ENTEGRIS INC
Form 10-K
February 17, 2017
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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, 2016
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 or a smaller reporting company. (Check one):

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

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

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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 July 2, 2016, the last business day of registrant's most recently completed second fiscal quarter, was $1,819,711,619. 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 14, 2017, 141,220,481 shares of the registrant's Common Stock were outstanding.

DOCUMENTS INCORPORATED BY REFERENCE

Portions of the registrant's Definitive Proxy Statement for its 2017 Annual Meeting of Stockholders scheduled to be held on May 24, 2017, or the 2017 Proxy Statement, which will be filed with the Securities and Exchange Commission, or SEC, not later than 120 days after December 31, 2016, are incorporated by reference into Part III of this Annual Report on Form 10-K. With the exception of the portions of the 2017 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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FOR THE FISCAL YEAR ENDED DECEMBER 31, 2016

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PART I

Item 1. Business.

THE 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. Entegris seeks to leverage its unique breadth of capabilities to create value for its customers by developing mission-critical solutions to maximize manufacturing yields and enable higher device performance.

To produce faster and more powerful semiconductors, manufacturing technology has been rapidly moving to smaller process nodes, adopting new device architecture, such as FinFET transistors and 3D-NAND, and utilizing new and innovative manufacturing materials. Maximizing yields in this increasingly complex manufacturing environment requires the effective development and application of these new materials, a reliable and consistent supply, contamination-free transportation, storage and delivery, seamless integration into the semiconductor manufacturing process, and even higher levels of purity and contaminant control throughout the entire process.

Entegris is uniquely positioned to deliver advanced and specialty materials, free from contamination, with optimized packaging and delivery solutions, and in-process filtration and purification to ensure that liquid chemistries and gases are free from contaminants before reaching the wafer. Our technology portfolio includes approximately 20,000 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 (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 Advanced Materials Handling (AMH) segment 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. The Microcontamination Control (MC) segment offers solutions to purify critical liquid chemistries and gases used in semiconductor manufacturing processes and other high-technology industries. While these segments have separate products and technical know-how, they share a single, global sales force, unified core systems and processes, global technology centers, strategic and technology roadmaps, and a focus on a common set of customers. The Company leverages its expertise from these three segments technologies to create new and increasingly integrated solutions for its customers.

SEMICONDUCTOR INDUSTRY BACKGROUND

Semiconductors, or integrated circuits, are key components in modern electronic devices such as computers, smart phones, tablets, home appliances, digital cameras, televisions, light bulbs and automobiles. 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 provide specialty materials and chemicals utilized in many of these process steps, offer a broad range of products to monitor, protect, transport, and deliver these critical process materials during the manufacturing process and provide systems to purify liquid chemistry and gases throughout the manufacturing process. The process steps that rely most heavily on our products are described below.

Deposition. The two main deposition processes are physical vapor deposition, where a thin film is deposited on a wafer surface in a low-pressure gas environment, and chemical vapor deposition, where a thin film is deposited on a wafer surface using a gas medium and a chemical bonding process. In addition, electro-plating technology is used for the deposition of low resistance conductive materials such as copper. Our advanced precursor materials and electro-plating chemicals are utilized to enable the composition, uniformity and thickness of deposited films and our

filtration and purification products are used to remove defects and contaminants from liquids and gases used during the deposition process. These products are critical to ensuring the performance of the semiconductor circuit and, consequently, the manufacturing yield.

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 oversized 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

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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 that uses light to print, or pattern, 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 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 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. We expect an increased need for wet chemistries capable of selectively removing material at advanced technology nodes to drive demand for selective wet etch formulations.

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 and photoresists 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 assure the purity of these chemicals.

Transportation and Protection. Our wafer and reticle carriers are high-purity “micro-environments” that carry wafers between each of the above process steps, protecting them from damage and contamination during transportation. Front-end wafer processing can involve hundreds of steps and take several weeks. As a result, a batch of 25 fully processed wafers, the standard number of wafers that can be transported in one of our 200 mm and 300 mm products, can be worth several million dollars. It is essential that the wafer be well protected to minimize the risk of any damage. Our products enable semiconductor manufacturers to: minimize contamination (often measured in parts per trillion); protect semiconductor devices from electrostatic discharge and shock; avoid process interruptions; prevent damage or abrasion to wafers and materials during automated processing caused by contact with other materials or equipment; prevent damage due to abrasion or vibration of work-in-process and finished goods during transportation to and from customer and supplier facilities; and eliminate the dangers associated with handling toxic chemicals.

