charges, most notably depreciation and amortization of $127.3 million, and share-based compensation expense of $17.1 million. These operating cash flows were partly offset by changes in operating assets and liabilities, mainly due to an increase in accounts receivables and inventories, an increase in accounts payable and accrued liabilities, and an offset in income taxes payable and refundable income taxes.

Working capital was $759.7 million at December 31, 2018, which included $482.1 million in cash and cash equivalents, a decrease from $766.6 million as of December 31, 2017, which included $625.4 million in cash and cash equivalents.

Accounts receivable increased by $38.6 million during 2018, or $17.5 million after accounting for the effect of foreign currency translation and acquisitions. The net increase reflects the year-over-year increase in fourth quarter sales of the Company's products. The Company's days sales outstanding measure (DSO) stood at 50 days at December 31, 2018 compared to 48 days at the beginning of the year.

Inventories at December 31, 2018 increased by $70.1 million from a year earlier, or $38.1 million after accounting for foreign currency translation, acquisitions and the provision for excess and obsolete inventory. The net increase reflects higher levels of all categories of inventory, due to higher sales and production activity.

Accounts payable and accrued liabilities were $65.9 million higher than a year ago, or $20.0 million higher after accounting for the effect of foreign currency translation and acquisitions. The increase reflects higher accounts payable associated with increased levels of business activity and higher accrued bonuses in 2018.
Investing activities Cash flow used in investing activities totaled $485.9 million in 2018.
Acquisition of property and equipment totaled $110.2 million, which primarily reflected investments in equipment and tooling. Capital expenditures in 2018 generally reflected more normalized capital spending levels. The Company expects its capital expenditures in 2019 to be approximately $110 million.
On January 22, 2018, the Company acquired PSS, which provides particle sizing instrumentation for liquid applications to the semiconductor and life science industries. The total purchase price of the acquisition was approximately $37.3 million in cash, funded from the Company’s existing cash on hand. The transaction is described in further detail in note 3 to the Company’s consolidated financial statements.
On June 25, 2018, the Company acquired the SPG business. SPG is a leading provider of high-capacity gas purification systems used in semiconductor manufacturing and adjacent markets. The total purchase price of the acquisition was approximately $352.7 million in cash or $341.5 million net of cash received, subject to revision for customary working capital adjustments. The transaction is described in further detail in note 3 to the Company’s consolidated financial statements.
Financing activities Cash flow provided by financing activities totaled $34.4 million during 2018.
The Company previously had (a) a senior secured term loan facility maturing April 30, 2021 (the “Previous Term Loan Facility”) that provided financing of $460 million and (b) a senior secured asset-based revolving credit facility maturing April 30, 2019 (the “ABL Facility” and together with the Previous Term Loan Facility, the “Previous Credit Facilities”) that provided financing of $75 million, subject to a borrowing base.

On November 6, 2018, the Company obtained a new $700 million senior secured credit facility, consisting initially of (a) term loans in an aggregate principal amount of $400 million (the “New Term Loan Facility”) and (b) revolving commitments in an aggregate amount of $300 million (the “New Revolving Facility”, and together with the New Term Loan Facility, the “New Credit Facilities”). The New Term Loan Facility matures November 6, 2025 and the New Revolving Facility matures November 6, 2023. Borrowings under the New Credit Facilities bear interest at a rate per annum equal to, at the Company’s option, a base rate (such as prime rate or LIBOR) plus, an applicable margin. The Company may voluntarily prepay outstanding term loans under the New Term Loan Facility at any time without premium or penalty other than customary “breakage” costs with respect to LIBOR loans, provided, however, that if on or prior to May 6, 2019 the Company prepays any term loan in connection with a repricing transaction, the Company must pay a prepayment premium of 1.00% of the aggregate principal amount of the term loans so prepaid. The Company may voluntarily reduce the unutilized portion of the New
Revolving Facility and repay outstanding revolving loans under the New Revolving Facility at any time without premium or penalty other than customary “breakage” costs with respect to LIBOR loans. The Company used approximately $109 million of the proceeds of the term loans under the New Term Loan Facility to repay and terminate its Previous Credit Facilities. As of December 31, 2018, the New Term Loan Facility was fully drawn at closing and the Company had no outstanding borrowings and $0.2 million undrawn outstanding letters of credit under the New Revolving Facility.
Through December 31, 2018, the Company was in compliance with all applicable financial covenants included in the terms of its credit facilities.
The Company also has lines of credit with two banks that provide for borrowings of Japanese yen for the Company’s Japanese subsidiary equivalent to an aggregate of approximately $10.9 million. There were no outstanding borrowings under these lines of credit at December 31, 2018.
In addition, the Company repurchased shares of the Company’s common stock during 2018 at a total cost of $173.8 million under the stock repurchase program authorized by the Company’s Board of Directors. During 2018, the Company’s Board of Directors declared a cash dividend of $0.07 per share during the first, second, third and fourth quarters of 2018, which totaled $39.8 million. The Company paid $14.7 million for taxes related to the net share settlement of equity awards, offset by proceeds received of $5.6 million in connection with common shares issued

under the Company's stock plans.

At December 31, 2018, the Company's shareholders' equity stood at $1,012.0 million, up 2% from $993.0 million at the beginning of the year. The 2018 increase reflects net income of $240.8 million, additional paid-in capital of $17.1 million associated with the Company's share-based compensation expense and these increases to shareholders' equity were partly offset by cash dividends paid of $39.8 million, the repurchase and retirement of the Company's stock of $179.3 million and favorable foreign currency translation effects of $10.2 million mainly associated with the strengthening of the U.S. dollar versus the Korean won.

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As of December 31, 2018, the Company's sources of available funds were its cash and cash equivalents of $482.1 million, funds available under the New Revolving Facility and international credit facilities and cash flow generated from operations. As of December 31, 2018, the amount of cash and cash equivalents held in certain of our foreign operations totaled approximately $180.1 million. As of December 31, 2018, we had not repatriated any of these funds to the U.S. However, to the extent we repatriate these funds to the U.S., we will be required to pay income taxes in certain U.S. states and applicable foreign withholding taxes on those amounts during the period when such repatriation occurs. We have accrued taxes for the tax effect of repatriating the funds to the U.S.

The Company believes its existing balances of domestic cash and cash equivalents and operating cash flows will be sufficient to meet the Company's domestic cash needs arising in the ordinary course of business for the next twelve months. If available liquidity is not sufficient to meet the Company's operating and debt service obligations as they come due, management would need to pursue alternative arrangements through additional equity or debt financing in order to meet the Company's cash requirements. There can be no assurance that any such financing would be available on commercially acceptable terms, or at all.

New Accounting Pronouncements

Recently adopted accounting pronouncements Refer to note 1 to the Company's consolidated financial statements for a discussion of accounting pronouncements implemented in 2018. Other than the adoption of ASU 2014-09, there were no recently issued accounting pronouncements adopted in 2018.

Recently issued accounting pronouncements Refer to note 1 of the Company's consolidated financial statements for a discussion of accounting pronouncements recently issued but not yet adopted.

Contractual Obligations

The following table summarizes the maturities of the Company's significant financial obligations as of December 31, 2018:

(In thousands)	Total	2019	2020	2021	2022	2023	Thereafter
Long-term debt[1]	$950,000	$4,000	$4,000	$4,000	$4,000	$4,000	$930,000
Interest[2]	302,267	43,518	43,337	43,156	42,975	42,794	86,487
Pension obligations	6,473	36	33	217	201	251	5,735
Capital lease obligations	5,250	1,000	1,000	1,000	1,000	1,000	250
Capital purchase obligations[3]	30,668	30,668	—	—	—	—	—
Operating leases	64,894	11,360	8,906	6,836	5,431	5,208	27,153
Total	$1,359,552	$90,582	$57,276	$55,209	$53,607	$53,253	$1,049,625

Unrecognized tax benefits[4]

[1]Debt obligations are classified based on their stated maturity date, regardless of their classification on the Company's consolidated balance sheets.

[2]Interest projections on both variable and fixed rate long-term debt are based on interest rates effective as of December 31, 2018 and do not include $11.1 million for net unamortized discounts and debt issuance costs.

[3]Capital purchase obligations represent commitments for the construction or purchase of property, plant and equipment. They were not recorded as liabilities on the Company's consolidated balance sheet as of December 31, 2018, as the Company had not yet received the related goods or taken title to the property.

[4]The Company had $12.3 million of total gross unrecognized tax benefits at December 31, 2018. The timing of any payments associated with these unrecognized tax benefits will depend on a number of factors. Accordingly, the Company cannot make reasonably reliable estimates of the amount and period of potential cash settlements, if any, with taxing authorities and are not included in the table above.

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Non-GAAP Information The Company's consolidated financial statements are prepared in conformity with accounting principles generally accepted in the United States (GAAP).

The Company also provides certain non-GAAP financial measures as a complement to financial measures provided in accordance with GAAP in order to better assess and reflect trends affecting the Company's business and results of operations. Regulation G, "Conditions for Use of Non-GAAP Financial Measures," and other regulations under the Securities Exchange Act of 1934, as amended, define and prescribe the conditions for use of certain non-GAAP financial information. The Company provides non-GAAP financial measures of Adjusted EBITDA and Adjusted Operating Income together with related measures thereof, and non-GAAP Earnings Per Share (EPS).

Adjusted EBITDA, a non-GAAP term, is defined by the Company as net income before (1) income tax expense, (2) interest expense (3) interest income (4) other expense (income), net, (5) charge for fair value write-up of acquired inventory sold, (6) deal costs, (7) integration costs, (8) severance related to organization realignment (9) impairment of equipment and intangibles, (10) loss on sale of subsidiary, (11) amortization of intangible assets and (12) depreciation. Adjusted Operating Income, another non-GAAP term, is defined by the Company as Adjusted EBITDA exclusive of the depreciation addback noted above. The Company also utilizes non-GAAP measures whereby Adjusted EBITDA and Adjusted Operating Income are each divided by the Company's net sales to derive Adjusted EBITDA Margin and Adjusted Operating Margin, respectively.

Non-GAAP EPS, a non-GAAP term, is defined by the Company as net income before (1) charge for fair value write-up of inventory sold (2) deal costs (3) integration costs, (4) severance related to organizational realignment, (5) impairment of equipment and intangibles, (6) loss on debt extinguishment (7) loss on sale of subsidiary, (8) gain on sale of short-term investment (9) amortization of intangible assets, (10) the tax effect of those adjustments to net income and discrete tax items (11) the tax effect of legal entity restructuring and (12) the Tax Cuts and Jobs Act.

The Company provides supplemental non-GAAP financial measures to better understand and manage its business and believes these measures provide investors and analysts additional and meaningful information for the assessment of the Company's ongoing results. Management also uses these non-GAAP measures to assist in the evaluation of the performance of its business segments and to make operating decisions.

Management believes the Company's non-GAAP measures help indicate the Company's baseline performance before certain gains, losses or other charges that may not be indicative of the Company's business or future outlook and offer a useful view of business performance in that the measures provide a more consistent means of comparing performance. The Company believes the non-GAAP measures aid investors' overall understanding of the Company's results by providing a higher degree of transparency for such items and providing a level of disclosure that will help investors understand how management plans, measures and evaluates the Company's business performance.

Management believes that the inclusion of non-GAAP measures provides consistency in its financial reporting and facilitates investors' understanding of the Company's historical operating trends by providing an additional basis for comparisons to prior periods.

Management uses Adjusted EBITDA and Adjusted Operating Income to assist it in evaluations of the Company's operating performance by excluding items that management does not consider as relevant in the results of its ongoing operations. Internally, these non-GAAP measures are used by management for planning and forecasting purposes, including the preparation of internal budgets; for allocating resources to enhance financial performance; for evaluating the effectiveness of operational strategies; and for evaluating the Company's capacity to fund capital expenditures, secure financing and expand its business.

In addition, and as a consequence of the importance of these non-GAAP financial measures in managing its business, the Company's Board of Directors uses non-GAAP financial measures in the evaluation process to determine management compensation.

The Company believes that certain analysts and investors use Adjusted EBITDA, Adjusted Operating Income and non-GAAP EPS as supplemental measures to evaluate the overall operating performance of firms in the Company's industry. Additionally, lenders or potential lenders use Adjusted EBITDA measures to evaluate the Company's creditworthiness.

The presentation of non-GAAP financial measures is not meant to be considered in isolation, as a substitute for, or superior to, financial measures or information provided in accordance with GAAP. Management strongly encourages

investors to review the Company’s consolidated financial statements in their entirety and to not rely on any single financial measure.

Management notes that the use of non-GAAP measures has limitations:

First, non-GAAP financial measures are not standardized. Accordingly, the methodology used to produce the Company’s non-GAAP financial measures is not computed under GAAP and may differ notably from the methodology used by other companies. For example, the Company’s non-GAAP measure of Adjusted EBITDA may not be directly comparable to EBITDA or an adjusted EBITDA measure reported by other companies.

Second, the Company’s non-GAAP financial measures exclude items such as amortization and depreciation that are recurring. Amortization of intangibles and depreciation have been, and will continue to be for the foreseeable future, a significant

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recurring expense with an impact upon the Company's results of operations, notwithstanding the lack of immediate impact upon cash flows.

Third, there is no assurance the Company will not have future restructuring activities, gains or losses on sale of equity investments, contingent consideration fair value adjustments or similar items and, therefore, may need to record additional charges (or credits) associated with such items, including the tax effects thereon. The exclusion of these items from the Company's non-GAAP measures should not be construed as an implication that these costs are unusual, infrequent or non-recurring.

Management considers these limitations by providing specific information regarding the GAAP amounts excluded from these non-GAAP financial measures and evaluating these non-GAAP financial measures together with their most directly comparable financial measures calculated in accordance with GAAP. The calculations of Adjusted EBITDA, Adjusted operating income, and non-GAAP EPS, and reconciliations between these financial measures and their most directly comparable GAAP equivalents are presented below in the accompanying tables.

The reconciliation of GAAP measures to Adjusted Operating Income and Adjusted EBITDA for the years ended December 31, 2018, 2017 and 2016 are presented below:

In thousands	2018	2017	2016
Net sales	$1,550,497	$1,342,532	$1,175,270
Net income	$240,755	$85,066	$97,147
Adjustments to net income			
Income tax expense	13,677	99,665	22,852
Interest expense	34,094	32,343	36,846
Interest income	(3,839)	(715)	(318)
Other expense (income), net	8,002	25,458	(991)
GAAP – Operating income	292,689	241,817	155,536
Charge for fair value write-up of acquired inventory sold	6,868	—	—
Deal costs	5,121	—	—
Integration costs	3,237	—	—
Severance related to organizational realignment	460	2,700	2,405
Impairment of equipment and intangibles [1]	—	10,400	5,826
Loss on sale of subsidiary	466	—	—
Amortization of intangible assets	62,152	44,023	44,263
Adjusted operating income	370,993	298,940	208,030
Depreciation	65,116	58,208	55,623
Adjusted EBITDA	$436,109	$357,148	$263,653
Adjusted operating margin	23.9%	22.3%	17.7%
Adjusted EBITDA – as a % of net sales	28.1%	26.6%	22.4%

[1]Includes product line impairment charges of $5,330 and $5,826 classified as cost of sales for the years ended December 31, 2017 and 2016, respectively.

Includes intangible impairment charge of $3,866 classified as selling, general and administrative expense for the year ended December 31, 2017.

Includes product line impairment charge of $320 classified as selling, general and administrative expense for the year ended December 31, 2017.

Includes product line impairment charge of $884 classified as engineering, research and development expense for the year ended December 31, 2017.

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The reconciliation of GAAP measures to Non-GAAP Earnings per share for the years ended December 31, 2018, 2017 and 2016 are presented below:

In thousands, except per share data	2018	2017	2016
Net income	$240,755	$85,066	$97,147
Adjustments to net income:			
Charge for fair value write-up of acquired inventory sold	6,868	—	—
Deal costs	5,121	—	—
Integration costs	3,237	—	—
Severance related to organizational realignment	460	2,700	2,405
Impairment of equipment and intangibles[1]	—	13,200	5,826
Loss on debt extinguishment	2,319	20,687	—
Loss on sale of subsidiary	466	—	—
Gain on sale of short-term investment	—	—	(156)
Amortization of intangible assets	62,152	44,023	44,263
Tax effect of adjustments to net income and discrete tax items [2]	(17,812)	(26,046)	(16,637)
Tax effect of legal entity restructuring	(34,478)	—	—
Tax effect of Tax Cuts and Jobs Act	683	66,713	—
Non-GAAP net income	$269,771	$206,343	$132,848
Diluted earnings per common share	$1.69	$0.59	$0.68
Effect of adjustments to net income	$0.20	$0.85	$0.25
Diluted non-GAAP earnings per common share	$1.89	$1.44	$0.94

[1]Includes product line impairment charges of $5,330 and $5,826 classified as cost of sales for the years ended December 31, 2017 and 2016, respectively.
Includes intangible impairment charge of $3,866 classified as selling, general and administrative expense for the year ended December 31, 2017.
Includes product line impairment charge of $320 classified as selling, general and administrative expense for the year ended December 31, 2017.
Includes product line impairment charge of $884 classified as engineering, research and development expense for the year ended December 31, 2017.
Includes product line impairment charge of $2,800 classified as other expense for the year ended December 31, 2017.
[2]The tax effect of the non-GAAP adjustments was calculated using the applicable marginal tax rate during the respective years.

