SEMICONDUCTOR INDUSTRY ASSOCIATION

August 6, 2025

Via Regulatory Portal

Ms. Julia Khersonsky
Deputy Assistant Secretary for Strategic Trade
Bureau of Industry and Security
U.S. Department of Commerce
1401 Constitution Avenue, NW
Washington, D.C. 20230

cc. Mr. Stephen Astle, Director, Defense Industrial Base Division, Office of Strategic Industries and Economic Security

Re: Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Polysilicon and its Derivatives

Dear Ms. Khersonsky,

The Semiconductor Industry Association (SIA) welcomes the opportunity to respond to the Bureau of Industry and Security's (BIS) *Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Polysilicon and its Derivatives* 90 Fed. Reg. 15950 (July 16, 2025) (the "Notice").

SIA has been the voice of the U.S. semiconductor industry for nearly half a century. Our member companies, representing more than 99 percent of the U.S. semiconductor industry by revenue, as well as major non-U.S. chip firms, are engaged in the full range of research, design, manufacture, and back-end assembly, test, and packaging of semiconductors. SIA also represents a range of semiconductor ecosystem suppliers including companies that manufacture critical semiconductor materials and their derivatives, such as high-purity polysilicon and silicon wafers, respectively.

Semiconductors are historically a top U.S. export sector, running a healthy trade surplus for nearly three decades.[1] The semiconductor was invented in America more than 65 years ago, and the U.S. semiconductor industry remains the global leader in semiconductor technology and innovation, driving America's economic strength, national security, and global competitiveness in a range of downstream industries. More information about SIA and the semiconductor industry is available at www.semiconductors.org.

Strengthening U.S. semiconductor supply chains is a top priority for SIA and its members in our efforts to support U.S. economic security and national security, and to maintain global

[1] U.S. International Trade Commission, "DataWeb," accessed March 3, 2025, HTS codes: 8541 (excluding photovoltaic cells and modules) and 8542.

technological leadership. We support President Trump's goal of reshoring U.S. semiconductor manufacturing. To that end, as the Trump Administration pursues a strategy in support of U.S. semiconductor manufacturing, it is critically important to advance policies designed to make U.S. semiconductor production cost-effective, maintain the U.S. lead in design and core intellectual property development and the manufacture of critical inputs such as polysilicon, and increase demand for end-market products that incorporate chips—both here at home and abroad.

Firms involved in semiconductor manufacturing rely on specialized material suppliers. The production of semiconductor-grade polysilicon is a necessary step in the semiconductor production process. This ultra-pure polysilicon is further processed into silicon wafers used to manufacture chips. This submission will discuss the difference between semiconductor-grade polysilicon versus similar but distinct material used for other industries, as well as for silicon wafers, the primary derivative product of polysilicon used in semiconductor manufacturing.

We urge the administration to work closely with SIA and its member companies in crafting trade and economic policies that will achieve our shared goal of advancing U.S. leadership in advanced semiconductor technology and materials, and supporting industry investments in building new U.S. capacity, including by maintaining cost-competitive access to critical inputs such as semiconductor-grade polysilicon and silicon wafers.

I. Production and Use of Polysilicon and Silicon Wafers in Semiconductor Manufacturing

Semiconductor manufacturing begins with production of the wafer, i.e., a thin, round slice of a semiconductor material varying in size from 6 inches to 12 inches in diameter. The production of semiconductor substances, like semiconductor-grade polysilicon, are necessary processes required to produce semiconductor wafers and ultimately manufacture a semiconductor device. Gallium nitride, gallium arsenide, silicon carbide, germanium, and others undergo similar processes to produce compound semiconductor wafers, which we understand to be outside the scope of this investigation.

The production stages for polysilicon and silicon wafers in the semiconductor supply chain are as follows:

- **Mining and Refinement of Metallurgical Grade Silicon:** Silicon dioxide, also known as silica which is found in sand, is mined and refined into metallurgical grade silicon. Metallurgical grade silicon is used by the aluminum, steel, chemical, and electronics industries due to its deoxidizing/alloys-building and semi-conductive properties. U.S. government experts estimated that polysilicon accounted for about 12% of metallurgical grade silicon shipments in 2022.[2] Metallurgical grade silicon is classified in the harmonized

[2] U.S. Department of Energy, "Solar Photovoltaics: Supply Chain Deep Dive Assessment," February 24, 2022. https://www.energy.gov/sites/default/files/2022-02/Solar%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf

tariff schedule of the United States (HTSUS) under HTS codes 2804.61.00 and 2804.69.10, depending on level of purity.[3]

- **Polysilicon Production:** Metallurgical grade silicon is processed into ultra-pure polysilicon rods. These rods are broken down into chunks and chips that are sold to wafer producers. Polysilicon is classified under HTS code 2804.61.00.