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

Semiconductor manufacturing continues to increase in complexity as new materials and new process technologies have been introduced to enable future generations of higher-performing and smaller devices and to achieve productivity gains for manufacturers. At advanced technology nodes, there has been an increasing need for innovative materials and the reliable, consistent and quality-controlled supply of these materials. These critical materials must be pure during the various stages of manufacture, from delivery to the manufacturer to point-of-use on the wafer. Manufacturers are requiring a greater level of integration of these materials into the manufacturing process and fab operation. We expect these trends to continue and to increase the need and demand for our advanced materials, our

products designed to monitor, protect, transport, and deliver critical materials and our purification solutions. We have been collaborating with our customers to develop new materials, to develop enhanced methods of filtration and purification and to introduce advanced materials packaging and monitoring capabilities that will address the challenges of the advanced technology nodes.

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.

The market for semiconductors has grown significantly over the past few decades. This trend is expected to continue as the Internet of Things, the connectivity of a broad range of devices, such as home devices, automobiles and smart grids, grows. We believe that the Internet of Things will drive growth in the demand for semiconductors and create significant opportunities for our products.

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Emerging applications relating to the autonomous car, cloud computing, machine learning and artificial intelligence, and virtual reality, along with 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.

Our customers require greater capabilities from their key materials suppliers. For example, our customers require that their suppliers demonstrate a focus on sustainability, scalability, and flexible manufacturing, with increasing importance on quality control capabilities. We have responded to these demands by deploying resources to enable us to align with the requirements of our customers and drive operational excellence. We believe these trends will allow us to leverage our manufacturing and operational capabilities, along with our broad technology portfolio, to become an increasingly important strategic supplier to our customers.

The semiconductor industry is currently undergoing consolidation, with a number of major firms merging or being acquired, and we have seen our customer base within the semiconductor industry consolidate. While we continue to strengthen our relationships in the semiconductor industry, we seek to leverage 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.

An additional factor that could spur future industry growth is semiconductor industry development in China, which currently represents a relatively small portion of global semiconductor production. Expansion and growth of the semiconductor industry in China could increase the need and demand for our products.

OUR BUSINESS STRATEGY

Our objective is to be a leading global provider of advanced materials and material handling and contamination control solutions used in processing and manufacturing in high-technology industries. We intend to leverage our market-leading position and strengthen our core business in the semiconductor industry. We will also build upon our position as a worldwide developer, manufacturer and supplier of advanced specialty materials, filtration and purification solutions, delivery systems, and materials packaging solutions to grow our business in other high value-added manufacturing process markets. Our strategy includes the following key elements:

Technology Leadership. We continuously improve our 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. 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.

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, 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 AMH segment. 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 believe our diverse expertise in areas of increasing importance to semiconductor manufacturers is a competitive advantage.

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 flexible product offerings for semiconductor device and capital equipment manufacturers as they seek to consolidate their supplier relationships and pursue advanced technology nodes.

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 in Taiwan and South Korea to support our important customers in these regions, established new sales and service offices in China in anticipation of a growing semiconductor manufacturing base in that country, expanded our presence in Singapore to enhance our global and regional management of supply chain and manufacturing processes, and increased our investment in advanced technology centers in Taiwan and South Korea. We service our customer relationships in Asia, Europe and the Middle East predominantly via direct sales and support personnel and to a lesser extent through selected independent sales representatives and distributors.

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Operational Excellence. We have established leading-edge manufacturing plants located in the United States, France, Malaysia, Japan, South Korea and Taiwan that possess the advanced manufacturing capabilities described under Manufacturing below. Our strategy is 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 quickly responding to customer feedback concerning prototypes and that has the ability to quickly commercialize and ramp production of prototypes accepted by our customers.

Strong Relationships with Broad Customer Base. We have strong relationships with our customers, which include leading semiconductor manufacturers, original equipment manufacturers (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 large 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.

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 any particular market.