Item 7A. Quantitative and Qualitative Disclosure About Market Risks

Entegris' principal financial market risks are sensitivities to interest rates and foreign currency exchange rates. The Company's interest-bearing cash equivalents and short-term investments are subject to interest rate fluctuations. The Company's cash equivalents are instruments with maturities of three months or less. A 100 basis point change in interest rates would potentially increase or decrease annual net income by approximately $0.7 million annually.
The cash flows and results of operations of the Company's foreign-based operations are subject to fluctuations in foreign exchange rates. The Company occasionally uses derivative financial instruments to manage the foreign currency exchange rate risks associated with its foreign-based operations. At December 31, 2018, the Company had no net exposure to any foreign currency forward contracts.

Item 8. Financial Statements and Supplementary Data.

The information called for by this item is set forth in the Consolidated Financial Statements covered by the Report of Independent Registered Public Accounting Firm at the end of this report.

Item 9. Changes in and Disagreements with Accountants on Accounting and Financial Disclosure.

This item is not applicable.

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Item 9A. Controls and Procedures.
Evaluation of Disclosure Controls and Procedures

Based on management's evaluation (with the participation of our principal executive officer and principal financial officer), as of the end of the period covered by this report, our principal executive officer and principal financial officer have concluded that our disclosure controls and procedures (as defined in Rules 13a-15(e) and 15d-15(e) under the Securities Exchange Act of 1934, as amended (the Exchange Act)), are effective to provide reasonable assurance that information required to be disclosed by us in reports that we file or submit under the Exchange Act is recorded, processed, summarized, and reported within the time periods specified in SEC rules and forms, and is accumulated and communicated to management, including our principal executive officer and principal financial officer, as appropriate, to allow timely decisions regarding required disclosure.

Changes in Internal Control Over Financial Reporting

During the quarter ended December 31, 2018, the Company identified a material weakness in internal control related to ineffective risk assessment associated with implementation of certain third party software upgrades and Information Technology (IT) program change controls. As a result of an ineffective software upgrade provided by the software vendor that occurred on December 15, 2018, an automated configuration was changed that affected wire transfer instructions for a one week period and resulted in material expenditures being routed to an unauthorized intermediary bank and vendor payments being recorded in error.

The Company took immediate action when the unauthorized payments were discovered. The expenditures were recovered. Those transactions were corrected and the majority of the vendor payments were subsequently paid by the Company prior to the issuance of these consolidated financial statements.

The Company remediated the material weakness described above as of December 31, 2018, by obtaining the software to correct the automated configuration and enhancing our program change controls related to the third party software upgrade changes affecting our ERP system during 2018, which included monitoring by an external specialist.

Management concluded based on the remediation actions described above that our risk assessment and IT program change controls were designed and implemented effectively as of December 31, 2018.

There were no other changes to our internal control over financial reporting (as defined in Rules 13a-15(f) and 15d-15(f) under the Exchange Act) that occurred during the quarter ended December 31, 2018 that have materially affected, or are reasonably likely to materially affect, our internal control over financial reporting.

Management Report on Internal Control Over Financial Reporting

Our management is responsible for establishing and maintaining adequate internal control over financial reporting (as defined in Rules 13a-15(f) and 15d-15(f) under the Exchange Act) to provide reasonable assurance regarding the reliability of our financial reporting and the preparation of consolidated financial statements for external purposes in accordance with GAAP.

Management assessed our internal control over financial reporting as of December 31, 2018. Management based its assessment on criteria established in Internal Control-Integrated Framework issued by the Committee of Sponsoring Organizations of the Treadway Commission (2013 framework). Management's assessment included evaluation of elements such as the design and operating effectiveness of key financial reporting controls, process documentation, accounting policies, and our overall control environment.

The Company acquired the SAES Pure Gas business (SPG) on June 25, 2018. In the conduct of its assessment of the effectiveness of the Company's internal control over financial reporting for the year ended December 31, 2018, management has excluded total assets of approximately $434 million and net sales of approximately $62 million related to SPG that are included in the consolidated financial statements of Entegris and its subsidiaries as of and for the year ended December 31, 2018. Management must include SPG in the conduct of its assessment of the effectiveness of the Company's internal control over financial reporting no later than the second quarter of 2019.

Based on its assessment, management has concluded that our internal control over financial reporting was effective as of the end of the fiscal year to provide reasonable assurance regarding the reliability of financial reporting and the preparation of consolidated financial statements for external reporting purposes in accordance with GAAP. We reviewed the results of management's assessment with the Audit Committee of our Board of Directors.

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KPMG LLP, the independent registered public accounting firm which audited the consolidated financial statements included in this annual report, has issued an attestation report on our internal control over financial reporting.

Inherent Limitations on Effectiveness of Controls

Our management, including the principal executive officer and principal financial officer, does not expect that our disclosure controls and procedures or our internal control over financial reporting will prevent or detect all errors and all fraud. A control system, no matter how well-designed and operated, can provide only reasonable, not absolute, assurance that the control system's objectives will be met. The design of a control system must reflect the fact that there are resource constraints, and the benefits of controls must be considered relative to their costs. Further, because of the inherent limitations in all control systems, no evaluation of controls can provide absolute assurance that misstatements due to error or fraud will not occur or that all control issues and instances of fraud, if any, have been detected.

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Report of Independent Registered Public Accounting Firm
The Board of Directors and Stockholders
Entegris, Inc.:
Opinion on Internal Control Over Financial Reporting

We have audited Entegris, Inc. and subsidiaries' (the Company) internal control over financial reporting as of December 31, 2018, based on criteria established in Internal Control - Integrated Framework (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission. In our opinion, the Company maintained, in all material respects, effective internal control over financial reporting as of December 31, 2018, based on criteria established in Internal Control - Integrated Framework (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission.

We also have audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) (PCAOB), the consolidated balance sheets of the Company as of December 31, 2018 and 2017, the related consolidated statements of operations, comprehensive income, equity, and cash flows for each of the years in the three-year period ended December 31, 2018, and the related notes (collectively, the consolidated financial statements), and our report dated February 11, 2019 expressed an unqualified opinion on those consolidated financial statements.

The Company acquired SAES Pure Gas during 2018, and management excluded from its assessment of the effectiveness of the Company's internal control over financial reporting as of December 31, 2018, SAES Pure Gas' internal control over financial reporting associated with total assets of $434 million and total revenues of $62 million included in the consolidated financial statements of the Company as of and for the year ended December 31, 2018. Our audit of internal control over financial reporting of the Company also excluded an evaluation of the internal control over financial reporting of SAES Pure Gas.

Basis for Opinion

The Company's management is responsible for maintaining effective internal control over financial reporting and for its assessment of the effectiveness of internal control over financial reporting, included in the accompanying Management's Annual Report on Internal Control Over Financial Reporting" appearing under Item 9A of the Company's December 31, 2018 Annual Report on Form 10-K . Our responsibility is to express an opinion on the Company's internal control over financial reporting based on our audit. We are a public accounting firm registered with the PCAOB and are required to be independent with respect to the Company in accordance with the U.S. federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audit in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether effective internal control over financial reporting was maintained in all material respects. Our audit of internal control over financial reporting included obtaining an understanding of internal control over financial reporting, assessing the risk that a material weakness exists, and testing and evaluating the design and operating effectiveness of internal control based on the assessed risk. Our audit also included performing such other procedures as we considered necessary in the circumstances. We believe that our audit provides a reasonable basis for our opinion.

Definition and Limitations of Internal Control Over Financial Reporting

A company's internal control over financial reporting is a process designed to provide reasonable assurance regarding the reliability of financial reporting and the preparation of financial statements for external purposes in accordance with generally accepted accounting principles. A company's internal control over financial reporting includes those policies and procedures that (1) pertain to the maintenance of records that, in reasonable detail, accurately and fairly

reflect the transactions and dispositions of the assets of the company; (2) provide reasonable assurance that transactions are recorded as necessary to permit preparation of financial statements in accordance with generally accepted accounting principles, and that receipts and expenditures of the company are being made only in accordance with authorizations of management and directors of the company; and (3) provide reasonable assurance regarding prevention or timely detection of unauthorized acquisition, use, or disposition of the company's assets that could have a material effect on the financial statements.

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Because of its inherent limitations, internal control over financial reporting may not prevent or detect misstatements. Also, projections of any evaluation of effectiveness to future periods are subject to the risk that controls may become inadequate because of changes in conditions, or that the degree of compliance with the policies or procedures may deteriorate.

/s/ KPMG LLP
Minneapolis, Minnesota
February 11, 2019
Item 9B. Other Information.
None.

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PART III

Item 10. Directors, Executive Officers and Corporate Governance.

Except as set forth below, the information required by this Item 10 has been omitted from this report, and is incorporated by reference to the sections “Section 16(a) Beneficial Ownership Reporting Compliance,” “Election of Directors,” “Corporate Governance” in our definitive Proxy Statement for the Entegris, Inc. Annual Meeting of Stockholders to be held on April 30, 2019, and to be filed with the Securities and Exchange Commission pursuant to Regulation 14A within 120 days after the end of our 2018 fiscal year.

Information called for by this item with respect to registrant’s executive officers is set forth under “Executive Officers of the Registrant” in Part I of this report.

At their first meeting following the August 10, 2005 merger described under “Our History” in Item 1 of Part I above, our Board of Directors adopted a code of business ethics, The Entegris, Inc. Code of Business Ethics applicable to all of our executives, directors and employees as well as a set of corporate governance guidelines, which have been updated from time to time. The Entegris, Inc. Code of Business Ethics, the Corporate Governance Guidelines and the charters for our Audit & Finance Committee, Governance & Nominating Committee and our Management Development & Compensation Committee all appear on our website at http://www.Entegris.com under “Investors - Corporate Governance”. The Entegris Code of Business Ethics, Corporate Governance Guidelines and committee charters are also available in print to any shareholder that requests a copy. Copies may be obtained by contacting our Assistant Secretary through our corporate headquarters. The Company intends to comply with the requirements of Item 5.05 of Form 8-K with respect to any amendment to or waiver of the provisions of the Entegris, Inc. Code of Business Ethics applicable to the registrant’s Chief Executive Officer, Chief Financial Officer or Chief Accounting Officer by posting notice of any such amendment or waiver at the same location on our website.

Item 11. Executive Compensation.

The information required by this Item 11 has been omitted from this report, and is incorporated by reference to the sections entitled “Compensation of Executive Officers” and “Management Development & Compensation Committee Report” in our definitive Proxy Statement for the Entegris, Inc. Annual Meeting of Stockholders to be held on April 30, 2019, and to be filed with the Securities and Exchange Commission pursuant to Regulation 14A within 120 days after the end of our 2018 fiscal year.

Item 12. Security Ownership of Certain Beneficial Owners and Management and Related Stockholder Matters.

Securities Authorized for Issuance Under Equity Compensation Plans:

As of December 31, 2018, our equity compensation plan information is as follows:

Equity Compensation Plan Information

	Number of securities to be issued upon exercise of outstanding options, warrants and rights	Weighted-average exercise price of outstanding options, warrants and rights (1)	Number of securities remaining available for future issuance under equity compensation plans (excluding securities reflected in column (a)) (2)
Plan category	(a)	(b)	(c)
Equity compensation plans approved by security holders	3,279,155	$ 18.22	8,730,786
Equity compensation plans not approved by security holders	—	—	—
Total	3,279,155	$ 18.22	8,730,786

(1) The weighted average exercise price does not take into account the shares issuable upon outstanding restricted stock unit vesting, which have no exercise price.

(2)

These shares are available under the 2010 Stock Plan for future issuance for stock options, restricted stock units, performance shares and stock awards in accordance with the terms of the 2010 Stock Plan.

The other information called for by this Item 12 has been omitted from this report, and is incorporated by reference to the section entitled "Ownership of Entegris Common Stock" in our definitive Proxy Statement for the Entegris, Inc. Annual Meeting of Stockholders to be held on April 30, 2019, and to be filed with the Securities and Exchange Commission pursuant to Regulation 14A within 120 days after the end of our 2018 fiscal year.

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Item 13. Certain Relationships and Related Transactions, and Director Independence.

The information required by this Item 13 has been omitted from this report, and is incorporated by reference to the section entitled “Corporate Governance” in our definitive Proxy Statement for the Entegris, Inc. Annual Meeting of Stockholders to be held on April 30, 2019, and to be filed with the Securities and Exchange Commission pursuant to Regulation 14A within 120 days after the end of our 2018 fiscal year.

Item 14. Principal Accountant Fees and Services.

The information required by this Item 14 has been omitted from this report, and is incorporated by reference to the section entitled “Proposal 2 - Ratification of Selection of Independent Registered Public Accounting Firm for 2019” in our definitive Proxy Statement for the Entegris, Inc. Annual Meeting of Stockholders to be held on April 30, 2019, and to be filed with the Securities and Exchange Commission pursuant to Regulation 14A within 120 days after the end of our 2018 fiscal year.

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PART IV

Item 15. Exhibits and Financial Statement Schedules.

(a) The following documents are filed as a part of this report:

1. Financial Statements. The Consolidated Financial Statements listed under Item 8 of this report and in the Index to Consolidated Financial Statements on page F-1 of this report are incorporated by reference herein.

2. Exhibits.

A. The following exhibits are incorporated by reference:

Reg. S-K Item 601(b) Reference	Document Incorporated	Referenced Document on file with the Commission
(2)	Agreement and Plan of Merger, dated as of January 27, 2019, by and between Entegris, Inc., and Versum Materials, Inc.	Exhibit 2.1 to Entegris, Inc. Current Report on Form 8-K filed on January 29, 2019
(2)	Purchase Agreement, dated as of June 6, 2018, by and among Entegris, Inc., Entegris (Shanghai) Microelectronics Trading Company Limited and SAES Getters S.p.A.	Exhibit 2.1 to Entegris, Inc. Current Report on Form 8-K filed on June 7, 2018.
(3)	By-Laws of Entegris, Inc., as amended December 17, 2008	Exhibit 3 to Entegris, Inc. Annual Report on Form 10-K for the fiscal year ended December 31, 2008
(3)	Amended and Restated Certificate of Incorporation of Entegris, Inc., as amended	Exhibit 3.1 to Entegris, Inc. Annual Report on Form 10-K for the fiscal year ended December 31, 2011
(4)	Form of certificate representing shares of Common Stock, $.01 par value per share	Exhibit 4.1 to Form S-4 Registration Statement of Entegris, Inc. and Eagle DE, Inc. (No. 333-124719)
(4)	Indenture, dated as of November 10, 2017, by and among the Company, certain of subsidiaries of the Company and Wells Fargo Bank, National Association Bank, as trustee, including the form of note representing the 2026 Notes	Exhibit 4.1 to Entegris, Inc. Current Report on Form 8-K filed with the Securities and Exchange Commission on November 13, 2017
(10)	Credit and Guaranty Agreement dated as of November 6, 2018, among Entegris, Inc., Certain Subsidiaries of Entegris, Inc., as Guarantors, the Lenders Party Hereto and Goldman Sachs Bank USA, as Administrative Agent and Collateral Agent	Exhibit 10.1 to Entegris, Inc. Current Report on Form 8-K filed with the Securities and Exchange Commission on November 6, 2018.
(10)	Pledge and Security Agreement dates as of November 6, 2018, among Entegris, Inc., The Guarantors Party hereto and Goldman Sachs Bank USA, as Collateral Agent	Exhibit 10.1 to Entegris, Inc. Current Report on Form 8-K filed with the Securities and Exchange Commission on November 6, 2018.
(10)	Entegris, Inc. – 2010 Stock Plan, as amended*	Exhibit 10.1 to Entegris, Inc. Quarterly Report on Form 10-Q for the period ended July 3, 2010
(10)	Entegris, Inc. Outside Directors' Stock Option Plan*	Exhibit 10.2 to Entegris, Inc. Registration Statement on Form S-1 (No. 333-33668)
(10)	Entegris, Inc. Amended and Restated Employee Stock Purchase Plan*	Exhibit 4.1 to Entegris, Inc. Registration Statement on Form S-8 (No. 333-211444)
(10)	Second Amended and Restated Entegris Incentive Plan*	Exhibit 10.1 to Entegris, Inc. Current Report on Form 8-K filed with the

		Securities and Exchange Commission on May 24, 2017
(10)	Trust Agreement between Entegris, Inc. Fidelity Management Trust Company and Entegris Inc. 401(k) Savings and Profit Sharing Plan Trust, dated December 29, 2007.	Exhibit 10.3 to Entegris, Inc. Annual Report on Form 10-K for the fiscal year ended December 31, 2007