  Ingot and Blank Wafer Production: Ultra-pure polysilicon is melted down and further processed into large monosilicon crystal ingots (e.g., 7 feet and 600lbs for 300mm ingots) with perfect atomic alignment throughout the entire structure. During this essential mono-crystal growth process, final semiconductor chip parameters are initially defined. Silicon ingots are classified under HTS 3818.00.00.

  Cylindrical crystal ingots are further processed to achieve a uniform diameter, after which diamond saw blades slice the ingot into usable, thin wafers. The cut wafers are refined and modified through a series of mechanical and chemical processes and undergo a variety of additional process steps (e.g., polishing, epitaxial deposition, bonding, etc.) depending on final chip application. Silicon wafers in this form are classified under HTS 3818.00.00 and are now ready to be sent to chip fabrication facilities, where they are used as the foundational starting material for manufacturing integrated circuits.

For a more fulsome explanation of the semiconductor development and manufacturing process, see Appendix A and the SIA and Boston Consulting Group's report, "Emerging Resilience in The Semiconductor Supply Chain."[4]

II. Polysilicon used for semiconductors vs other industries

It is important to distinguish polysilicon by its purity grade, which determines the product's final end use. The semiconductor and solar industries are the two major consumers of polysilicon, accounting for 2.4% and 97.6% of annual consumption—forecasted at 33,500 metric tons (MT) and 1,379,400 MT in 2025, respectively (See Figure 1). Polysilicon used for semiconductors—or electronic grade material—requires the highest level of purity, equal to or greater than 99.999999999% (11 nines, or "11"N). By contrast, polysilicon used in the solar industry is of a lesser grade, generally requiring 6N to 10N (99.9999% to 99.99999999%) purity to produce solar wafers.

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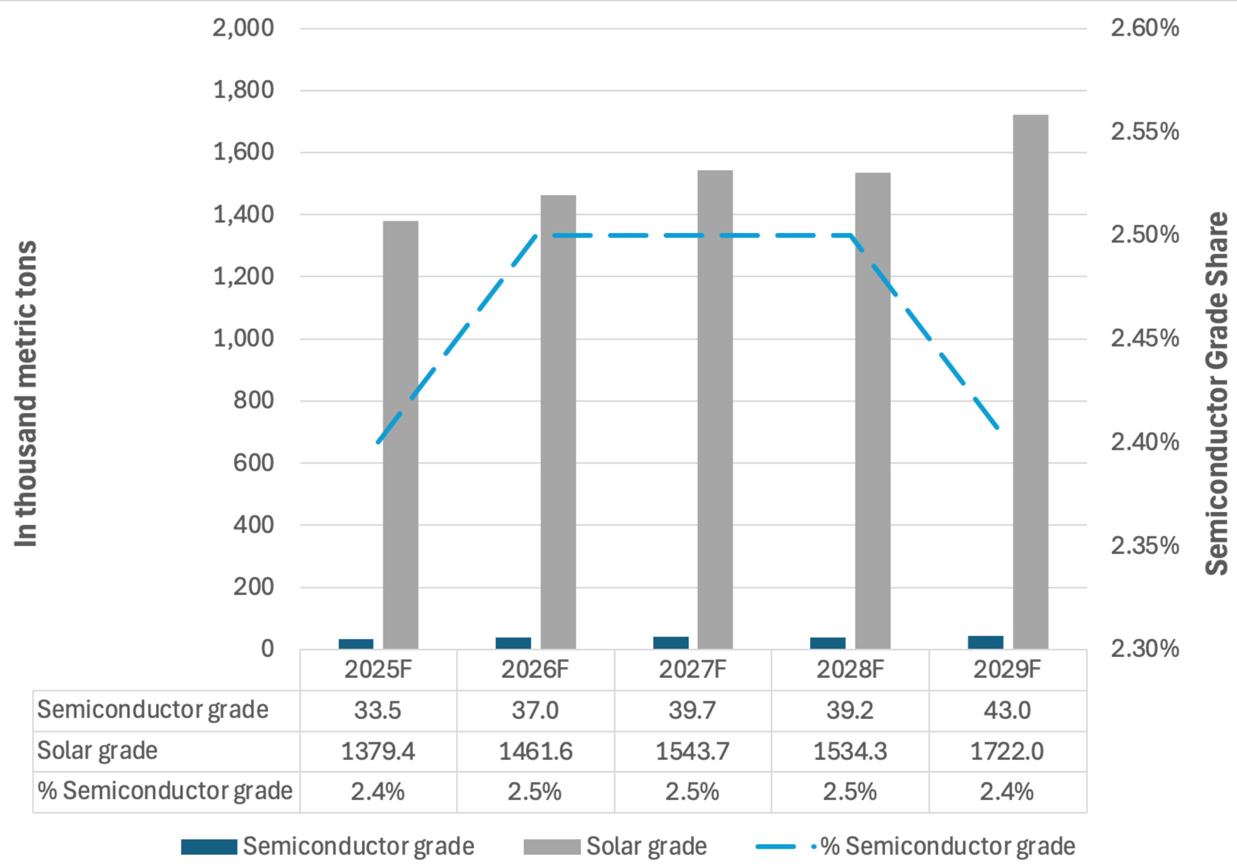
[3] U.S. International Trade Commission, "Silicon Metal from Bosnia and Herzegovina, Iceland, and Kazakhstan," Publication 5180, April 2021. https://www.usitc.gov/publications/701_731/pub5180.pdf