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 and achieve benefits of increased scale. The ATMI acquisition is an example of this strategy, bringing 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. Finally, we are continuously evaluating opportunities for strategic alliances, such as the strategic alliance with Enthone, joint development programs and collaborative marketing efforts with key customers and other industry leaders.

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 (SCEM);

Advanced Materials Handling (AMH); and Microcontamination Control (MC). The Company leverages its expertise from these three segments to create new and increasingly integrated solutions for its 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 and safe and efficient delivery systems to support semiconductor and other advanced manufacturing processes. Utilized in critical semiconductor manufacturing processes such as deposition, cleaning, and integration of complex materials, these products enable enhanced device performance. When used in conjunction with products from our MC and AMH segments, these materials provide unique solutions to advance semiconductor manufacturing processes.

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Specialty Gas Products. Our specialty gas solutions provide advanced safety and process capabilities to semiconductor manufacturers. Our SDS cylinders store and deliver hazardous gases, such as arsine, phosphine, germanium 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, providing significant safety and environmental improvements over traditional high-pressure cylinders, and allow more process gas to be stored in the cylinder, providing significantly higher rates of productivity than traditional methods of gas delivery. New generations of SDS products further dramatically increase the gas storage capacity, reducing tool down time and, therefore, resulting in significant cost savings for our customers. We also offer VAC, a complementary technology to SDS where select implant gases are stored under high pressure but delivered sub-atmospherically.

Specialty Materials Products. Specialty materials products are made from specialized graphite, silicon carbide and/or a variety of unique, high purity coatings and serve as critical components in semiconductor manufacturing equipment at various stages of the semiconductor manufacturing process, including dry or plasma etch, chemical vapor deposition and ion implant. Our POCO® premium graphite is used to make precision consumable electrodes for electrical discharge machining, hot glass contact materials for use in glass product manufacturing and forming, and a number of graphite consumable products for various industrial applications, including aerospace, optical, medical devices and printing. Our high-performance specialty coatings, such as our Pegasus™ coatings, provide corrosion and erosion resistance and desired conductivity, minimize particle generation and prevent contamination on critical components used in semiconductor and other high-technology manufacturing operations.

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, such as our UltraPur™ 4MS and UltraPur™ TEOS products. 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 and integrate the surface of a semiconductor wafer during the manufacturing process. For example, our Viaform® product (a trademark of and exclusively licensed from Enthone Inc. (Enthone), a subsidiary of Alent plc (acquired by Platform Specialty Products Corporation in late 2015)) includes inorganic and proprietary organic molecules that provide the wiring for copper interconnects and allows manufacturers to eliminate processing steps. 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 resulting in improved capability and consistency in our customers' processes. Our line of consumable PVA roller brush products are used to clean the wafer following the CMP process and our line of pad conditioners, based on our silicon carbide capabilities, offer unique preparation solutions for each distinct CMP pad application, with significant improvement in CMP pad life.

ADVANCED MATERIALS HANDLING SEGMENT

The AMH segment 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. These systems and products improve our customers’ yields by protecting wafers from abrasion, degradation and contamination during 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. The effective management and maintenance of the entire fluidics system, from initial production of process chemistry, to transportation and dispensing onto the wafer, is critical to enhance device yield.

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. We also offer a front-opening shipping box, or FOSB, for the transportation and automated interface of 300 mm wafers.

We provide front opening unified pods, or FOUPs, wafer transport and process carriers and standard mechanical interface pods, or SMIF pods, which meet a spectrum of industry standard wafer handling needs, in sizes up to

300mm. These microenvironment products safely and accurately deliver wafers to the various process fabrication steps and are optimized with filtration products from our MC segment to ensure the purest ambient environment around the wafer.

Chemical Containers. We produce a wide range of flexible packaging and polymer containers that chemical companies use to ship process chemistries to semiconductor fabs. Our packaging ensures the purity of the chemistry during transportation to enhance yields for the fab. We optimize the compatibility and performance of these products on chemistries through close collaboration with our SCEM segment. We have a broad portfolio of packaging products, from low-volume containers to transport high-value photoresist chemistries, such as our NOWPak® products, to large intermediate bulk containers, or IBCs, for high volume chemical consumption, such as our FluoroPure® products.