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(10)	Entegris, Inc. - 401(k) Savings and Profit Sharing Plan (2017 Restatement)*	Exhibit 10.1 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 17, 2017
(10)	Entegris, Inc. 2007 Deferred Compensation Plan*	Exhibit 10.2 to Entegris, Inc. Quarterly Report on Form10-Q for the fiscal period ended June 30, 2007
(10)	Amended and Restated Supplemental Executive Retirement Plan for Key Salaried Employees*	Exhibit 10.2 to Entegris, Inc. Annual Report on Form 10-K for the fiscal year ended December 31, 2008
(10)	Amendment to Amended and Restated SERP*	Exhibit 10.15 to Entegris, Inc. Annual Report on Form 10-K for the fiscal year ended December 31, 2009.
(10)	Lease Agreement, dated April 1, 2002 between Nortel Networks HPOCS Inc. and Mykrolis Corporation, relating to Executive office, R&D and manufacturing facility located at 129 Concord Road Billerica, MA	Exhibit 10.1.3 to Mykrolis Corporation's Quarterly Report on Form 10-Q for the quarter ended March 31, 2002
(10)	Amendment of Lease between Entegris, Inc. and KBS Rivertech, LLC dated April 1, 2012	Exhibit 10.1 to Entegris, Inc. Quarterly Report on Form 10-Q for the period ended June 30, 2012
(10)	Second Amendment of Lease, dated March 8, 2016, between Entegris, Inc. and KBS Rivertech, LLC	Exhibit 10.1 to Entegris, Inc. Current Report on Form 8-K filed with the Securities and Exchange Commission on March 11, 2016
(10)	Fluoropolymer Purchase and Sale Agreement, by and between E.I. Du Pont De Nemours and Company and the Registrant, dated January 1, 2011, as amended	Exhibit 10.2 to Entegris, Inc. Quarterly Report on Form 10-Q for the quarter ended April 2, 2011
(10)	Form of Indemnification Agreement between Entegris, Inc. and each of its executive officers and Directors	Exhibit 10.30 to Entegris, Inc. Annual Report on Form 10-K for the fiscal year ended August 27, 2005
(10)	Form of Executive Change of Control Termination Agreement between Entegris, Inc. and certain of its executive officers*	Exhibit 10.31 to Entegris, Inc. Annual Report on Form 10-K for the fiscal year ended August 27, 2005
(10)	Form of Revised Executive Change of Control Termination Agreement between Entegris, Inc. and certain of its executive officers executed in 2015 (other than those executive officers who executed the form previously filed)*	Exhibit 10.1 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 29, 2016
(10)	Entegris, Inc. 2011 Stock Option Award Agreement*	Exhibit 10.3 to Entegris, Inc. Annual Report on Form 10-K for the fiscal year ended December 31, 2012
(10)	Entegris, Inc. 2012 Stock Option Grant Agreement*	Exhibit 10.3 to Entegris, Inc. Quarterly Report on Form 10-Q for the fiscal period ended March 31, 2012
(10)	Entegris, Inc. 2013 Stock Option Grant Agreement*	Exhibit 10.2 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 26, 2015
(10)	Entegris, Inc. 2013 RSU Unit Award Agreement*	Exhibit 10.1 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and

		Exchange Commission on February 26, 2015
(10)	Entegris, Inc. 2014 RSU Unit Award Agreement*	Exhibit 10.3 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 26, 2015
(10)	Entegris, Inc. 2014 Stock Option Grant Agreement*	Exhibit 10.4 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 26, 2015

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(10)	Entegris, Inc. 2015 Performance Share Award Agreement*	Exhibit 10.2 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 29, 2016
(10)	Entegris, Inc. 2015 RSU Unit Award Agreement*	Exhibit 10.3 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 29, 2016
(10)	Entegris, Inc. 2015 Stock Option Grant Agreement*	Exhibit 10.4 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 29, 2016
(10)	Entegris, Inc. 2016 Performance Share Award Agreement*	Exhibit 10.2 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 17, 2017
(10)	Entegris, Inc. 2016 RSU Unit Award Agreement*	Exhibit 10.3 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 17, 2017
(10)	Entegris, Inc. 2016 Stock Option Grant Agreement*	Exhibit 10.4 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 17, 2017
(10)	Entegris, Inc. 2017 Performance Share Award Agreement*	Exhibit 10.1 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 15, 2018
(10)	Entegris, Inc. 2017 RSU Unit Award Agreement*	Exhibit 10.2 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 15, 2018
(10)	Entegris, Inc. 2017 Stock Option Grant Agreement*	Exhibit 10.3 to Entegris, Inc. Annual Report on Form 10-K filed with the Securities and Exchange Commission on February 15, 2018
(10)	Executive Employment Agreement, effective November 28, 2012, between the Registrant and Bertrand Loy*	Exhibit 10.1 to Entegris, Inc. Annual Report on Form 10-K for the fiscal year ended December 31, 2012
(10)	Amendment No. 1, dated April 26, 2013, to Executive Change in Control Termination Agreement, between Entegris, Inc. and Bertrand Loy*	Exhibit 99.1 to Entegris, Inc. Current Report on Form 8-K filed with the Securities and Exchange Commission on April 26, 2013
(10)	Severance Protection Agreement, dated May 13, 2011 between Entegris, Inc. and Gregory B. Graves*	Exhibit 10.2 to Entegris, Inc. Quarterly Report on Form 10-Q for the period ended July 2, 2011
(10)	Amendment No. 1, dated as of February 23, 2016, to the Severance Protection Agreement by and between Entegris, Inc. and Gregory B. Graves*	Exhibit 10.2 to Entegris, Inc. Quarterly Report on Form 10-Q filed with the Securities and Exchange Commission on April 28, 2016

* A "management contract or compensatory plan"

B. The Company hereby files as exhibits to this Annual Report on Form 10-K the following documents:
Reg. S-K
Item 601(b)

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Reference	Exhibit No.	Documents Filed Herewith
(10)	10.1	Entegris, Inc. 2018 Performance Share Award Agreement*
(10)	10.2	Entegris, Inc. 2018 RSU Unit Award Agreement*
(10)	10.3	Entegris, Inc. 2018 Stock Option Grant Agreement*
(21)	21	Subsidiaries of Entegris, Inc.
(23)	23	Consent of Independent Registered Public Accounting Firm
(24)	24	Power of Attorney by the Directors of Entegris, Inc.
(31)	31.1	Certification required by Rule 13a-14(a) in accordance with Section 302 of the Sarbanes—Oxley Act of 2002.
(31)	31.2	Certification required by Rule 13a-14(a) in accordance with Section 302 of the Sarbanes—Oxley Act of 2002.
(32)	32.1	Certification required by Rule 13a-14(b) and 18 U.S.C. Section 1350, as adopted pursuant to Section 906 of the Sarbanes-Oxley Act of 2002.
(32)	32.2	Certification required by Rule 13a-14(b) and 18 U.S.C. Section 1350, as adopted pursuant to Section 906 of the Sarbanes-Oxley Act of 2002.
(101)	101.INS	XBRL Instance Document
(101)	101.SCH	XBRL Taxonomy Extension Schema Document
(101)	101.CAL	XBRL Taxonomy Extension Calculation Linkbase Document
(101)	101.DEF	XBRL Taxonomy Extension Definition Linkbase Document
(101)	101.LAB	XBRL Taxonomy Extension Label Linkbase Document
(101)	101.PRE	XBRL Taxonomy Extension Presentation Linkbase Document

* A “management contract or compensatory plan”

Item 16. Form 10-K Summary.

None.

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SIGNATURES

Pursuant to the requirements of Section 13 or 15(d) of the Securities Exchange Act of 1934, the Registrant has duly caused this report to be signed on its behalf by the undersigned thereunto duly authorized.

ENTEGRIS, INC.

Date: February 11, 2019 By /s/ BERTRAND LOY
Bertrand Loy
President & Chief Executive Officer

Pursuant to the requirements of the Securities Exchange Act of 1934, this report has been signed below by the following persons on behalf of the Registrant and in the capacities and on the dates indicated.

SIGNATURE	TITLE	DATE
/s/ BERTRAND LOY Bertrand Loy	President, Chief Executive Officer and Director (Principal executive officer)	February 11, 2019
/s/ GREGORY B. GRAVES Gregory B. Graves	Executive Vice President, Chief Financial Officer & Treasurer (Principal financial officer)	February 11, 2019
/s/ MICHAEL D. SAUER Michael D. Sauer	Vice President, Controller & Chief Accounting Officer (Principal accounting officer)	February 11, 2019
PAUL L.H. OLSON* Paul L.H. Olson	Director, Chairman of the Board	February 11, 2019
MICHAEL A. BRADLEY* Michael A. Bradley	Director	February 11, 2019
R. NICHOLAS BURNS* R. Nicholas Burns	Director	February 11, 2019
JAMES F. GENTILCORE* James F. Gentilcore	Director	February 11, 2019
JAMES P. LEDERER* James P. Lederer	Director	February 11, 2019
AZITA SALEKI-GERHARDT* Azita Saleki-Gerhardt	Director	February 11, 2019
BRIAN F. SULLIVAN*	Director	February 11, 2019

Brian F. Sullivan
*By /s/ Gregory B. Graves
Gregory B. Graves,
Attorney-in-fact

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ENTEGRIS, INC.
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Report of Independent Registered Public Accounting Firm

To the Board of Directors and Stockholders
Entegris, Inc.:

Opinion on the Consolidated Financial Statements

We have audited the accompanying consolidated balance sheets of Entegris, Inc. and subsidiaries (the Company) as of December 31, 2018 and 2017, the related consolidated statements of operations, comprehensive income, equity, and cash flows for each of the years in the three year period ended December 31, 2018, and the related notes (collectively, the consolidated financial statements). In our opinion, the consolidated financial statements present fairly, in all material respects, the financial position of the Company as of December 31, 2018 and 2017, and the results of its operations and its cash flows for each of the years in the three year period ended December 31, 2018, in conformity with U.S. generally accepted accounting principles.

We also have audited, in accordance with the standards of the Public Company Accounting Oversight Board (United States) (PCAOB), the Company's internal control over financial reporting as of December 31, 2018, based on criteria established in Internal Control - Integrated Framework (2013) issued by the Committee of Sponsoring Organizations of the Treadway Commission, and our report dated February 11, 2019 expressed an unqualified opinion on the effectiveness of the Company's internal control over financial reporting.

Change in Accounting Principle

As discussed in Note 2 to the financial statements, the Company has changed its method of accounting for revenue in 2018 due to the adoption of FASB Accounting Standards Codification (Topic 606), Revenue from Contracts with Customers.

Basis for Opinion

These consolidated financial statements are the responsibility of the Company's management. Our responsibility is to express an opinion on these consolidated financial statements based on our audits. We are a public accounting firm registered with the PCAOB and are required to be independent with respect to the Company in accordance with the U.S. federal securities laws and the applicable rules and regulations of the Securities and Exchange Commission and the PCAOB.

We conducted our audits in accordance with the standards of the PCAOB. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the consolidated financial statements are free of material misstatement, whether due to error or fraud. Our audits included performing procedures to assess the risks of material misstatement of the consolidated financial statements, whether due to error or fraud, and performing procedures that respond to those risks. Such procedures included examining, on a test basis, evidence regarding the amounts and disclosures in the consolidated financial statements. Our audits also included evaluating the accounting principles used and significant estimates made by management, as well as evaluating the overall presentation of the consolidated financial statements. We believe that our audits provide a reasonable basis for our opinion.

/s/ KPMG LLP

We or our predecessor firms have served as the Company's auditor since 1966.

Minneapolis, Minnesota
February 11, 2019

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ENTEGRIS, INC. AND SUBSIDIARIES
CONSOLIDATED BALANCE SHEETS

(In thousands, except share and per share data)	December 31, 2018	December 31, 2017
ASSETS		
Current assets:		
Cash and cash equivalents	$482,062	$625,408
Trade accounts and notes receivable, net	222,055	183,434
Inventories, net	268,140	198,089
Deferred tax charges and refundable income taxes	17,393	18,012
Other current assets	39,688	32,665
Total current assets	1,029,338	1,057,608
Property, plant and equipment, net	419,529	359,523
Other assets:		
Goodwill	550,202	359,688
Intangible assets, net	295,687	182,430
Deferred tax assets and other noncurrent tax assets	10,162	9,103
Other noncurrent assets	12,723	7,820
Total assets	$2,317,641	$1,976,172
LIABILITIES AND EQUITY		
Current liabilities:		
Long-term debt, current maturities	$4,000	$100,000
Accounts payable	93,055	68,762
Accrued payroll and related benefits	78,288	64,860
Other accrued liabilities	62,732	34,514
Income taxes payable	31,593	22,835
Total current liabilities	269,668	290,971
Long-term debt, excluding current maturities	934,863	574,380
Pension benefit obligations and other liabilities	31,795	32,130
Deferred tax liabilities and other noncurrent tax liabilities	69,290	85,673
Commitments and contingent liabilities	—	—
Equity:		
Preferred stock, par value $.01; 5,000,000 shares authorized; none issued and outstanding	—	—
Common stock, par value $.01; 400,000,000 shares authorized; issued and outstanding shares as of December 31, 2018: 136,179,381 and 135,976,981; issued and outstanding shares as of December 31, 2017: 141,282,539	1,362	1,413
Treasury stock, common, at cost: 202,400 and 0 shares held as of December 31, 2018 and December 31, 2017	(7,112)	—
Additional paid-in capital	837,658	867,699
Retained earnings	213,753	147,418
Accumulated other comprehensive loss	(33,636)	(23,512)
Total equity	1,012,025	993,018
Total liabilities and equity	$2,317,641	$1,976,172

See the accompanying notes to consolidated financial statements.

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ENTEGRIS, INC. AND SUBSIDIARIES
CONSOLIDATED STATEMENTS OF OPERATIONS

(In thousands, except per share data)	Year ended December 31, 2018	Year ended December 31, 2017	Year ended December 31, 2016
Net sales	$1,550,497	$1,342,532	$1,175,270
Cost of sales	830,666	733,547	666,579
Gross profit	719,831	608,985	508,691
Selling, general and administrative expenses	246,534	216,194	201,901
Engineering, research and development expenses	118,456	106,951	106,991
Amortization of intangible assets	62,152	44,023	44,263
Operating income	292,689	241,817	155,536
Interest expense	34,094	32,343	36,846
Interest income	(3,839)	(715)	(318)
Other expense (income), net	8,002	25,458	(991)
Income before income tax expense	254,432	184,731	119,999
Income tax expense	13,677	99,665	22,852
Net income	$240,755	$85,066	$97,147
Basic net income per common share	$1.71	$0.60	$0.69
Diluted net income per common share	$1.69	$0.59	$0.68
Weighted average shares outstanding			
Basic	141,026	141,553	141,093
Diluted	142,610	143,518	142,050

See the accompanying notes to consolidated financial statements.

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ENTEGRIS, INC. AND SUBSIDIARIES
CONSOLIDATED STATEMENTS OF COMPREHENSIVE INCOME

(In thousands)	Year ended December 31, 2018	Year ended December 31, 2017	Year ended December 31, 2016
Net income	$240,755	$85,066	$97,147
Other comprehensive (loss) income, net of tax			
Foreign currency translation adjustments	(10,183)	29,294	(7,352)
Reclassification of cumulative translation adjustment associated with liquidated and planned sale of subsidiaries	—	1,702	—
Reclassification adjustment associated with sale of available-for-sale investments	—	—	(611)
Pension liability adjustments, net of income tax (benefit) expense of $(13), $(26), and $82 for year ended December 31, 2018, 2017, and 2016	59	(232)	462
Other comprehensive (loss) income	(10,124)	30,764	(7,501)
Comprehensive income	$230,631	$115,830	$89,646

See the accompanying notes to consolidated financial statements.

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ENTEGRIS, INC. AND SUBSIDIARIES
CONSOLIDATED STATEMENTS OF EQUITY

(In thousands)	Common shares outstanding	Common stock	Treasury shares	Treasury stock	Additional paid-in capital	Retained earnings (deficit)	Foreign currency translation adjustments	Available-for-sale investments - Change in net unrealized gains	Defined benefit pension adjustments	Total
Balance at December 31, 2015	140,716	$1,407	—	$—	$848,667	$(416)	$(46,237)	$611	$(1,149)	$802,883
Shares issued under stock plans	1,123	11	—	—	815	—	—	—	—	826
Share-based compensation expense	—	—	—	—	13,436	—	—	—	—	13,436
Repurchase and retirement of common stock	(519)	(5)	—	—	(3,140)	(4,428)	—	—	—	(7,573)
Pension liability adjustment	—	—	—	—	—	—	—	—	462	462
Available-for-sale investment, change in net unrealized gain, net of taxes	—	—	—	—	—	—	—	(611)	—	(611)
Foreign currency translation	—	—	—	—	—	—	(7,352)	—	—	(7,352)
Net income	—	—	—	—	—	97,147	—	—	—	97,147
Balance at December 31, 2016	141,320	1,413	—	—	859,778	92,303	(53,589)	—	(687)	899,218
Shares issued under stock plans	1,040	11	—	—	(332)	—	—	—	—	(321)
Share-based compensation expense	—	—	—	—	15,306	—	—	—	—	15,306
Repurchase and retirement of common stock	(1,077)	(11)	—	—	(6,565)	(21,424)				(28,000)
Dividends declared ($0.07 per share)	—	—	—	—	—	(9,896)	—	—	—	(9,896)
Pension liability adjustment	—	—	—	—	—	—	—	—	(232)	(232)
Foreign currency translation	—	—	—	—	—	—	29,294	—	—	29,294
	—	—	—	—	—	—	1,702	—	—	1,702

Reclassification of cumulative translation adjustment associated with liquidated and planned sale of subsidiaries										
Cumulative effect of change in accounting principle	—	—	—	—	(488)	1,369	—	—	—	881
Net income	—	—	—	—	—	85,066	—	—	—	85,066
Balance at December 31, 2017	141,283	1,413	—	—	867,699	147,418	(22,593)	—	(919)	993,018
Shares issued under stock plans	1,120	11	—	—	(9,120)	—	—	—	—	(9,109)
Share-based compensation expense	—	—	—	—	17,112	—	—	—	—	17,112
Repurchase and retirement of common stock	(6,224)	(62)	202	(7,112)	(38,066)	(134,075)				(179,315)
Dividends declared ($0.28 per share)	—	—	—	—	33	(39,755)	—	—	—	(39,722)
Pension liability adjustment	—	—	—	—	—	—	—	—	59	59
Foreign currency translation	—	—	—	—	—	—	(10,183)	—	—	(10,183)
Cumulative effect of change in accounting principle	—	—	—	—	—	(590)	—	—	—	(590)
Net income	—	—	—	—	—	240,755	—	—	—	240,755
Balance at December 31, 2018	136,179	$1,362	202	$(7,112)	$837,658	$213,753	$(32,776)	$—	$(860)	$1,012,025

See the accompanying notes to consolidated financial statements.