[4] SIA and Boston Consulting Group, "Emerging Resilience in The Semiconductor Supply Chain," May 2024. https://www.semiconductors.org/wp-content/uploads/2024/05/Report_Emerging-Resilience-in-the-Semiconductor-Supply-Chain.pdf

Figure 1: Forecasted Demand for Semiconductor- v Solar- Grade Polysilicon, 2025–29 (MT)



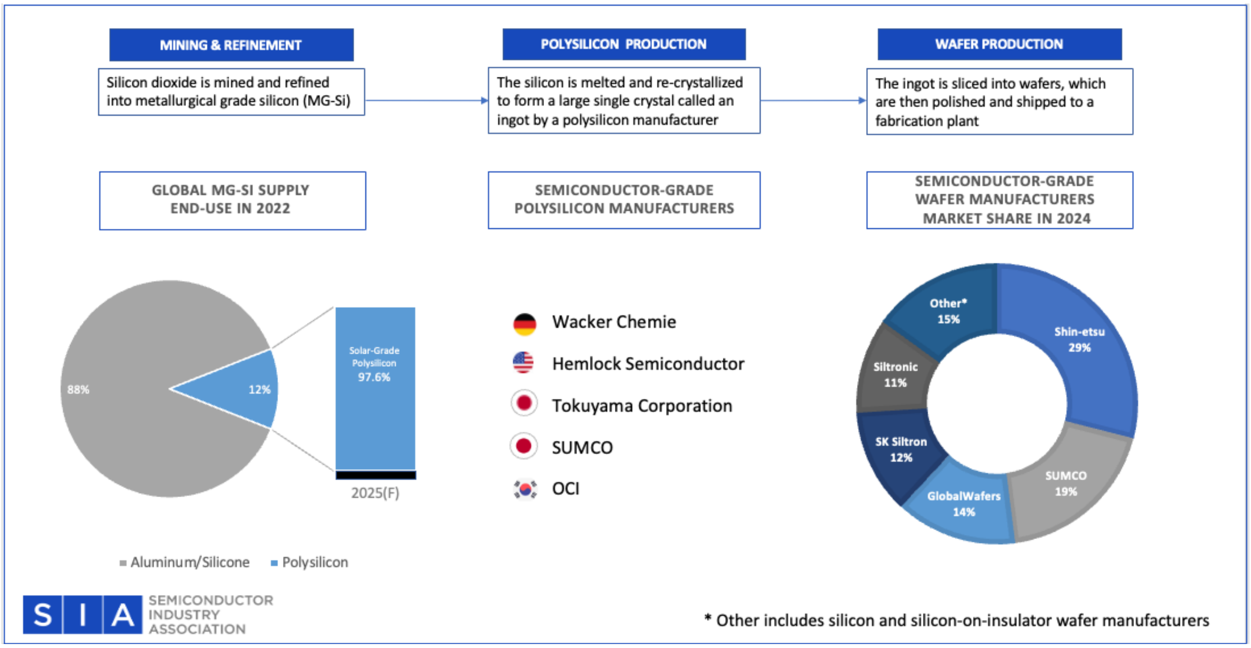
	2025F	2026F	2027F	2028F	2029F
Semiconductor grade	33.5	37.0	39.7	39.2	43.0
Solar grade	1379.4	1461.6	1543.7	1534.3	1722.0
% Semiconductor grade	2.4%	2.5%	2.5%	2.5%	2.4%

Source: TECHCET, estimates for photovoltaic (PV) based upon BloombergNEF installation forecasts.