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Fluidics. We are a leader in high-purity fluid transfer products such as valves, fittings, tubing, pipe, custom fabricated products and associated connection systems, such as our PrimeLock® connections, for high-purity chemical applications. Our comprehensive product line provides our semiconductor manufacturers, process tool makers and chemical customers with a single-source provider for their process chemical management needs throughout the manufacturing process.

Our patented digital valve control technology improves chemical uniformity on wafers and improves ease of optimized system operation. Our IntelliGen® integrated high-precision liquid dispense systems enable the uniform application of advanced chemistries during the wafer fabrication process, integrating our valve control and 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.

The AMH segment collaborates closely with the SCEM segment in developing products that are compatible with advanced chemistries to enhance yield, while integrating liquid filtration technology from our MC segment to deliver the most consistent, defect-free chemistry.

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 chemistry and gas filtration and purification products are critical to the semiconductor manufacturing process because they directly reduce defects and improve manufacturing yield. Our proprietary filters remove chemical and nanometer-sized contaminants and bubbles from the different fluids and gases used in the manufacturing process, including photolithography, deposition, planarization and surface etching and cleaning. Our products prevent defects that could result contamination altering the physical and electrical properties of our customers' products.

Liquid Microcontamination Control Products. We offer a variety of unique products that are optimized to control contaminants in our customers' liquid processes. Our Torrento® series of filters is an example of one line of our products used in leading-edge applications for the filtration of aggressive acid and base chemistries for both semiconductor fabs as well as specialty chemical manufacturers including our SCEM segment. 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. Our metal filters, such as stainless steel and nickel filters, reduce out gassing and improve corrosion resistance. Our purifiers chemically react with and absorb contaminants, such as oxygen and water, to prevent contamination, and our vent diffusers reduce particle contamination and processing cycle times. Our GateKeeper® gas purifiers leverage technology developed from our SCEM segment and effectively remove 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 without adding particles to the wafers under process.

Other products. We also offer our eVOLV™ wet chemical process to recycle electronic waste and recover precious metals and other high-value materials from discarded printed circuit boards and semiconductor chips.

OUR CUSTOMERS AND MARKETS

Our most significant customers include semiconductor device manufacturers, OEMs that provide equipment to semiconductor device manufacturers, gas and chemical manufacturing companies, leading wafer grower companies and manufacturers of high-precision electronics. We also sell our products to flat panel display OEMs, materials suppliers and manufacturers, primarily in in Japan, Korea, China and other parts of Asia.

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

In 2016, 2015 and 2014, net sales to our top ten customers accounted for 45%, 44% and 42%, respectively, of combined net sales. In 2016, 2015 and 2014, one customer, Taiwan Semiconductor Manufacturing Company Limited, accounted for $161.9 million, $134.1 million and $130.9 million of net sales, respectively, or approximately 14%, 12% and 14% of our net sales, respectively, including sales from each of our three reporting segments. International net sales represented 78%, 77% and 75%, respectively, of net sales in 2016, 2015 and 2014. Approximately 2,300

customers purchased products from us during 2016.

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.

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SALES, MARKETING AND SUPPORT

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, 2016, our sales and marketing force consisted of 478 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 products. Our sales representatives provide our customers with worldwide 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 the United States and approximately ten other countries, 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:

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

We believe that we compete favorably with respect to all of the factors listed above, but there are no assurances that we will continue to do so. 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, narrow-portfolio focused companies. 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. Key competitors include Pall Corporation (which was acquired by Danaher Corporation in 2015), Shin-Etsu Polymer Co., Ltd., Gemu Valves, Inc., Tokyo Keiso Co., Ltd., Mersen (France), Versum Materials, Inc., DuPont Electronic Technologies, Dow Chemical Company (including Rohm and Haas), Air Liquide, Praxair, Inc., SAES Pure Gas, Inc., Donaldson Company, Inc. and Parker Hannifin Corp.

ENGINEERING, RESEARCH AND DEVELOPMENT

We believe that technology is important to success in each 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 2016, 2015 and 2014 were $107.0 million, $105.9 million and $87.7 million, respectively. As of December 31, 2016, we had 436 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 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.

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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 solid precursors for deposition, specialty coatings for key applications and new CMP pad conditioners. 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, Connecticut, Minnesota, Massachusetts, Colorado, Texas, Japan, Korea, Taiwan, France, China, 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.