ENTEGRIS, INC. AND SUBSIDIARIES
CONSOLIDATED STATEMENTS OF CASH FLOWS

(In thousands)	Year ended December 31, 2018	Year ended December 31, 2017	Year ended December 31, 2016
Operating activities:			
Net income	$240,755	$85,066	$97,147
Adjustments to reconcile net income to net cash provided by operating activities:			
Depreciation	65,116	58,208	55,623
Amortization	62,152	44,023	44,263
Share-based compensation expense	17,112	15,306	13,436
Provision for deferred income taxes	(11,876)	1,628	(16,284)
Charge for excess and obsolete inventory	4,496	9,405	9,302
Amortization of debt issuance costs	1,834	2,864	3,947
Loss on extinguishment of debt	2,429	20,687	—
Other	9,948	16,026	9,744
Changes in operating assets and liabilities, net of effects of acquisitions:			
Trade accounts receivable and notes receivable	(17,473)	(15,401)	(25,298)
Inventories	(38,100)	(20,214)	(19,871)
Accounts payable and other accrued liabilities	19,950	15,975	31,294
Other current assets	(13,677)	(3,330)	185
Income taxes payable, refundable income taxes and noncurrent taxes payable	(30,381)	64,516	3,408
Other	291	(1,386)	659
Net cash provided by operating activities	312,576	293,373	207,555
Investing activities:			
Acquisition of property and equipment	(110,153)	(93,597)	(65,260)
Acquisition of business, net of cash acquired	(380,694)	(20,000)	—
Proceeds from sale or maturities of short-term investments	—	—	1,726
Other	4,903	1,142	(3,152)
Net cash used in investing activities	(485,944)	(112,455)	(66,686)
Financing activities:			
Proceeds from long-term debt	402,000	550,000	—
Payments of long-term debt	(135,850)	(460,000)	(75,000)
Payments for debt issuance costs	(7,400)	(7,333)	—
Payments for debt extinguishment costs	—	(16,200)	—
Payments for dividends	(39,591)	(9,896)	—
Issuance of common stock from employee stock plans	5,577	5,566	4,844
Taxes paid related to net share settlement of equity awards	(14,686)	(5,887)	(4,018)
Repurchase and retirement of common stock	(173,781)	(28,000)	(7,573)
Other	(1,858)	(999)	—
Net cash provided by (used in) financing activities	34,411	27,251	(81,747)
Effect of exchange rate changes on cash and cash equivalents	(4,389)	10,850	(2,558)
(Decrease) increase in cash and cash equivalents	(143,346)	219,019	56,564
Cash and cash equivalents at beginning of year	625,408	406,389	349,825
Cash and cash equivalents at end of year	$482,062	$625,408	$406,389

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Supplemental Cash Flow Information

(In thousands)	Year ended December 31, 2018	Year ended December 31, 2017	Year ended December 31, 2016
Non-cash transactions:			
Equipment purchases in accounts payable	$ 17,624	$ 8,608	$ 5,104
Repurchase and retirement of common stock to be settled	$ 5,534	$ —	$ —
Capital lease obligations incurred	$ —	$ 4,768	$ —
Dividends payable	$ 131	$ —	$ —
Schedule of interest and income taxes paid:			
Interest paid	$ 26,248	$ 30,392	$ 32,085
Income taxes, net of refunds received	$ 54,415	$ 33,330	$ 35,722

See the accompanying notes to consolidated financial statements.

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ENTEGRIS, INC.
NOTES TO CONSOLIDATED FINANCIAL STATEMENTS
DECEMBER 31, 2018

(1) SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

Nature of Operations Entegris, Inc. (Entegris or the Company) is a leading global developer, manufacturer and supplier of microcontamination control products, specialty chemicals and advanced materials handling solutions for manufacturing processes in the semiconductor and other high-technology industries.

Principles of Consolidation The consolidated financial statements include the accounts of the Company and its majority-owned subsidiaries. Intercompany profits, transactions and balances have been eliminated in consolidation.

Use of Estimates and Basis of Presentation The preparation of consolidated financial statements in conformity with accounting principles generally accepted in the United States requires management to make judgments, estimates and assumptions that affect the amounts reported in the consolidated financial statements and accompanying notes. On an ongoing basis, Entegris evaluates its estimates, including those related to receivables, inventories, property, plant and equipment, intangible assets, accrued liabilities, income taxes and share-based compensation, among others. Actual results could differ from those estimates.

Cash and Cash Equivalents Cash and cash equivalents include cash on hand and highly liquid debt securities with original maturities of three months or less, which are valued at cost and approximates fair value.

Allowance for Doubtful Accounts An allowance for uncollectible trade receivables is estimated based on a combination of write-off history, aging analysis and any specific, known troubled accounts. The Company maintains an allowance for doubtful accounts that management believes is adequate to cover expected losses on trade receivables.

Inventories Inventories are stated at the lower of cost and net realizable value. Cost is determined by the first-in, first-out (FIFO) method.

Property, Plant, and Equipment Property, plant and equipment are carried at cost and are depreciated on the straight-line method over the estimated useful lives of the assets. When assets are retired or disposed of, the cost and related accumulated depreciation are removed from the accounts, and gains or losses are recognized in the same period. Maintenance and repairs are expensed as incurred, while significant additions and improvements are capitalized. Long-lived assets, including property, plant and equipment, are reviewed for impairment whenever events or changes in circumstances indicate that the carrying amount of an asset or group of assets may not be recoverable based on estimated future undiscounted cash flows. The amount of impairment, if any, is measured as the difference between the net book value and the estimated fair value of the asset(s).

Fair Value of Financial Instruments The carrying value of cash equivalents, accounts receivable, accounts payable, accrued payroll and related benefits, and other accrued liabilities approximates fair value due to the short maturity of those instruments.

The fair value of long-term debt, including current maturities, based upon models utilizing market observable (Level 2) inputs and credit risk, was $929 million at December 31, 2018 compared to the carrying amount of long-term debt, including current maturities, of $939 million.

Goodwill and Intangible Assets Goodwill represents the excess of acquisition costs over the fair value of the net assets of businesses acquired. Goodwill is not subject to amortization, but is tested for impairment annually at August 31, the Company’s annual testing date, and whenever events or changes in circumstances indicate that impairment may have occurred. The Company compares the carrying value of its reporting units, including goodwill, to their fair value. For reporting units in which the assessment indicates that it is more likely than not that the fair value is more than its carrying value, goodwill is not considered impaired. If the carrying value of the reporting unit exceeds fair value, goodwill is considered impaired.

Based on its annual analysis, the Company determined there was no indication of impairment of goodwill and the estimated fair value of each reporting unit substantially exceeded its carrying value.

Amortizable intangible assets include, among other items, patented, unpatented and other developed technology and customer-based intangibles, and are amortized using the straight-line method over their respective estimated useful lives. The Company reviews intangible assets, along with other long-lived assets - primarily property, plant and

equipment - for impairment if changes in circumstances or the occurrence of events suggest the remaining value may not be recoverable.

Derivative Financial Instruments The Company records derivatives as assets or liabilities on the balance sheet and measures such instruments at fair value. Changes in fair value of derivatives are recorded each period in the Company's consolidated statements of operations.

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The Company periodically enters into forward foreign currency contracts to reduce exposures relating to rate changes in certain foreign currencies. Certain exposures to credit losses related to counterparty nonperformance exist. However, the Company does not anticipate nonperformance by the counterparties since they are large, well-established financial institutions. None of these derivatives is accounted for as a hedge transaction. Accordingly, changes in the fair value of forward foreign currency contracts are recorded as other expense (income), net, in the Company's consolidated statements of operations. The fair values of the Company's derivative financial instruments are based on prices quoted by financial institutions for these instruments.

Foreign Currency Translation Assets and liabilities of certain foreign subsidiaries are translated from foreign currencies into U.S. dollars at period-end exchange rates, and the resulting gains and losses arising from translation of net assets located outside the U.S. are recorded as a cumulative translation adjustment, a component of accumulated other comprehensive loss in the consolidated balance sheets. Income statement amounts are translated at the weighted average exchange rates for the year. Translation adjustments are not adjusted for income taxes, as substantially all translation adjustments relate to permanent investments in non-U.S. subsidiaries. Gains and losses resulting from foreign currency transactions are included in other expense (income), net, in the Company's consolidated statements of operations.

Revenue Recognition Revenue is measured based on consideration specified in a contract with a customer, and excludes any sales incentives and amounts collected on behalf of third parties. The Company recognizes revenue when it satisfies a performance obligation by transferring control over a product or service to a customer.

Taxes assessed by a governmental authority that are both imposed on and concurrent with a specific revenue-producing transaction, that are collected by the Company from a customer, are excluded from revenue.

Shipping and handling costs associated with outbound freight after control over a product has transferred to a customer are accounted for as a fulfillment cost and are included in cost of goods sold.

Shipping and Handling Costs Shipping and handling costs incurred are recorded in cost of sales in the Company's consolidated statements of operations.

Engineering, Research and Development Expenses Engineering, research and development costs are expensed as incurred.

Share-based Compensation The Company measures the cost of employee services received in exchange for the award of equity instruments based on the fair value of the award at the date of grant. Compensation expense is recognized using the straight-line attribution method to recognize share-based compensation over the service period of the award, with adjustments recorded for forfeitures as they occur.

Income Taxes The Company accounts for income taxes under the asset and liability method, which requires the recognition of deferred tax assets and liabilities for the expected future tax consequences of events that have been included in the financial statements. Under this method, deferred tax assets and liabilities are determined on the basis of the differences between the financial statements and tax basis of assets and liabilities using enacted tax rates in effect for the year in which the differences are expected to reverse. The effect of a change in tax rates on deferred tax assets and liabilities is recognized in income tax expense in the period that includes the enactment date.

The Company recognizes deferred tax assets to the extent that it believes these assets are more likely than not to be realized. A valuation allowance is recorded to reduce deferred tax assets when it is more likely than not that the Company would not be able to realize all or part of its deferred tax assets. In making such a determination, the Company considers all available positive and negative evidence, including future reversals of existing temporary differences, projected future taxable income, tax-planning strategies, and results of recent operations. If the Company determines that it would be able to realize its deferred tax assets in the future in excess of their net recorded amount, the Company would make an adjustment to the deferred tax asset valuation allowance, which would reduce the provision for income taxes.

The Company's policy for recording interest and penalties associated with audits and unrecognized tax benefits is to record such items as a component of income before taxes. Penalties and interest to be paid or received are recorded in other expense (income), net, in the statement of operations.

Comprehensive Income (Loss) Comprehensive income (loss) represents the change in equity resulting from items other than shareholder investments and distributions. The Company’s foreign currency translation adjustments, unrealized gains and losses on available-for-sale investments, and minimum pension liability adjustments are included in accumulated other comprehensive loss. Comprehensive income (loss) and the components of accumulated other comprehensive loss are presented in the accompanying consolidated statements of comprehensive income (loss) and consolidated statements of equity.

Recent Accounting Pronouncements Adopted in 2018 In May 2014, the Financial Accounting Standards Board (FASB) issued Accounting Standards Update (AS) No. 2014-09, Revenue from Contracts with Customers. ASU No. 2014-09 supersedes previous revenue recognition requirements and requires entities to recognize revenue when control of the promised goods or services is transferred to customers at an amount that reflects the consideration to which the entity expects to be

entitled to in exchange for those goods or services. The Company adopted the provisions of ASU No. 2014-09 as of January 1, 2018 using the modified retrospective transition method. See note 2 to the Consolidated financial statements for further details.

Recent Accounting Pronouncements Yet to be Adopted In February 2016, the FASB established Topic 842, Leases, by issuing Accounting Standards Update (ASU) No. 2016-02, which requires lessees to recognize leases on-balance sheet and disclose key information about leasing arrangements. Topic 842 was subsequently amended by ASU No. 2018-01, Land Easement Practical Expedient for Transition to Topic 842; ASU No. 2018-10, Codification Improvements to Topic 842, Leases; and ASU No. 2018-11, Targeted Improvements. The new standard establishes a right-of-use model (ROU) that requires a lessee to recognize a ROU asset and lease liability on the balance sheet for all leases with a term longer than 12 months. Leases will be classified as finance or operating, with classification affecting the pattern and classification of expense recognition in the income statement.

The new standard is effective for the Company on January 1, 2019, with early adoption permitted. A modified retrospective transition approach is required, applying the new standard to all leases existing at the date of initial application. We expect to adopt the new standard on January 1, 2019 and use the effective date as the date of initial application. Consequently, the Company will not recast its comparative period financial statements or provide the disclosures required by the new standard for the comparative periods.

The new standard provides a number of optional practical expedients in transition. The Company expects to elect the ‘package of practical expedients’, which permits the Company not to reassess under the new standard our prior conclusions about lease identification, lease classification and initial direct costs. The Company also expects to elect the practical expedient pertaining to land easements, which allows the Company not to evaluate all existing land easements in connection with the adoption of the new lease requirements to assess whether they meet the definition of a lease. The Company does not expect to elect the use-of-hindsight practical expedient and therefore will not reassess the lease terms for purposes of calculation of the lease liabilities and right-of-use assets at the initial adoption.

The Company expects that this standard will have a material effect on the Company’s consolidated balance sheets. On adoption, the Company currently expects to recognize additional operating liabilities and right-of-use assets of approximately $40 to $60 million. The Company does not expect this standard to have a material impact on our annual consolidated statement of operations and/or cash flows. While the Company continues to assess all of the effects of adoption, the Company currently believes the most significant effects relate to the recognition of new right-of-use assets and lease liabilities on the balance sheet for real estate operating leases and the Company expects to provide significant new disclosures about the leasing activities.

The new standard also provides practical expedients for an entity’s ongoing accounting. The Company currently expects to elect the short-term lease recognition exemption for all leases that qualify. This means, for those leases that qualify, the Company will not recognize right-of-use assets or lease liabilities, and this includes not recognizing right-of-use assets or lease liabilities for existing short-term leases of those assets in transition. The Company also currently expects to elect the practical expedient to not separate lease and non-lease components for all leases other than leases of real estate, and this includes not separating lease and non-lease components for all leases other than leases of real estate in transition.

2. REVENUES

Adoption of ASC ASU No. 2014-09, Revenue from Contracts with Customers On January 1, 2018, the Company adopted ASU No. 2014-09 using the modified retrospective method applied to those contracts which were not completed as of January 1, 2018. Results for reporting periods beginning after January 1, 2018 are presented under the provisions of ASU No. 2014-09, while prior period amounts are not adjusted and continue to be reported in accordance with previous accounting guidance.

The Company adopted ASU No. 2014-09 with a date of initial application of January 1, 2018. As a result, the Company changed its accounting policy for revenue recognition for two items as detailed below. The first change concerns transactions where the Company offers customers incentives in the form of free products. The new revenue standard requires that a portion of the transaction price be allocated to the free product and deferred until the product has been delivered. The Company previously accrued for undelivered free product as a charge to cost of goods sold. The second change concerns revenue recognition involving certain shipping terms that included freight and export

costs. Under the new revenue standard, the Company recognizes revenue at the point at which products are delivered to a particular port or loaded onto a vessel and control has transferred, whereas prior to the date of initial application of ASU No. 2014-09, revenue recognition was previously deferred for those sales until they reached their destination. The Company adopted ASU No. 2014-09 using the modified retrospective method, recognizing the cumulative effect of application as an adjustment to the opening balance of equity at January 1, 2018. Therefore, prior year information has not been adjusted and continues to be reported under previous applicable guidance. The details of the impact of the changes made to the Company's balance sheet date as of January 1, 2018 are reflected in the following table.

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(In thousands)	Increase (decrease)
Trade accounts and note receivable	$ 765
Inventory	(223)
Other accrued liabilities	1,276
Deferred tax liabilities and other noncurrent tax liabilities	(144)
Retained earnings	(590)

Based on an analysis of the financial statement line items affected in 2018 in the application of ASU No. 2014-09 as compared with previous reporting, the Company has determined that the quantitative changes to each financial statement line item are immaterial. As a result, for the year ended December 31, 2018, the Company is not disclosing the quantitative amount by which each financial statement line item is affected in the current reporting by the application of Topic 606 as compared with the guidance that was in effect before the change.

As part of its adoption of ASU No. 2014-09 in the first quarter of 2018, the Company elected to use the allowed practical expedient, pursuant to which it has excluded disclosures of transaction prices allocated to remaining performance obligations and when it expects to recognize such revenue for all periods prior to the date of initial application of ASU No. 2014-09.

Revenue Recognition Revenue is measured based on consideration specified in a contract with a customer, and excludes any sales incentives and amounts collected on behalf of third parties. The Company recognizes revenue when it satisfies a performance obligation by transferring control over a product or service to a customer.

Taxes assessed by a governmental authority that are both imposed on and concurrent with a specific revenue-producing transaction, that are collected by the Company from a customer, are excluded from revenue.

Shipping and handling costs associated with outbound freight after control over a product has transferred to a customer are accounted for as a fulfillment cost and are included in cost of goods sold.

The Company recognizes the incremental costs of obtaining contracts as an expense when incurred if the amortization period of the assets that the Company otherwise would have recognized is one year or less.

When the Company receives consideration, or such consideration is unconditionally due, from a customer prior to transferring goods or services to the customer under the terms of a sales contract, the Company records deferred revenue, which represents a contract liability. Such deferred revenue typically results from advance payments received on sales of the Company’s products. The deferred revenue balance at quarter end is deemed immaterial and, accordingly, the Company does not make the required disclosures.