Five suppliers represent the majority of global semiconductor-grade polysilicon manufacturing: Wacker Chemie (Germany), Hemlock Semiconductor (USA), Tokuyama Corporation (Japan), Sumco (Japan), and OCI (Korea). Wacker and Hemlock account for approximately three-quarters of the global semiconductor polysilicon market share. The semiconductor wafer market is similarly concentrated, with five suppliers representing the majority of semiconductor wafer production, namely Shin-Etsu Handotai and Sumco headquartered in Japan but with U.S.-based capacity in Washington and Arizona, and New Mexico, respectively; GlobalWafers, headquartered in Taiwan but with U.S.-based capacity in Texas and Missouri; SK Siltron, headquartered in South Korea but with U.S.-based capacity in Michigan;[5] and Siltronic, headquartered in Germany but with U.S.-based capacity in Oregon (See Figure 2). U.S.-based capacity of semiconductor wafers alone cannot meet rising domestic demand, particularly for advanced silicon wafers (e.g., 300mm advanced wafers) used for artificial intelligence and other high-performance applications.

[5] SK Siltron's capacity in Michigan is dedicated to the production of silicon carbide wafers.

Figure 2: Semiconductor-Grade Polysilicon and Derivatives Supply Chain



Source: SIA analysis on U.S. Department of Energy and TECHCET data.

Forecasted annual global demand for solar-grade polysilicon in 2025 is 1,379,400 MT, whereas demand for semiconductor-grade polysilicon is projected to reach only 33,500 MT, or 2.4% of total demand (See Figure 1). Though the market for semiconductor-grade polysilicon is distinct from the market for solar-grade polysilicon, companies that manufacture semiconductor-grade polysilicon, particularly domestic producers, depend on high-volume production of solar-grade polysilicon to achieve economies of scale and capacity utilization rates necessary to produce the ultra-pure polysilicon for semiconductor manufacturing.[6] Industry experts estimate that the cost to produce semiconductor-grade polysilicon can be up to 30 times greater than the cost of producing solar-grade polysilicon.[7]

The markets for solar-grade versus semiconductor-grade polysilicon also operate very differently. The market share positions of semiconductor-grade and solar-grade polysilicon have shifted over the last 25 years due in part to government incentives. The solar-grade polysilicon market experiences greater price volatility, can be bought via spot prices, and is primarily concentrated in China due to government subsidies that have fueled overproduction. China is the leading global producer of polysilicon with a 94.7% total production capacity of which 98% is production capacity for solar-grade polysilicon.[8] However, Chinese producers currently lack the equipment and know-how to produce semiconductor-grade polysilicon at scale.

[6] BIS, "Transcript: Virtual Forum for Risks in the Semiconductor Manufacturing and Advanced Packaging Supply Chain," April 8, 2021. https://www.bis.doc.gov/index.php/documents/pdfs/2744-virtual-forum-for-risks-in-the-semiconductor-manufacturing-and-advanced-packaging-supply-chain-unofficial-transcript/file
[7] TECHCET, "2025-2026 CMR™ Silicon Wafers," June 26, 2025. https://techcet.com/product/silicon-wafers/
[8] Johannes Bernreuter, "The Polysilicon Market Outlook 2029," June 24, 2025. https://www.bernreuter.com/polysilicon/industry-reports/polysilicon-market-outlook-2029/.

Despite the differences between markets for solar- and semiconductor-grade polysilicon, their production is intertwined. Because of economies of scale needed to produce semiconductor-grade polysilicon, firms must produce high volumes of solar-grade polysilicon to sustain capacity utilization. Therefore, impacts to the market for solar-grade polysilicon affect the market for semiconductor-grade polysilicon. While the fair market value for U.S.-produced solar-grade polysilicon is $24/kg, we understand from SIA member companies that Chinese producers sell solar-grade polysilicon for one-fifth of this value.