The Company is using the practical expedient that allows it to omit disclosures of remaining performance obligations that have original expected durations of one year or less.

Nature of goods and services The following is a description of principal activities from which the Company generates its revenues. The Company has three reportable segments. For more detailed information about reportable segments, see note 9 to the consolidated financial statements. For each of the three reportable segments, the recognition of revenue regarding the nature of goods and services provided by the segments are similar and described below. The Company recognizes revenue product sales at a point in time following the transfer of control of such products to the customer, which generally occurs upon shipment, or delivery depending on the terms of the underlying contracts. For product sales contracts that contain multiple performance obligations, the Company allocates the transaction price to each performance obligation identified in the contract based on relative standalone selling prices, or estimates of such prices, and recognizes the related revenue as control of each individual product is transferred to the customer, in satisfaction of the corresponding performance obligations.

The Company generally recognizes revenue for sales of services over time as the Company has satisfied the performance obligation. The payment terms and revenue recognized is based on time and materials.

The Company also enters into arrangements to license its intellectual property. These arrangements typically permit the customer to use a specialized manufacturing process and in return the Company receives a royalty fee. If applicable, the Company recognizes revenue when the subsequent sale or usage occurs. If not applicable, the Company recognizes revenue at a point in time when transfer of control of the license has occurred.

The Company offers certain customers cash discounts and volume rebates as sales incentives. The discounts and volume rebates are recorded as a reduction in sales at the time revenue is recognized in an amount estimated based on historical experience and contractual obligations. The Company periodically reviews the assumptions underlying its estimates of discounts and volume rebates and adjusts its revenues accordingly.

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In addition, the Company offers free product rebates to certain customers. The Company utilizes an adjusted market approach to estimate the stand-alone selling price of the loyalty program and allocates a portion of the consideration received to the free product offering. The free product offering is redeemable upon future purchases of the Company's products. The amount associated with free product rebates is deferred in the balance sheet and is recognized as revenue when the free product is redeemed or when the likelihood of redemption is remote. The Company deems the amount immaterial for disclosure. The Company applies the practical expedient in ASU No. 2014-09 and does not disclose information about remaining performance obligations that have original expected durations of one year or less.

The Company provides for the estimated costs of fulfilling our obligations under product warranties at the time the related revenue is recognized. The Company estimates the costs based on historical failure rates, projected repair costs, and knowledge of specific product failures (if any). The specific warranty terms and conditions vary depending upon the product sold and the country in which we do business, but generally include parts and labor over a period generally ranging from 90 days to one year. The Company regularly reevaluates its estimates to assess the adequacy of the recorded warranty liabilities and adjust the amounts as necessary.

The Company's contracts are generally short-term in nature. Most contracts do not exceed twelve months. Payment terms vary by the type and location of the Company's customers and the products or services offered. The term between invoicing and when payment is due is not significant. For certain products or services and customer types, the Company requires payment before the products or services are delivered to the customer. Those customers that prepay are represented by the contract liabilities below until the performance obligations are satisfied.

The following table provides information about contract liabilities from contracts with customers. The contract liabilities are included in other accrued liabilities balance in the consolidated balance sheet.

(In thousands)	December 31, 2018	December 31, 2017
Contract liabilities - current	$ 15,364	$ 3,210

Significant changes in the contract liabilities balances during the period are as follows:

(In thousands)	2018
Revenue recognized that was included in the contract liability balance at the beginning of the period	$(3,210)
Increases due to cash received, excluding amounts recognized as revenue during the period	5,918
Business combination	9,446

(3) ACQUISITION

SAES Pure Gas

On June 25, 2018, the Company acquired the SAES Pure Gas business (SPG), from SAES Getters S.p.A. for approximately $352.7 million in cash, or $341.5 million net of cash acquired, subject to revision for customary working capital adjustments, funded from the Company's existing cash on hand. The acquisition was accounted for under the acquisition method of accounting and the results of operations of SPG are included in the Company's consolidated financial statements as of and since June 25, 2018. Direct costs of $4.8 million associated with the acquisition of SPG, consisting mainly of professional and consulting fees, were expensed as incurred for the year ended December 31, 2018. These costs are included in selling, general and administrative expense in the Company's consolidated statements of operations. Since the date of acquisition through December 31, 2018, SPG reported net sales and net loss of $62.2 million and $2.6 million , respectively, which are included in the Company's consolidated income statement.

SPG, based in San Luis Obispo, California, is a leading provider of high-capacity gas purification systems used in semiconductor manufacturing and adjacent markets, and reports into the Microcontamination Control division of the Company. This acquisition expands the gas purification solutions portfolio in our Microcontamination Control Division with high-capacity products suited for bulk chemical purification applications.

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The following table summarizes the provisional allocation of the purchase price to the fair values assigned to the assets acquired and liabilities assumed at the date of the SPG acquisition:

(In thousands):	As of June 30, 2018	As of December 31, 2018
Trade accounts and notes receivable, net	$15,805	$19,173
Inventories, net	46,073	42,758
Other current assets	424	1,322
Property, plant and equipment, net	7,345	6,653
Identifiable intangible assets	178,220	150,430
Deferred tax asset	—	831
Other noncurrent assets	398	12
Current liabilities	(26,196)	(26,473)
Deferred tax liabilities	(42,110)	(35,533)
Other noncurrent liabilities	(1,006)	(1,412)
Net assets acquired	178,953	157,761
Goodwill	162,251	183,729
Total purchase price, net of cash acquired	$341,204	$341,490

The fair value of acquired inventories of $42.8 million is valued at the estimated selling price less the cost of disposal and reasonable profit for the selling effort. The fair value write-up of acquired work-in-process and finished goods inventory was $8.9 million, the amount of which will be amortized over the expected turn of the acquired inventory. Accordingly, a $6.9 million incremental cost of sales charge associated with the fair value write-up of inventory acquired in the acquisition of SPG was recorded for the year ended December 31, 2018.

The fair value of acquired property, plant and equipment of $6.7 million is valued at its value-in-use.

The Company recognized the following finite-lived intangible assets as part of the acquisition of SPG:

(In thousands)	Amount	Weighted average life in years
Developed technology	$20,070	8.0
Trademarks and trade names	6,670	12.0
Customer relationships	107,790	12.0
Other	15,900	0.9
	$150,430	10.0

The acquired identifiable intangible assets are being amortized on a straight-line basis. The fair value of acquired identifiable intangible assets was determined using the “income approach”. In performing these valuations, the key underlying probability-adjusted assumptions of the discounted cash flows were projected revenues, gross margin expectations, discount rate and operating cost estimates. The valuations were based on the information that was available as of the acquisition date and the expectations and assumptions that have been deemed reasonable by the Company’s management. There are inherent uncertainties and management judgment required in these determinations. The fair value measurements of the assets acquired and liabilities assumed were based on valuations involving significant unobservable inputs, or Level 3 in the fair value hierarchy.

The purchase price of SPG exceeded the net of the acquisition-date amounts of the identifiable assets acquired and the liabilities assumed by $183.7 million. Cash flows used to determine the purchase price included strategic and synergistic benefits (investment value) specific to the Company, which resulted in a purchase price in excess of the fair value of identifiable net assets. The purchase price also included the fair values of other assets that were not identifiable, not separately recognizable under accounting rules (e.g., assembled workforce) or of immaterial value in addition to a going-concern element that represents the Company’s ability to earn a higher rate of return on the group of assets than would be expected on the separate assets as determined during the valuation process. This additional investment value resulted in goodwill. No amount of goodwill is expected to be deductible for income tax purposes.

The final valuation of assets acquired and liabilities assumed is expected to be completed as soon as possible, but no later than
one year from the acquisition date. Given the size and complexity of the acquisition, the valuation of certain assets and liabilities, is still being completed, and is subject to final review. The Company's valuation of SPG's tax accounts is provisional

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pending the completion of and the Company's final review of SPG's tax accounts . To the extent that the Company's estimates require adjustment, the Company will modify the values.

Pro Forma Results (Unaudited)

The following unaudited pro forma financial information presents the combined results of operations of the Company as if the acquisition of SPG had occurred as of the beginning of the years presented. The unaudited pro forma financial information is not necessarily indicative of what the Company’s consolidated results of operations actually would have been had the acquisition occurred at the beginning of each year. In addition, the unaudited pro forma financial information does not attempt to project the future results of operations of the combined company.

(In thousands, except per share data) (Unaudited)	Year ended December 31, 2018	Year ended December 31, 2017
Net sales	$1,604,194	$1,437,357
Net income	273,625	67,009
Per share amounts:		
Net income per common share - basic	$1.94	$0.47
Net income per common share - diluted	$1.92	$0.47

The unaudited pro forma financial information above gives effect to the following:

a. The elimination of transactions between Entegris and SPG, which upon completion of the acquisition would be considered intercompany. This reflects the elimination of intercompany sales and associated intercompany accounts.

b. Incremental amortization and depreciation expense related to the estimated fair value of identifiable intangible assets and property, plant and equipment from the purchase price allocation.

The unaudited pro forma financial information above for the year ended December 31, 2018 excludes the incremental charge of $8.9 million reported in cost of sales for the sale of acquired inventory that was written-up to fair value, respectively.

The pro forma data does not include data for Particle Sizing Systems, LLC and Flex Concepts, Inc. for the period prior to their acquisitions due to the immaterial impact on the pro forma financial information for the year ended December 31, 2018.

Particle Sizing Systems

On January 22, 2018, the Company acquired Particle Sizing Systems, LLC (PSS), which provides particle sizing instrumentation for liquid applications to the semiconductor and life science industries. The acquired assets and assumed liabilities became part of the Company’s Advanced Materials Handling (AMH) segment. The transaction was accounted for under the acquisition method of accounting and the results of operations of PSS are included in the Company’s consolidated financial statements since January 22, 2018. The acquisition does not constitute a material business combination.

The purchase price for PSS was cash consideration of $37.3 million, funded from the Company’s existing cash on hand. Costs associated with the acquisition of the product line were not significant and were expensed as incurred.

The purchase price of PSS exceeds the net of the acquisition-date amounts of the identifiable assets acquired and the liabilities assumed by $8.8 million. Cash flows used to determine the purchase price included strategic and synergistic benefits (investment value) specific to the Company, which resulted in a purchase price in excess of the fair value of identifiable net assets. This additional investment value resulted in goodwill, which is expected to be deductible for income tax purposes.

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The following table summarizes the final allocation of the purchase price to the fair values assigned to the assets acquired and liabilities assumed at the date of acquisition:

(In thousands):	As of March 31, 2018	As of December 31, 2018
Trade accounts and notes receivable, net	$3,616	$3,898
Inventories, net	1,889	1,827
Other current assets	14	23
Property, plant and equipment, net	—	103
Identifiable intangible assets	20,000	25,600
Other noncurrent assets	21	3
Accounts payables	(438)	(294)
Other accrued liabilities	(2,799)	(2,667)
Net assets acquired	22,303	28,493
Goodwill	15,353	8,804
Total purchase price	$37,656	$37,297

As of December 31, 2018, the Company has finalized its fair value determinations of the assets acquired and liabilities assumed. The valuation of the assets acquired and liabilities assumed was based on the information that was available as of the acquisition date, and the expectations and assumptions that have been deemed reasonable by the Company's management.

Intangible assets, consisting mostly of technology-related intellectual property, generally will be amortized on a straight-line basis over an expected useful life currently estimated at approximately 9.4 years. In performing the valuation of intangible assets, the Company used independent appraisals, discounted cash flows and other factors, as the best evidence of fair value. The key underlying assumptions of the discounted cash flows were projected revenues, gross margin expectations and operating cost estimates. There are inherent uncertainties and management judgment required in these determinations. No assurance can be given that the underlying assumptions will occur as projected. The fair value measurement of the assets acquired and liabilities assumed were based on valuation involving significant unobservable inputs, or Level 3 in the fair value hierarchy.

Flex Concepts

On June 26, 2018, the Company acquired Flex Concepts, Inc. (Flex), a technology company focused on single-use fluid handling bags, tubing manifolds and hardware for the life sciences industry. The purchase price of Flex was for cash consideration of $1.9 million. The transaction was accounted for under the acquisition method of accounting and the results of operations of Flex are included in the Company's consolidated financial statements since June 26, 2018. The acquisition does not constitute a material business combination.

During the year ended December 31, 2018, the Company finalized its fair value determinations of the assets acquired and liabilities assumed. The valuation of the assets acquired and liabilities assumed was based on the information that was available as of the acquisition date and the expectations and assumptions that have been deemed reasonable by the Company's management.

Water and Chemical Filtration Product Line

On April 24, 2017, the Company acquired the microelectronic water and chemical filtration product line of W.L. Gore & Associates, Inc. (Gore). The acquired assets became part of the Company's Microcontamination Control (MC) segment. The transaction was accounted for under the acquisition method of accounting and the results of operations of the product line are included in the Company's consolidated financial statements as of and since April 24, 2017. The acquisition of the product line's assets and liabilities does not constitute a material business combination.

The purchase price for the product line was cash consideration of $20.0 million, funded from the Company's existing cash on hand. Costs associated with the acquisition of the product line were not significant and were expensed as incurred.

The purchase price of the product line exceeds the net of the acquisition-date amounts of the identifiable assets acquired and the liabilities assumed by $8.0 million. Cash flows used to determine the purchase price included

strategic and synergistic benefits (investment value) specific to the Company, which resulted in a purchase price in excess of the fair value of identifiable net assets. This additional investment value resulted in goodwill, which was deductible for income tax purposes.

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The following table summarizes the final allocation of the purchase price to the fair values assigned to the assets and liabilities assumed at the date of acquisition:

(In thousands)	Amount
Other current assets	$726
Property, plant and equipment, net	2,447
Identifiable intangible assets	8,820
Net assets acquired	11,993
Goodwill	8,007
Total purchase price	$20,000

Intangible assets, consisting mostly of technology-related intellectual property, generally will be amortized on a straight-line basis over an estimated useful life of approximately 7 years.

As part of the accounting for this transaction, the Company allocated the purchase price of the acquired product line based on the fair value of all the assets acquired. The valuation of the assets acquired was based on the information that was available as of the acquisition date and the expectations and assumptions that have been deemed reasonable by the Company's management.

In performing these valuations, the Company used independent appraisals, discounted cash flows and other factors, as the best evidence of fair value. The key underlying assumptions of the discounted cash flows were projected revenues, gross margin expectations and operating cost estimates. There are inherent uncertainties and management judgment required in these determinations. No assurance can be given that the underlying assumptions will occur as projected. The fair value measurement of the assets acquired and liabilities assumed was based on valuation involving significant unobservable inputs, or Level 3 in the fair value hierarchy.

(4) TRADE ACCOUNTS AND NOTES RECEIVABLE

Trade accounts and notes receivable from customers at December 31, 2018 and 2017 consist of the following:

(In thousands)	2018	2017
Accounts receivable	$218,098	$179,194
Notes receivable	4,850	5,100
Total trade accounts and notes receivable	222,948	184,294
Less allowance for doubtful accounts	893	860
Trade accounts and notes receivable, net	$222,055	$183,434

(5) INVENTORIES

Inventories at December 31, 2018 and 2017 consist of the following:

(In thousands)	2018	2017
Raw materials	$100,770	$58,226
Work-in-process	31,412	16,193
Finished goods [(a)]	135,958	123,670
Inventories, net	$268,140	$198,089

[(a)] Includes consignment inventories held by customers for $12.5 million and $15.6 million at December 31, 2018 and 2017, respectively.

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(6) PROPERTY, PLANT AND EQUIPMENT

Property, plant, and equipment at December 31, 2018 and 2017 consists of the following:

(In thousands)	2018	2017	Estimated useful lives in years
Land	$21,913	$16,795	
Buildings and improvements	185,175	174,615	5-35
Manufacturing equipment	298,529	274,723	5-10
Canisters and cylinders	90,790	77,325	3-12
Molds	72,089	80,198	3-5
Office furniture and equipment	142,818	121,345	3-8
Construction in progress	69,437	42,288	
Total property, plant and equipment	880,751	787,289	
Less accumulated depreciation	461,222	427,766	
Property, plant and equipment, net	$419,529	$359,523	

The table below sets forth the depreciation expense for the years ended December 31, 2018, 2017 and 2016:

(In thousands)	2018	2017	2016
Depreciation expense	$65,116	$58,208	$55,623

(7) GOODWILL AND INTANGIBLE ASSETS

Goodwill activity for each of the Company's reportable segments that carry goodwill, Specialty Chemicals and Engineered Materials (SCEM), Microcontamination Control (MC) and Advanced Materials Handling (AMH), for the years ended December 31, 2018 and 2017 is shown below:

(In thousands)	SCEM	MC	AMH	Total
December 31, 2016	$297,858	$—	$47,411	$345,269
Purchase accounting adjustments	—	8,007	—	8,007
Other, including foreign currency translation	6,412	—	—	6,412
December 31, 2017	304,270	8,007	47,411	359,688
Addition due to acquisitions	—	183,729	9,660	193,389
Other, including foreign currency translation	(2,847)	(28)	—	(2,875)
December 31, 2018	$301,423	$191,708	$57,071	$550,202

As of December 31, 2018, goodwill amounted to approximately $550.2 million, an increase of $190.5 million from the balance at December 31, 2017. The increase in goodwill in 2018 reflects the acquisition of SPG, PSS and Flex described in note 3 offset by the decrease to foreign currency translation. The increase in goodwill in 2017 reflects the acquisition of the microelectronic water and chemical filtration product line of Gore described in note 3. In addition, goodwill increased due to foreign currency translation.

Identifiable intangible assets at December 31, 2018 and 2017 consist of the following:

2018

(In thousands)	Gross carrying Amount	Accumulated amortization	Net carrying value	Weighted average life in years
Developed technology	248,776	176,421	72,355	7.0
Trademarks and trade names	25,643	14,749	10,894	10.5
Customer relationships	328,050	133,068	194,982	10.8
Other	36,306	18,850	17,456	4.1
	$638,775	$ 343,088	$295,687	8.9

2017

(In thousands)	Gross carrying amount	Accumulated amortization	Net carrying value	Weighted average life in years
Developed technology	206,224	149,215	57,009	6.6
Trademarks and trade names	16,807	13,712	3,095	9.9
Customer relationships	220,806	110,281	110,525	10.3
Other	20,032	8,231	11,801	6.7
	$463,869	$ 281,439	$182,430	8.5

The table below sets forth the amortization expense for the years ended December 31, 2018, 2017, and 2016:

(In thousands)	2018	2017	2016
Amortization expense	$62,152	$44,023	$44,263

The amortization expense for each of the five succeeding years and thereafter relating to intangible assets currently recorded in the Company’s consolidated balance sheets is estimated to be the following at December 31, 2018:

(In thousands)	2019	2020	2021	2022	2023	Thereafter	Total
Future amortization expense	$63,444	$42,229	$35,771	$35,189	$34,500	$ 84,554	$295,687

(8) DEBT

Long-term debt at December 31, 2018 and 2017 consists of the following:

(In thousands)	December 31, 2018	December 31, 2017
Senior secured term loan facility due 2021	$ —	$ 133,850
Senior secured term loan facility due 2025	400,000	—
Senior unsecured notes due 2026	550,000	550,000
	950,000	683,850
Unamortized discount and debt issuance costs	11,137	9,470
Total long-term debt	938,863	674,380
Less current maturities of long-term debt	4,000	100,000
Long-term debt less current maturities	$ 934,863	$ 574,380

Annual maturities of long-term debt, excluding unamortized discount and issuance costs, due as of December 31, 2018 are as follows:

(In thousands)	2019	2020	2021	2022	2023	Thereafter	Total
Contractual debt obligation maturities*	$4,000	4,000	4,000	4,000	4,000	930,000	$950,000

*Subject to Excess Cash Flow payments to the lenders, see discussion below.

In November 2018, the Company entered into the New Term Loan Facility and the New Revolving Facility described below. The Company used the net proceeds of the term loans under the New Term Loan Facility to repay and terminate the Previous Credit Facilities, described below, to pay fees and expenses related to the issuance and the redemption, and for general corporate purposes. Going forward, the Company will use the New Revolving Facility for its general corporate purposes.

Debt issuance costs of $5.1 million paid to third parties are capitalized as debt issuance costs in connection with the New Credit Facilities. These debt issuance costs are being amortized as interest expense in the Company’s consolidated statements of operations over the term of the debt instrument using the straight-line method. The term loans under the Previous Term Loan Facility were repaid without premium or penalty at 100% of the outstanding principal amount, plus accrued and unpaid interest.

2026 Senior Unsecured Notes

On November 10, 2017, the Company issued $550 million aggregate principal amount of 4.625% senior unsecured notes due February 10, 2026. The 2026 Notes were issued under an indenture dated as of November 10, 2017 (the “2026 Notes Indenture”) by and among the Company and Wells Fargo Bank, National Association, as trustee. Interest on the 2026 Notes is payable semi-annually in arrears on February 15 and August 15, which commenced on February 15, 2018.

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The 2026 Notes are guaranteed, jointly and severally, fully and unconditionally, on a senior unsecured basis, by, subject to certain exclusions, each of the Company’s domestic subsidiaries that guarantee indebtedness under the New Credit Facilities.

As provided in the 2026 Notes Indenture, the Company may at its option on one or more occasions redeem all or a part of the 2026 Notes at a redemption price equal to (a) 100% of the principal amount of the 2026 Notes redeemed plus a make-whole premium if redeemed prior to November 10, 2020, or (b) 100% of the principal amount of the 2026 Notes redeemed plus a percentage of principal amount between 100% and 103.469% of the aggregate principal amount of notes to be redeemed depending on the period of redemption, if redeemed on or after November 10, 2020, plus, in each case, accrued and unpaid interest on the amount of 2026 Notes being redeemed.

Upon a change in control accompanied by certain rating events, the Company is required to offer to repurchase all of the 2026 Notes at a price in cash equal to 101% of the aggregate principal amount thereof, plus accrued and unpaid interest, if any, to, but not including, the date of repurchase.

The 2026 Notes Indenture contains covenants that, among other things and subject to certain exceptions, limit the Company’s ability and the ability of the Company’s restricted subsidiaries to create liens, enter into sale and leaseback transactions, engage in consolidations or mergers, or sell, transfer or otherwise dispose of all or substantially all of their assets. The 2026 Notes Indenture also, subject to certain exceptions, limits the ability of any subsidiary of the Company that is not a guarantor under the 2026 Notes to incur indebtedness. The Company is in compliance with all of the above covenants at December 31, 2018.

The 2026 Notes Indenture also provides for events of default which, if certain of them occur, would permit the trustee or the holders of at least 25% in aggregate principal amount of the then outstanding 2026 Notes to declare the principal, premium, if any, interest and any other monetary obligations on all the then-outstanding 2026 Notes to be due and payable immediately.

Senior Secured Credit Facilities

On November 6, 2018, the Company entered into a credit and guaranty agreement (the “Credit Agreement”) with Goldman Sachs Bank USA, as administrative agent and collateral agent, and the lenders party thereto, that provides senior secured financing in an aggregate principal amount of $700 million, consisting initially of (a) term loans in an aggregate principal amount of $400 million (the “New Term Loan Facility”) and (b) revolving commitments in an aggregate amount of $300 million (the “New Revolving Facility”, and together with the New Term Loan Facility, the “New Credit Facilities”). Borrowings under the New Credit Facilities bear interest at a rate per annum equal to, at the Company’s option, a base rate (such as prime rate or LIBOR) plus, an applicable margin. The Company’s interest rate on the term loans under the New Term Loan Facility is 4.52% at December 31, 2018. In addition to paying interest on the outstanding principal under the New Credit Facilities, the Company will pay (i) with respect to the New Term Loan Facility, customary agency fees, and (ii) with respect to the New Revolving Facility, a commitment fee in respect of the unutilized commitments thereunder and customary letter of credit fees and agency fees. The initial commitment fee is 0.20% per annum.

The Company may voluntarily prepay outstanding term loans under the New Term Loan Facility at any time without premium or penalty other than customary “breakage’ costs with respect to LIBOR loans, provided, however, that if on or prior to May 6, 2019 the Company prepays any term loan in connection with a repricing transaction, the Company must pay a prepayment premium of 1.00% of the aggregate principle amount of the term loans so prepaid. The company may voluntarily reduce the unutilized portion of the New Revolving Facility and repay outstanding revolving loans under the New Revolving Facility at any time without premium or penalty other than customary “breakage” costs with respect to LIBOR loans.

The Credit Agreement requires scheduled quarterly installment payments of 0.25% of the aggregate principal amount of the outstanding term loans commencing March 31, 2019. The Credit Agreement does not require scheduled amortization under the New Revolving Facility.

The Credit Agreement also requires the Company to prepay outstanding term loans, subject to certain exceptions, with (a) up to 50% of the Company’s annual Excess Cash Flow (as defined in the Credit Agreement) and (b) 100% of the net cash proceeds of (i) certain asset sales and casualty and condemnation events, subject to reinvestment rights and certain other exceptions; and (ii) any incurrence or issuance of certain debt, other than debt permitted under the New

Credit Facilities.
The New Term Loan Facility matures November 6, 2025 and the New Revolving Facility matures November 6, 2023. At December 31, 2018 the only outstanding amounts under the New Revolving Facility were undrawn outstanding letters of credit of $0.2 million.
All obligations under the New Credit Facilities are unconditionally guaranteed by certain of the Company's wholly-owned domestic subsidiaries and are secured, subject to certain exceptions, by substantially all of the Company's assets and the assets of the Company's subsidiaries that have guaranteed the New Credit Facilities.
The New Credit Facilities contain a number of negative covenants that, subject to certain exceptions, restrict the Company's ability and each of the Company's subsidiaries' ability to incur additional indebtedness; pay dividends on its capital stock or redeem, repurchase or retire its capital stock or its other indebtedness; make investments, loans and acquisitions, create

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restrictions on the payment of dividends or other amounts to the Company from the Company's restricted subsidiaries; engage in transactions with its affiliates; sell assets, including capital stock of its subsidiaries; materially alter the business it conducts; consolidate or merge, incur liens; and engage in sale-leaseback transactions. If at any time, commencing with the fiscal quarter ending March 31, 2019, the Company has revolving borrowings, unreimbursed letter of credit drawings and undrawn letters of credit outstanding in an amount in excess of 35.0% of the commitment amount under the New Revolving Facility, the Credit Agreement requires the Company to maintain a secured net leverage ratio of at least 3.25 to 1.0. The Company is in compliance with all of the above covenants at December 31, 2018.

Previous Senior Secured Loan Facilities

On April 30, 2014, the Company entered into (a) a term loan credit and guaranty agreement with Goldman Sachs Bank USA, as administrative agent, collateral agent, sole lead arranger, sole bookrunner and sole syndication agent, that provided senior secured financing of $460.0 million (the "Previous Term Loan Facility") and (b) an asset based revolving credit and guaranty agreement with Goldman Sachs Bank USA, as administrative agent, collateral agent, sole lead arranger, sole bookrunner and sole syndication agent, that provided senior secured financing of $75.0 million, subject to a borrowing base (the "Previous ABL Loan Facility"). As stated above, the Previous Term Loan Facility and the Previous ABL Loan Facility were repaid in full in November 2018. The repayment of the Previous Term Loan Facility and the Previous ABL Loan Facility resulted in a loss of $2.3 million on extinguishment of debt, which is included in other expense (income), net in the Company's consolidated statement of operations.

(9) LEASE COMMITMENTS

As of December 31, 2018, the Company was obligated under noncancellable operating lease agreements for certain sales offices and manufacturing facilities, manufacturing equipment, vehicles, information technology equipment and warehouse space. Future minimum lease payments for noncancellable operating leases with initial or remaining terms in excess of one year as of December 31, 2018, are as follows:

(In thousands)	2019	2020	2021	2022	2023	Thereafter	Total
Future minimum lease payments	$11,360	8,906	6,836	5,431	5,208	27,153	$64,894

Total rental expense for all equipment and building operating leases for the years ended December 31, 2018, 2017 and 2016, were $11.5 million, $10.6 million and $13.3 million, respectively.

(10) ASSET RETIREMENT OBLIGATIONS

The Company has asset retirement obligations (AROs) related to environmental disposal obligations associated with cylinders used to supply customers with gas products, and certain restoration obligations associated with its leased facilities.

Changes in the carrying amounts of the Company's AROs for the years ended December 31, 2018 and 2017 are shown below:

(In thousands)	2018	2017
Balance at beginning of year	$12,167	$11,529
Liabilities settled	(758)	(577)
Liabilities incurred	884	412
Accretion expense	510	215
Revision of estimate	(260)	588
Balance at end of year	$12,543	$12,167

ARO liabilities expected to be settled within twelve months are included in the consolidated balance sheets in other accrued liabilities, while all other ARO liabilities are included in pension benefit obligations and other liabilities in the consolidated balance sheets.

(11) INCOME TAXES

On December 22, 2017, the U.S. government enacted comprehensive tax legislation commonly referred to as the Tax Cuts and Jobs Act. The Tax Cuts and Jobs Act made broad and complex changes to the U.S. tax code that affected 2017, most notably a reduction of the U.S. corporate income tax rate from 35 percent to 21 percent for tax years beginning after December 31, 2017. The Tax Cuts and Jobs Act also provided for a one-time transition tax on the mandatory deemed repatriation of cumulative foreign earnings as of December 31, 2017 and the acceleration of

depreciation for certain assets placed into service after September 27, 2017 as well as prospective changes beginning in 2018, including the repeal of the domestic manufacturing deduction, additional limitations on executive compensation and limitations on the deductibility of interest.

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The Security and Exchange Commission (SEC) staff issued Staff Accounting Bulletin (SAB) 118, which provided guidance on accounting for the tax effects of the Tax Cuts and Jobs Act. SAB 118 provided a measurement period that should not extend beyond one year from the Tax Cuts and Jobs Act enactment date for entities to complete the accounting under ASC 740. In accordance with SAB 118, an entity must reflect the income tax effects of those aspects of the Tax Cuts and Jobs Act for which the accounting under Accounting Standards Codification (ASC) 740 is complete. To the extent that an entity's accounting for certain income tax effects of the Tax Cuts and Jobs Act is incomplete but it is able to determine a reasonable estimate, it must record a provisional estimate in the financial statements. If an entity cannot determine a provisional estimate to be included in the financial statements, it should continue to apply ASC 740 on the basis of the provisions of the tax laws that were in effect immediately before the enactment of the Tax Cuts and Jobs Act.

During the tax year ended December 31, 2018, the Company has finalized its accounting for the income tax effects of the Tax Cuts and Jobs Act in accordance with its understanding of the Tax Cuts and Jobs Act and the guidance available as of the date of this filing. The Company recognized the following measurement period adjustments to the provisional amount recorded in its 2017 Annual Report on Form 10-K in connection with the Tax Cuts and Jobs Act.

Reduction of U.S. federal corporate tax rate

The Company measures deferred tax assets and liabilities using enacted tax rates that will apply in the years in which the temporary differences are expected to be recovered or paid. Accordingly, the Company's deferred tax assets and liabilities were remeasured to reflect the reduction in the U.S. corporate income tax rate from 35 percent to 21 percent, resulting in a $10.2 million decrease in income tax expense and a corresponding decrease in net deferred tax liabilities for the year ended December 31, 2017. Included in this benefit were provisional amounts related to certain deferred tax assets and liabilities where the necessary information was not available, prepared or analyzed. Examples of this include fixed assets and compensation. The tax return was completed during the reporting period and the Company determined the impact on the remeasurement of deferred tax assets and liabilities to be complete. The Company recognized a measurement period increase to income tax expense of $0.6 million related to the remeasurement of deferred tax assets and liabilities, with a corresponding adjustment to the deferred tax liabilities.

Transition Tax on Foreign Earnings

The Deemed Repatriation Transition Tax ("Transition Tax") is a tax on previously untaxed accumulated and current earnings and profits (E&P) of certain of the Company's foreign subsidiaries. To calculate the amount of the Transition Tax, the Company must determine, in addition to other factors, the amount of post-1986 E&P of the relevant subsidiaries, as well as the amount of non-U.S. income taxes paid on such earnings. The Company recognized provisional income tax expense of $73.0 million for the year ended December 31, 2017 related to the one-time Transition Tax on certain foreign earnings. On the basis of revised E&P computations that were completed during the reporting period, the Company has determined the Transition Tax calculation to be complete. The Company recognized an additional measurement-period adjustment of $0.1 million to the Transition Tax obligation, with a corresponding increase of $0.1 million to income tax expense.

Acceleration of Depreciation

The Company recorded a provisional benefit of $1.3 million attributable to the accelerated depreciation for certain assets placed into service after September 27, 2017. This resulted in a decrease of approximately $3.2 million to the current income tax payable and a corresponding increase in the deferred tax liabilities of approximately $1.9 million (after considering the effects of the reduction in income tax rates). The tax return was completed during the reporting period and the Company has determined the calculation attributable to accelerated depreciation to be complete. The Company recognized an additional measurement period adjustment decrease to income tax benefit, decrease to deferred tax liability and increase to income tax payable of $0.3 million, $0.4 million, and $0.7 million, respectively, during the measurement period.

Executive Compensation under Sec. 162(m)

The Tax Cuts and Jobs Act repeals the exceptions to the section 162(m) deduction limitation for commissions and performance-based compensation. The Tax Cuts and Jobs Act provides a transition rule which states that the expansion of section 162(m) does not apply to any remuneration paid under a written, binding contract in effect on November 2, 2017, which was not materially modified on or after this date. The Tax Cuts and Jobs Act did not

specifically define the criteria for a binding contract and no further guidance was provided on this topic during the tax year ended December 31, 2017. Additional guidance in the form of IRS Notice 2018-68 was received during the year ended December 31, 2018. Based on analysis of IRS Notice 2018-68, the Company determined there would be an immaterial impact to the 162(m) calculation. The Company has determined the calculation to be complete and the change remains immaterial during the measurement period.

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Global Intangible Low Taxed Income (GILTI)

The U.S. tax law changes created new rules that allow the Company to make an accounting policy election to treat taxes due on GILTI inclusions in taxable income as either a current period expense or reflect such inclusions related to temporary basis differences in the Company's measurement of deferred taxes. The Company has elected to treat the GILTI inclusion as a current period expense. The Company recorded tax expense related to GILTI of $2.3 million for the tax year ended December 31, 2018.

Undistributed Foreign Earnings

At December 31, 2018, there were approximately $32.9 million of accumulated undistributed earnings of subsidiaries outside of the United States, all of which are considered to be indefinitely reinvested. Management estimates that no material withholding taxes would be incurred if these undistributed earnings were distributed.