Despite the important differences, there is no distinction between high-purity polysilicon used for semiconductors versus material used for solar uses in the HTSUS—imports of both forms of polysilicon are classified under HTS 2804.61.00. As such, trade data does not provide a nuanced picture of polysilicon imports at different stages of processing and for different segments of the supply chain.

III. Silicon Wafers

Enabled by semiconductor-grade polysilicon, the silicon wafer market is a lynchpin for the global electronics ecosystem, providing the essential monocrystalline ultra-pure silicon substrate for the majority of semiconductors, from memory and logic chips to the most advanced AI and high-performance compute devices. A semiconductor product requires silicon wafers to meet very exacting specifications and must be qualified by both the manufacturer and the end customer.

As noted previously, silicon wafers are thin, circular slices of monosilicon ingots, and most integrated circuits are fabricated on top of this base material. The global semiconductor industry purchases $13.5 billion of silicon wafers annually, with projected growth to $18.3 billion by 2029, implying a compound annual growth rate of 6.4%.[9] This expansion is driven by strong demand for semiconductors in applications such as AI, 5G, IoT, automotive electronics, and consumer devices. Demand for semiconductor devices is driving growth in the silicon wafer market, with revenues for these devices projected to increase at a compound annual growth rate of 9.8% between 2024 and 2026.[10]

U.S. imports of silicon wafers play a critical role in meeting domestic demand, particularly for 300mm advanced wafers. U.S. silicon wafer revenue was estimated at $1.45 billion dollars in 2024.[11] The top import sources of silicon wafers are Japan, Taiwan, South Korea, and China (See Figure 3). The silicon wafer market is also highly concentrated. The six largest silicon wafer producers account for 92% of the global silicon wafer market. These firms actively invest in research and development to improve manufacturing processes, wafer quality, and develop new substrates like silicon-on-insulator wafers for better performance.

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[9] The total market includes fully depleted silicon on insulator (FD-SOI) wafer shipments. Ibid.

[10] SIA analysis on data from the World Semiconductor Trade Statistics (WSTS). WSTS, "Forecast: Spring 2025—Busan 2025," June 30, 2025.

[11] Revenue figure was for the Americas region. We are proxying that regional figure to the United States. Ibid.

Figure 3: U.S. imports of silicon wafers by country, 2020-24 (in actual USD)

Country	2020	2021	2022	2023	2024
Japan	708,509,610	726,137,933	838,220,453	573,259,418	624,743,863
Taiwan	191,227,040	210,104,914	259,798,548	153,404,225	202,135,504
S. Korea	149,981,421	158,940,371	188,556,916	199,078,073	184,747,426
China	46,828,394	112,983,868	192,844,150	189,651,579	140,931,265
Germany	121,613,014	141,122,885	160,940,279	107,654,155	117,344,973
France	98,655,628	134,181,994	133,182,177	76,231,004	69,939,854
All others	185,653,365	194,813,445	230,065,020	201,129,193	188,064,663
Total	**1,502,468,472**	**1,678,285,410**	**2,003,607,543**	**1,500,407,647**	**1,527,907,548**

Source: U.S. International Trade Commission, "DataWeb," Accessed on July 29, 2025.
Note: Silicon wafers reported are tracked under HTS 3818.00.00.

China is emerging as a potential competitor in the silicon wafer market. Industry experts have found that there is a large, concerted effort by the government to subsidize Chinese firms to domestically manufacture 200mm and 300mm silicon wafers.

IV. Conclusion

SIA and its members greatly appreciate the opportunity to comment on this investigation of imports of polysilicon and its derivatives. We urge BIS to consult closely with SIA and our member companies to understand and consider how potential trade action with respect to polysilicon and its derivatives may impact the semiconductor industry in the United States.

SIA and our member companies stand ready to work with BIS to reinforce U.S. economic strength, national security, innovation, and technology leadership. SIA is happy to answer any additional questions or respond to any additional requests for information. Please contact Carrie Esko (cesko@semiconductors.org) or Jaclyn Kellon (jkellon@semiconductors.org) with any follow-up requests.

Appendix A: Background on Polysilicon and Semiconductor Silicon Wafer Production

Polysilicon and Other Semiconductor Wafer Raw Material:

Semiconductive raw materials used to make a semiconductor wafer and device include, but are not limited to, semiconductor-grade polysilicon, silicon carbide, gallium nitride, gallium arsenide, or other compounds. During semiconductor wafer production, these semiconductive substances undergo processes not limited to crystal growth, wafer singulation, grinding or lapping, etching, polishing, cleaning, characterization, bonding, epitaxy, and packaging to make a final semiconductor wafer. These transformative process steps are integral to semiconductor wafer production and the manufacturing of a semiconductor device.