Income before income taxes for the years ended December 31, 2018, 2017 and 2016 was derived from the following sources:

(In thousands)	2018	2017	2016
Domestic	$61,545	$13,363	$(7,328)
Foreign	192,887	171,368	127,327
Income before income tax expense	$254,432	$184,731	$119,999

Income tax expense for the years ended December 31, 2018, 2017 and 2016 is summarized as follows:

(In thousands)	2018	2017	2016
Current:			
Federal	$(14,775)	$60,529	$7,759
State	1,605	808	(10)
Foreign	38,723	36,700	31,387
	25,553	98,037	39,136
Deferred (net of valuation allowance):			
Federal	(13,399)	249	(8,183)
State	(370)	(891)	250
Foreign	1,893	2,270	(8,351)
	(11,876)	1,628	(16,284)
Income tax expense	$13,677	$99,665	$22,852

Income tax (benefit) expense differs from the expected amounts based upon the statutory federal tax rates for the years ended December 31, 2018, 2017 and 2016 as follows:

(In thousands)	2018	2017	2016
Expected federal income tax at statutory rate	$53,431	$64,656	$42,000
State income taxes before valuation allowance, net of federal tax effect	605	(1,376)	(769)
Effect of foreign source income	2,359	(27,581)	(22,242)
Tax contingencies	468	2,816	1,103
Valuation allowance	527	3,195	1,713
U.S. federal research credit	(2,263)	(4,881)	(1,676)
Equity compensation	(3,826)	(2,321)	815
Transition tax	89	72,993	—
Remeasurement of deferred taxes	619	(10,248)	—
Incremental taxes on unremitted foreign earnings release	—	3,968	—
Foreign derived intangible income	(4,846)	—	—
Legal entity restructuring foreign tax credit	(25,080)	—	—
Legal entity restructuring dividends received deduction	(9,398)	—	—
Other items, net	992	(1,556)	1,908
Income tax expense	$13,677	$99,665	$22,852

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In 2012, Entegris' Korean subsidiary made commitments to produce a certain line of products in Korea. In return for this commitment, the Company has a tax holiday on income earned on sales of these products for five years and a partial holiday for two additional years. The income tax benefits attributable to this tax holiday are $4.0 million ($0.03 per diluted share), $7.4 million ($0.05 per diluted share) and $3.3 million ($0.02 per diluted share) for the years ended December 31, 2018, 2017 and 2016, respectively. The 2017 and 2016 effective tax rates include additional benefits of $4.3 million and $1.9 million, respectively, because the corporate tax rate in Korea is lower than the U.S. rate. The 2018 effective tax rate no longer includes additional benefits as the U.S. corporate tax rate is lower that the Korean tax rate.

The Company also has made employment and spending commitments to Singapore. In return for those commitments, the Company has been granted a partial tax holiday for eight years starting in 2013. During 2017, this agreement was extended to 2027 in exchange for revised employment and spending commitments. The income tax benefits attributable to the tax status are $6.3 million ($0.04 per diluted share), $4.7 million ($0.03 per diluted share) and $2.3 million ($0.02 per diluted share) for the years ending December 31, 2018, 2017 and 2016, respectively. The 2018, 2017 and 2016 effective tax rates include additional benefits of $3.6 million, $12.4 million and $6.5 million, because the corporate tax rate in Singapore is lower than the U.S. rate.

The significant components of the Company's deferred tax assets and deferred tax liabilities at December 31, 2018 and 2017 are as follows:

(In thousands)	2018	2017
Deferred tax assets attributable to:		
Accounts receivable	$247	$32
Inventory	4,085	4,132
Accruals not currently deductible for tax purposes	8,694	8,641
Net operating loss and credit carryforwards	15,878	15,184
Capital loss carryforward	2,450	2,391
Equity compensation	3,054	3,658
Asset impairments	452	452
Other, net	3,488	2,549
Gross deferred tax assets	38,348	37,039
Valuation allowance	(18,079)	(17,494)
Total deferred tax assets	20,269	19,545
Deferred tax liabilities attributable to:		
Purchased intangible assets	(50,128)	(28,956)
Depreciation	(3,874)	(2,512)
Total deferred tax liabilities	(54,002)	(31,468)
Net deferred tax liabilities	$(33,733)	$(11,923)

Deferred tax assets are generally required to be reduced by a valuation allowance if, based on the weight of available positive and negative evidence, it is more likely than not that some portion or all of the deferred tax assets will not be realized.

As of December 31, 2018 and 2017, the Company had a net U.S. deferred tax liability of $24.5 million and $5.1 million, respectively, which are composed of temporary differences and various tax credit carryforwards. Of the $24.5 million net U.S. deferred tax liability, $34.6 million relates to the acquisition of the SAES Pure Gas business during the year ended December 31, 2018. Management believes that it is more likely than not that the benefit from certain state net operating loss carryforwards, state credits, capital asset impairments, and a federal capital loss carryforward will not be realized. In recognition of this risk, management has provided a valuation allowance of $10.7 million and $10.6 million as of December 31, 2018 and 2017, respectively, on the related deferred tax assets. If the assumptions change and management determines the assets will be realized, the tax benefits relating to any reversal of the valuation allowance on deferred tax assets at December 31, 2018 will be recognized as a reduction of income tax expense.

At December 31, 2018, the Company had state operating loss and credit carryforwards of approximately $8.0 million, which begin to expire in 2019 and foreign operating loss carryforwards of $26.6 million, which begin to expire in 2019.

As of December 31, 2018 and 2017, the Company had a net non-U.S. deferred tax asset of $8.8 million and $10.7 million, respectively, for which management determined based upon the available evidence a valuation allowance of $7.3 million and $6.9 million as of December 31, 2018 and 2017, respectively, was required against the non-U.S. gross deferred tax assets. For other non-U.S. jurisdictions, management is relying upon projections of future taxable income to utilize deferred tax assets.

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Benefits from tax positions should be recognized in the financial statements only when it is more likely than not that the tax positions will be sustained upon examination by the appropriate taxing authority that would have full knowledge of all relevant information. A tax position that meets the more-likely-than-not recognition threshold is measured at the largest amount of benefit that is greater than fifty percent likely of being realized upon ultimate settlement. Tax positions that fail to meet the more-likely-than-not recognition threshold should be recognized in the first subsequent financial reporting period in which that threshold is met. Previously recognized tax positions that no longer meet the more-likely-than-not recognition threshold should be derecognized in the first subsequent financial reporting period in which that threshold is no longer met. The provisions also provide guidance on the accounting for and disclosure of unrecognized tax benefits, interest and penalties.

Reconciliations of the beginning and ending balances of the total amounts of gross unrecognized tax benefits for the years ended December 31, 2018 and 2017 are as follows:

(In thousands)	2018	2017
Gross unrecognized tax benefits at beginning of year	$12,561	$8,293
Increase in tax positions from prior years	61	298
Decrease in tax positions from prior years	(234)	—
Increases in tax positions for current year	2,970	4,724
Settlement of tax positions for current year	(2,577)	—
Lapse in statute of limitations	(486)	(754)
Gross unrecognized tax benefits at end of year	$12,295	$12,561

The total amount of net unrecognized tax benefits that, if recognized, would affect the effective tax rate was $9.3 million at December 31, 2018.

Penalties and interest paid or received are recorded in other income, net, in the consolidated statements of operations. For the years ended December 31, 2018 and 2017, the Company has accrued interest and penalties related to unrecognized tax benefits of $1.7 million and $1.0 million, respectively. Expenses of $0.8 million, $0.3 million and $0.1 million were recognized as interest and penalties in the consolidated statements of operations for the years ended December 31, 2018, 2017 and 2016, respectively.

The Company files income tax returns in the U.S. and in various state, local and foreign jurisdictions. The statutes of limitations related to both the consolidated Federal income tax return and state returns are closed for all years up to and including 2014 and 2014, respectively. With respect to foreign jurisdictions, the statute of limitations varies from country to country, with the earliest open year for the Company’s major foreign subsidiaries being 2012.

Due to the expiration of various statutes of limitations and settlement of audits, it is reasonably possible that the Company’s gross unrecognized tax benefit balance may decrease within the next twelve months by approximately $1.2 million.

(12) EQUITY

Dividend

Holders of the Company’s common stock are entitled to receive dividends when and if they are declared by the Company’s Board of Directors. The Company’s Board of Directors declared a cash dividend of $0.07 per share during the first, second, third and fourth quarters of 2018, which totaled $39.7 million. During 2017, the Company’s Board of Directors declared a cash dividend of $0.07 per share during the fourth quarter, which totaled $9.9 million.

On January 16, 2019, the Company’s Board of Directors declared a quarterly cash dividend of $0.07 per share to be paid on February 20, 2019 to shareholders of record as of January 30, 2019.

Future dividend declarations, if any, as well as the record and payment dates for such dividends, are subject to the final determination of the Company’s Board of Directors. Furthermore, the credit agreements governing the New Credit Facilities contain restrictions that may limit our ability to pay dividends.

Share Repurchase Program

On February 13, 2018, the Company’s Board of Directors authorized a repurchase program covering up to an aggregate of $100.0 million of the Company’s common stock in open market transactions and in accordance with one or more pre-arranged stock trading plans established in accordance with Rule 10b5-1 under the Securities and Exchange Act of 1934, as amended, over a period twenty-four months. On November 19, 2018, the Company’s Board

of Directors authorized the Company to repurchase an additional $250 million of its common stock under its repurchase program for a total repurchase amount of $350 million. The repurchase program represents a renewal and replacement of the repurchase program originally authorized on February 5, 2016, which had been subsequently renewed on February 15, 2017.

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The Company repurchased $179.3 million of shares and $28.0 million of shares for the years ended December 31, 2018 and December 31, 2017, respectively.

2010 Stock Plan

In 2009, the Company's Board of Directors approved the 2010 Stock Plan, subject to the approval by the Company's stockholders in 2010. The 2010 Stock Plan replaced the predecessor plans for future stock awards and stock option grants. Subsequent to the acquisition of ATMI, Inc. in 2014, the Company's Board of Directors approved the absorption of 5.7 million additional shares of the ATMI, Inc. 2010 Stock Plan (ATMI Plan) into the Company's 2010 Stock Plan for the remaining term of the ATMI Plan.

The 2010 Stock Plan has a term of ten years and provides for the issuance of stock options and other share-based awards to selected employees, directors, and other individuals or entities that provide services to the Company or its affiliates. Under the 2010 Stock Plan, the Board of Directors or a committee selected by the Board of Directors will determine for each award, the term, price, number of shares, rate at which each award is exercisable and whether restrictions are imposed on the shares subject to the awards. The exercise price for option awards generally may not be less than the fair market value per share of the underlying common stock on the date granted. The 2010 Stock Plan allows that after December 31, 2009 any stock awards that were awarded from the expired plans mentioned above that are forfeited, expired or otherwise terminated without issuance of such stock award again be available for issuance under the 2010 Stock Plan.

Stock Options

Stock option activity for the 2010 Stock Plan and predecessor plans for the years ended December 31, 2018, 2017 and 2016 is summarized as follows:

	2018		2017		2016	
(Shares in thousands)	Number of shares	Weighted average exercise price	Number of shares	Weighted average exercise price	Number of shares	Weighted average exercise price
Options outstanding, beginning of year	1,869	$ 13.46	1,907	$ 11.54	2,139	$ 10.57
Granted	296	31.10	335	21.60	549	12.20
Exercised	(727)	10.89	(359)	10.89	(633)	8.66
Expired or forfeited	(28)	26.41	(14)	12.78	(148)	12.32
Options outstanding, end of year	1,410	$ 18.22	1,869	$ 13.46	1,907	$ 11.54
Options exercisable, end of year	562	$ 13.68	872	$ 11.11	776	$ 10.65

Options outstanding for the Company's stock plans at December 31, 2018 are summarized as follows:

(Shares in thousands)	Options outstanding			Options exercisable	
Range of exercise prices	Number outstanding	Weighted average remaining life in years	Weighted-average exercise price	Number exercisable	Weighted average exercise price
$9.88 to $11.71	107	1.8 years	$ 11.09	107	$ 11.09
$12.20 to $12.20	438	4.1 years	12.20	190	12.20
$13.49 to $13.49	271	3.1 years	13.49	189	13.49
$21.60 to $21.60	313	5.1 years	21.60	76	21.60
$31.10 to $31.10	281	6.1 years	31.10	—	—
	1,410	4.4 years	18.22	562	13.68

The weighted average remaining contractual term for options outstanding and exercisable for all plans at December 31, 2018 was 4.4 years and 3.5 years, respectively.

For all plans, the Company had shares available for future grants of 8.7 million shares, 8.8 million shares, and 9.4 million shares at December 31, 2018, 2017 and 2016, respectively.

For all plans, the total pre-tax intrinsic value of stock options exercised during the years ended December 31, 2018 and 2017 was $16.7 million and $4.8 million, respectively. The aggregate intrinsic value, which represents the total pre-tax intrinsic value based on the Company’s closing stock price of $27.90 at December 31, 2018, which theoretically could have been received by

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the option holders had all option holders exercised their options as of that date, was $14.6 million and $8.0 million for options outstanding and options exercisable, respectively.

Share-based payment awards in the form of stock option awards for 0.3 million, 0.3 million and 0.5 million options were granted to employees during the years ended December 31, 2018, 2017 and 2016. Compensation expense is based on the grant date fair value. The awards vest annually over a three-year or four-year period and have a contractual term of 7 years. The Company estimates the fair value of stock options using the Black-Scholes valuation model. Key inputs and assumptions used to estimate the fair value of stock options include the grant price of the award, the expected option term, volatility of the Company’s stock, the risk-free rate and the Company’s dividend yield. Estimates of fair value are not intended to predict actual future events or the value ultimately realized by employees who receive equity awards, and subsequent events are not indicative of reasonableness of the original estimates of fair value made by the Company.

The fair value of each stock option grant was estimated at the date of grant using a Black-Scholes option pricing model. The following table presents the weighted-average assumptions used in the valuation and the resulting weighted-average fair value per option granted for the years ended December 31, 2018, 2017 and 2016:

Employee stock options:	2018		2017		2016	
Volatility	28.7	%	26.9	%	27.6	%
Risk-free interest rate	2.4	%	1.7	%	1.1	%
Dividend yield	0.9	%	—	%	—	%
Expected life (years)	3.9		4.1		4.0	
Weighted average fair value per option	$7.35		$5.25		$2.85	

A historical daily measurement of volatility is determined based on the expected life of the option granted. The risk-free interest rate is determined by reference to the yield on an outstanding U.S. Treasury note with a term equal to the expected life of the option granted. Expected life is determined by reference to the Company’s historical experience. The Company determines the dividend yield by dividing the expected annual dividend on the Company’s stock by the option exercise price.

Employee Stock Purchase Plan

The Company maintains the Entegris, Inc. Amended and Restated Employee Stock Purchase Plan (ESPP). The ESPP allows employees to elect, at six-month intervals, to contribute up to 10% of their compensation, subject to certain limitations, to purchase shares of common stock at a discount of 15% from the fair market value on the first day or last day of each six-month period. The Company treats the ESPP as a compensatory plan. At December 31, 2018, 1.9 million shares remained available for issuance under the ESPP. Employees purchased 0.2 million shares, 0.2 million shares, and 0.3 million shares, at a weighted-average price of $24.86, $16.92, and $11.56 during the years ended December 31, 2018, 2017 and 2016, respectively.

Restricted Stock Units

Restricted stock units are awards of common stock made under the 2010 Stock Plan that are subject to a risk of forfeiture if the awardee terminates employment with the Company prior to the lapse of the restrictions. The value of such restricted stock units is determined using the market price on the grant date. Compensation expense for restricted stock units is generally recognized using the straight-line single-option method. A summary of the Company’s restricted stock unit activity for the years ended December 31, 2018, 2017 and 2016 is presented in the following table:

	2018			2017			2016		
(Shares in thousands)	Number of shares		Weighted average grant date fair value	Number of shares		Weighted average grant date fair value	Number of shares		Weighted average grant date fair value
Unvested, beginning of year	1,857		$ 15.86	2,164		$ 12.49	1,882		$ 12.25
Granted	509		31.40	659		22.14	1,249		12.42
Vested	(732	)	15.07	(801	)	12.22	(711	)	11.74
Forfeited	(115	)	18.58	(165	)	14.48	(256	)	12.44

Unvested, end of year	1,519	21.24	1,857	15.86	2,164	12.49

The weighted average remaining contractual term for unvested restricted shares at December 31, 2018 and 2017 was 1.9 years and 2.1 years, respectively.

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During the years ended December 31, 2018, 2017 and 2016, the Company awarded performance stock for up to 0.2 million shares, 0.1 million shares and 0.2 million shares, respectively, to be issued upon the achievement of performance conditions under the Company's 2010 Stock Plan to certain officers and other key employees. Compensation expense is based on the grant date fair value. The awards vest on the third anniversary of the award date. The Company estimates the fair value of the Performance shares using a Monte Carlo simulation process.

As of December 31, 2018, the total compensation cost related to unvested stock options, performance stock and restricted stock unit awards not yet recognized was $3.0 million, $2.2 million and $20.6 million, respectively, and is expected to be recognized over the next 2.4 years on a weighted-average basis.

Valuation and Expense Information

The Company recognizes compensation expense for all share-based payment awards made to employees and directors based on their estimated fair values on the date of grant. Compensation expense is recognized using the straight-line attribution method to recognize share-based compensation over the service period of the award, with adjustments recorded for forfeitures as they occur. The following table summarizes the allocation of share-based compensation expense related to employee stock options, restricted stock awards and grants under the employee stock purchase plan for the years ended December 31, 2018, 2017 and 2016:

(In thousands)	2018	2017	2016
Cost of sales	$1,009	$1,031	$1,579
Engineering, research and development expenses	1,689	1,457	1,124
Selling, general and administrative expenses	14,414	12,818	10,733
Share-based compensation expense	17,112	15,306	13,436
Tax benefit	3,421	4,978	4,153
Share-based compensation expense, net of tax	$13,691	$10,328	$9,283

(13) BENEFIT PLANS

401(k) Plan

The Company maintains the Entegris, Inc. 401(k) Savings and Profit Sharing Plan (the 401(k) Plan) that qualifies as a deferred salary arrangement under Section 401(k) of the Internal Revenue Code. Under the Plan, eligible employees may defer a portion of their pre-tax wages, up to the Internal Revenue Service annual contribution limit. Entegris matches employees' contributions to a maximum match of 4% of the employee's eligible wages. The employer matching contribution expense under the Plan was $6.1 million, $5.1 million and $4.9 million in the fiscal years ended December 31, 2018, 2017 and 2016, respectively.

Defined Benefit Plans

The employees of the Company's subsidiaries in Japan, Taiwan and Germany are covered in defined benefit pension plans. The Company uses a December 31 measurement date for its pension plans.

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The tables below set forth the Company's estimated funded status as of December 31, 2018 and 2017:

(In thousands)	2018	2017
Change in benefit obligation:		
Benefit obligation at beginning of year	$7,682	$7,073
Service cost	50	38
Interest cost	62	46
Actuarial (gain) loss	75	302
Benefits paid	(560)	(222)
Other	11	7
Foreign exchange impact	(12)	438
Benefit obligation at end of year	7,308	7,682
Change in plan assets:		
Fair value of plan assets at beginning of year	908	743
Return on plan assets	31	5
Employer contributions	110	88
Benefits paid	(185)	—
Foreign exchange impact	(29)	72
Fair value of plan assets at end of year	835	908
Funded status:		
Plan assets less than benefit obligation - Net amount recognized	$(6,473)	$(6,774)

Amounts recognized in the consolidated balance sheets consist of:

(In thousands)	2018	2017
Noncurrent liability	$(6,473)	$(6,774)
Accumulated other comprehensive loss, net of taxes	860	919

Amounts recognized in accumulated other comprehensive loss, net of tax consist of:

(In thousands)	2018	2017
Net actuarial loss	$514	$490
Prior service cost	616	705
Gross amount recognized	1,130	1,195
Deferred income taxes	(270)	(276)
Net amount recognized	$860	$919

Information for pension plans with an accumulated benefit obligation in excess of plan assets:

(In thousands)	2018	2017
Projected benefit obligation	$6,473	$6,774
Accumulated benefit obligation	6,235	6,497
Fair value of plan assets	835	908

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The components of the net periodic benefit cost for the years ended December 31, 2018, 2017 and 2016 were as follows:

(In thousands)	2018	2017	2016
Pension benefits:			
Service cost	$50	$38	$66
Interest cost	62	46	91
Expected return on plan assets	(18)	(11)	(10)
Amortization of prior service cost	69	69	65
Amortization of net transition obligation	—	22	—
Amortization of plan loss	20	—	—
Recognized actuarial net loss	—	—	17
Net periodic pension benefit cost	$183	$164	$229

The estimated amount that will be amortized from accumulated other comprehensive income into net periodic benefit cost in 2019 is as follows:

(In thousands)	
Prior service cost	$68
Net actuarial loss	17
	$85

Assumptions used in determining the benefit obligation and net periodic benefit cost for the Company's pension plans for the years ended December 31, 2018, 2017 and 2016 are presented in the following table as weighted-averages:

	2018	2017	2016
Benefit obligations:			
Discount rate	0.76%	0.82%	0.63%
Rate of compensation increase	3.08%	3.05%	2.90%
Net periodic benefit cost:			
Discount rate	1.66%	1.45%	1.70%
Rate of compensation increase	3.18%	3.00%	3.43%
Expected return on plan assets	1.89%	1.80%	1.43%

The plans' expected return on assets as shown above is based on management's expectations of long-term average rates of return to be achieved by the underlying investment portfolios. In establishing this assumption, management considers historical and expected returns for the asset classes in which the plans are invested, as well as current economic and capital market conditions. The discount rate primarily used by the Company is based on market yields at the valuation date on government bonds as well as the estimated maturity of benefit payments.

Plan Assets

At December 31, 2018, the majority of the Company's pension plan assets are deposited in Bank of Taiwan in the form of money market funds, where the Bank of Taiwan is the assigned funding vehicle for the statutory retirement benefit. The remaining portion of the Company's plan assets is deposited in a German insurance company's investment fund. The fair value measurements of the Company's pension plan assets at December 31, 2018, by asset category are as follows:

(In thousands)		Quoted prices in active markets for identical assets	Significant observable inputs	Significant unobservable inputs
Asset category	Total	(Level 1)	(Level 2)	(Level 3)
Taiwan plan assets (a)	$669	$ 669	—	—
Germany plan assets (b)	$166	$ 166	—	—
	$835	$ 835	—	—

(a)

This category includes investments in the government of Taiwan's pension fund. The government of Taiwan is responsible for the strategy and allocation of the investment contributions.

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(b) This category includes investments in an insurer's balanced asset fund. The insurer is responsible for the strategy and allocation of the investment contributions. The Company selects a pre-packaged portfolio pooled investment fund that is conservative. The majority of the funs are invested broadly in German mortgage bonds, construction loans and government bonds with good credit rating.

The fair value measurements of the Company's pension plan assets at December 31, 2017, by asset category are as follows:

(In thousands)		Quoted prices in active markets for identical assets	Significant observable inputs	Significant unobservable inputs
Asset category	Total	(Level 1)	(Level 2)	(Level 3)
Taiwan plan assets (a)	$830	$ 830	—	—
Germany plan assets (b)	$78	$ 78	—	—
	$908	$ 908	—	—

(a) This category includes investments in the government of Taiwan's pension fund. The government of Taiwan is responsible for the strategy and allocation of the investment contributions.

(b) This category includes investments in an insurer's balanced asset fund. The insurer is responsible for the strategy and allocation of the investment contributions. The Company selects a pre-packaged portfolio pooled investment fund that is conservative. The majority of the funs are invested broadly in German mortgage bonds, construction loans and government bonds with good credit rating.

Cash Flows

The Company expects to make the following contributions and benefit payments:

(In thousands)	Contributions	Payments
2019	$ 93	$ 36
2020	—	33
2021	—	217
2022	—	201
2023	—	251
Years 2024-2028	—	2,197

(14) FAIR VALUE MEASUREMENTS

Generally accepted accounting principles establish a fair value hierarchy that prioritizes the inputs used to measure fair value. The three levels of the fair value hierarchy are as follows:

Level 1—Quoted prices in active markets accessible at the reporting date for identical assets and liabilities.

Level 2—Quoted prices for similar assets or liabilities in active markets. Quoted prices for identical or similar assets and liabilities in markets that are not considered active or financial instruments for which all significant inputs are observable, either directly or indirectly.

Level 3—Prices or valuations that require inputs that are significant to the valuation and are unobservable.

A financial instrument's level within the fair value hierarchy is based on the lowest level of any input that is significant to the fair value measurement.

Financial Assets Measured at Fair Value on a Recurring Basis

The following table presents the Company's financial assets and liabilities that are measured at fair value on a recurring basis at December 31, 2018 and 2017.

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(In thousands)	December 31, 2018 Level 1	Level 2	Level 3	Total	December 31, 2017 Level 1	Level 2	Level 3	Total
Assets:								
Other current assets								
Foreign currency contracts[(a)]	$—	$—	$ —	$—	$—	$ 36	$ —	$ 36
Total assets measured and recorded at fair value	$—	$—	$ —	$—	$—	$ 36	$ —	$ 36
Liabilities:								
Other accrued liabilities								
Foreign currency contracts[(a)]	$—	$589	$ —	$589	$—	$ —	$ —	$ —
Total liabilities measured and recorded at fair value	$—	$589	$ —	$589	$—	$ —	$ —	$ —

(a) Based on observable market transactions of spot currency rates and forward rates on equivalently-termed instruments.

A reconciliation of the net fair value of foreign currency contract assets and liabilities subject to master netting arrangements that are recorded in the December 31, 2018 and 2017 consolidated balance sheets to the net fair value that could have been reported in the respective consolidated balance sheet is as follows:

(In thousands)	December 31, 2018 Gross amounts of recognized liabilities	Gross amounts offset in the consolidated balance sheet	Net amount of liabilities in the consolidated balance sheet	December 31, 2017 Gross amounts of recognized assets	Gross amounts offset in the consolidated balance sheet	Net amount of assets in the consolidated balance sheet
Foreign exchange forward contracts	$589	$ —	$ 589	$36	$ —	$ 36

Losses associated with derivatives are recorded in other expense (income), net, in the consolidated statements of operations. Losses associated with derivative instruments not designated as hedging instruments for the years ended December 31, 2018, 2017 and 2016 were as follows:

(In thousands)	2018	2017	2016
Losses on foreign currency forward contracts	$(1,287)	$(2,209)	$(1,647)

(15) EARNINGS PER SHARE (EPS)

Basic EPS is computed by dividing net income by the weighted average number of shares of common stock outstanding during each period. The following table presents a reconciliation of the share amounts used in the computation of basic and diluted earnings per share:

(In thousands)	2018	2017	2016
Basic earnings per share—Weighted common shares outstanding	141,026	141,553	141,093
Weighted common shares assumed upon exercise of options and vesting of restricted stock units	1,584	1,965	957
Diluted earnings per share—Weighted common shares outstanding	142,610	143,518	142,050

The Company excluded the following shares underlying stock-based awards from the calculations of diluted EPS because their inclusion would have been anti-dilutive for the years ended December 31, 2018, 2017 and 2016:

(In thousands)	2018	2017	2016
Shares excluded from calculations of diluted EPS	267	303	434

(16) SEGMENT INFORMATION

The Company's financial segment reporting reflects an organizational alignment intended to leverage the Company's unique portfolio of capabilities to create value for its customers by developing mission-critical solutions to maximize manufacturing yields and enable higher performance of devices. While these segments have separate products and technical know-how, they

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share a global generalist sales force, common business systems and processes, technology centers, and strategic and technology roadmaps. The Company leverages its expertise from these three segments to create new and increasingly integrated solutions for its customers. The Company’s business is reported in the following segments:

- Specialty Chemicals and Engineered Materials (SCEM): SCEM provides high-performance and high-purity process chemistries, gases, and materials and safe and efficient delivery systems to support semiconductor and other advanced manufacturing processes.
- Microcontamination Control (MC): MC solutions purify critical liquid chemistries and gases used in semiconductor manufacturing processes and other high-technology industries.
- Advanced Materials Handling (AMH): AMH develops solutions to monitor, protect, transport, and deliver critical liquid chemistries and substrates for a broad set of applications in the semiconductor industry and other high-technology industries.

Inter-segment sales are not significant. In the first quarter of 2018, the Company updated its definition of segment profit. Segment profit is now defined as net sales less direct segment operating expenses, including certain general and administrative costs for the Company’s human resources, finance and information technology functions previously unallocated by the Company. The remaining unallocated expenses consist mainly of the Company’s corporate functions as well as interest expense, amortization of intangible assets and income tax expense. Prior year information was recast to reflect the change in the Company’s definition of segment profit.

Corporate assets consist primarily of cash and cash equivalents, deferred tax assets and deferred tax charges.

Summarized financial information for the Company’s reportable segments is shown in the following tables.

(In thousands)	2018	2017	2016
Net sales:			
SCEM	$530,241	$485,470	$428,328
MC	552,844	436,225	362,658
AMH	467,412	420,837	384,284
Total net sales	$1,550,497	$1,342,532	$1,175,270

(In thousands)	2018	2017	2016
Segment profit:			
SCEM	$129,754	$111,802	$77,328
MC	173,964	141,413	93,911
AMH	82,541	59,838	56,282
Total segment profit	$386,259	$313,053	$227,521

(In thousands)	2018	2017	2016
Total assets:			
SCEM	$757,381	$749,379	$766,126
MC	680,080	251,216	200,399
AMH	359,991	278,079	267,085
Corporate	520,189	697,498	465,922
Total assets	$2,317,641	$1,976,172	$1,699,532

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(In thousands)	2018	2017	2016
Depreciation and amortization:			
SCEM	$70,329	$66,514	$64,959
MC	33,590	13,744	9,995
AMH	22,805	21,003	23,697
Corporate	544	970	1,235
Total depreciation and amortization	$127,268	$102,231	$99,886

(In thousands)	2018	2017	2016
Capital expenditures:			
SCEM	$44,337	$44,350	$23,138
MC	38,331	27,178	9,880
AMH	26,545	18,378	31,634
Corporate	940	3,691	608
Total capital expenditures	$110,153	$93,597	$65,260

The following table reconciles total segment profit to income before income taxes and equity in net loss of affiliate:

(In thousands)	2018	2017	2016
Total segment profit	$386,259	$313,053	$227,521
Less:			
Amortization of intangibles	62,152	44,023	44,263
Unallocated general and administrative expenses	31,418	27,213	27,722
Operating income	292,689	241,817	155,536
Interest expense	34,094	32,343	36,846
Interest income	(3,839)	(715)	(318)
Other expense (income), net	8,002	25,458	(991)
Income before income tax expense	$254,432	$184,731	$119,999

In the following tables, revenue is disaggregated by country or region based on the ship to location of the customer for the years ended December 31, 2018, 2017 and 2016:

(In thousands)	2018			
	SCEM	MC	AMH	Total
Taiwan	$104,707	$118,208	$66,948	$289,863
United States	133,834	94,427	118,771	347,032
South Korea	82,890	74,623	84,883	242,396
Japan	52,731	110,997	47,027	210,755
China	68,365	84,652	51,368	204,385
Europe	32,088	40,635	65,352	138,075
Southeast Asia	55,626	29,302	33,063	117,991
	$530,241	$552,844	$467,412	$1,550,497

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	2017			
(In thousands)	SCEM	MC	AMH	Total
Taiwan	$113,279	$109,815	$66,620	$289,714
United States	117,602	70,834	97,903	286,339
South Korea	74,773	65,677	76,418	216,868
Japan	41,164	89,638	38,678	169,480
China	64,796	45,382	38,712	148,890
Europe	30,472	30,479	59,530	120,481
Southeast Asia	43,384	24,400	42,976	110,760
	$485,470	$436,225	$420,837	$1,342,532

(In thousands)	2016			
	SCEM	MC	AMH	Total
Taiwan	$107,806	$109,509	$73,994	$291,309
United States	98,436	57,594	97,838	253,868
South Korea	57,538	36,477	51,646	145,661
Japan	31,232	86,927	37,862	156,021
China	58,282	27,544	32,609	118,435
Europe	29,890	24,866	51,023	105,779
Southeast Asia	45,144	19,741	39,312	104,197
	$428,328	$362,658	$384,284	$1,175,270

The following table summarizes property, plant and equipment, net, attributed to significant countries for the years ended December 31, 2018, 2017 and 2016:

(In thousands)	2018	2017	2016
Property, plant and equipment:			
United States	$289,049	$257,584	$226,394
South Korea	41,698	39,562	33,441
Japan	34,276	23,648	25,248
Malaysia	31,138	19,212	19,180
Taiwan	18,804	16,073	14,151
Other	4,564	3,444	3,148
	$419,529	$359,523	$321,562

In the years ended December 31, 2018, 2017 and 2016, Taiwan Semiconductor Manufacturing Company Limited, accounted for $153.9 million, $167.9 million and $161.9 million of net sales, respectively, all of which include sales from all of the Company’s segments. In addition, in the year ended December 31, 2018 and 2017, Samsung Electronics Co. accounted for $164.3 million and $140.6 million of net sales, respectively, which include sales from all of the Company’s segments.

(17) COMMITMENTS AND CONTINGENT LIABILITIES

The Company is subject to various claims, legal actions, and complaints arising in the ordinary course of business. The Company believes the final outcome of these matters will not have a material adverse effect on its consolidated financial statements. The Company expenses legal costs as incurred.

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(18) QUARTERLY INFORMATION-UNAUDITED

(In thousands, except per share data)	Fiscal quarter ended March 31, 2018	June 30, 2018	September 29, 2018	December 31, 2018
Net sales	$367,199	$383,059	$ 398,597	$ 401,642
Gross profit	175,997	182,378	181,716	179,740
Net income	57,562	54,349	48,060	80,784
Basic net income per common share	0.41	0.38	0.34	0.58
Diluted net income per common share	0.40	0.38	0.34	0.57

(In thousands, except per share data)	Fiscal quarter ended April 1, 2017	July 1, 2017	September 30, 2017	December 31, 2017
Net sales	$317,377	$329,002	$ 345,591	$ 350,562
Gross profit	139,596	150,303	155,407	163,679
Net income (loss)	32,514	39,991	40,902	(28,341)
Basic net income (loss) per common share	0.23	0.28	0.29	(0.20)
Diluted net income (loss) per common share	0.23	0.28	0.28	(0.20)

(19) SUBSEQUENT EVENTS

On January 28, 2019, the Company and Versum Materials, Inc., a leading specialty materials supplier to the semiconductor industry, announced that they had entered into an Agreement and Plan of Merger, dated as of January 27, 2019, pursuant to which they agreed to combine in a merger of equals. Under the terms of the agreement, Versum will merge with and into Entegris, with Entegris surviving and continuing as the surviving corporation, and Versum stockholders will receive 1.120 shares of Company common stock for each existing Versum share.

In connection with the signing of the agreement, the Company entered into a First Amendment to the Credit Agreement, dated as of February 8, 2019, pursuant to which certain covenants were amended in order to permit the assumption of existing indebtedness of Versum upon closing of the merger. On February 8, 2019, the Company also terminated with no cost its $987 million incremental term loan commitment from Morgan Stanley Senior Funding, Inc., which was in place to backstop the credit agreement amendment.