In the case of a silicon wafer, for example, its formation can be traced all the way back to its most basic raw material—common sand. Silicon is the second most abundant element in the Earth's crust, mostly in the form of silica (SiO2) sand which in this state has no useful value to the semiconductor industry. By going through carbothermic reduction silica is transformed into metallurgical grade silicon, at which point it is about 98% pure silicon, but with no defined crystal orientation. The vast majority of metallurgical grade silicon is used for production of ferrosilicon (i.e., used in steel manufacturing), but it is still of no use in the semiconductor industry due to its low purity.

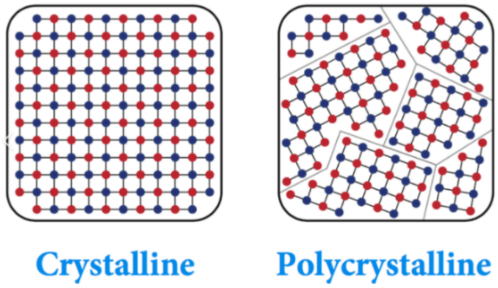
To achieve a substance with the purity needed for silicon wafer manufacturing, the metallurgical grade silicon must go through a further refinement called the 'Siemens' process. This process converts the silicon to a gaseous compound that is subsequently distilled to remove impurities and then decomposed in order to deposit back into a solid, polysilicon form. The majority of silicon in this form is used for the solar industry with the second largest consumer being semiconductor-grade silicon wafer manufacturers. The manufacture of semiconductors requires ultra-pure polysilicon produced to a purity level of at least eleven "9's"—that is, 99.999999999% pure. This form of polysilicon is the main raw material used to make silicon wafers and it is made only for use in semiconductor wafer manufacturing. Yet in this state, the pure form of polysilicon still requires a monosilicon crystal growth process to create the electrical properties required to produce a semiconductor silicon wafer.

Semiconductor Ingot Production:

In the case of silicon, before turning raw polysilicon into a semiconductor silicon wafer, it must go through a crystal growth process (e.g., the Czochralski method) to convert it into monosilicon, meaning that an entire single crystal silicon ingot will be grown from a seed crystal with perfect atomic alignment throughout. Other semiconductor substances, such as silicon carbide or gallium nitride, go through similar processes to create crystalline structures in the form of boules or ingots.

This highly technical process cannot be started without first having the finished chip fabrication specification. This specification is essential because the crystal growth process will define the final semiconductor wafer parameters of diameter, crystal orientation, resistivity, and supporting elements such as oxygen, nitrogen, and carbon. All these parameters are critical to the final fabrication process and to chip performance. Importantly, these chip parameters are defined by the crystal growth process as well as by the crystal prep materials used, including the crystal seed, dopant, polysilicon, and proprietary chemical compounds. Further, due to the natural segregation of impurities in silicon, crystal growth is itself a refining process that leaves impurities in the 'pot scrap' that are later discarded after the growth of the silicon ingot.

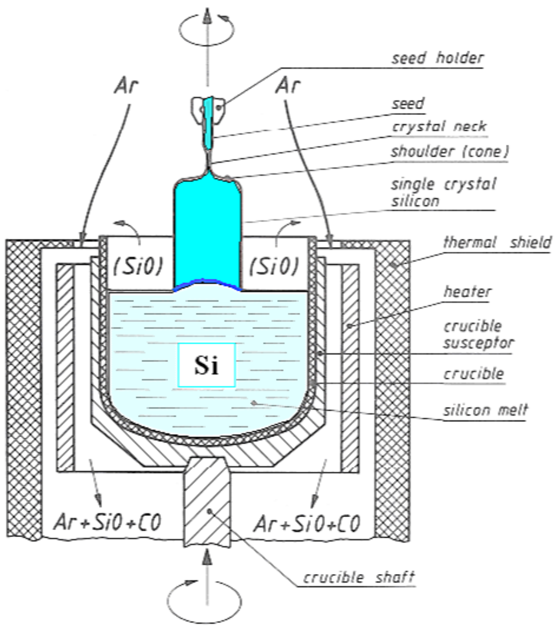
A Monosilicon Crystal is Required for Semiconductors

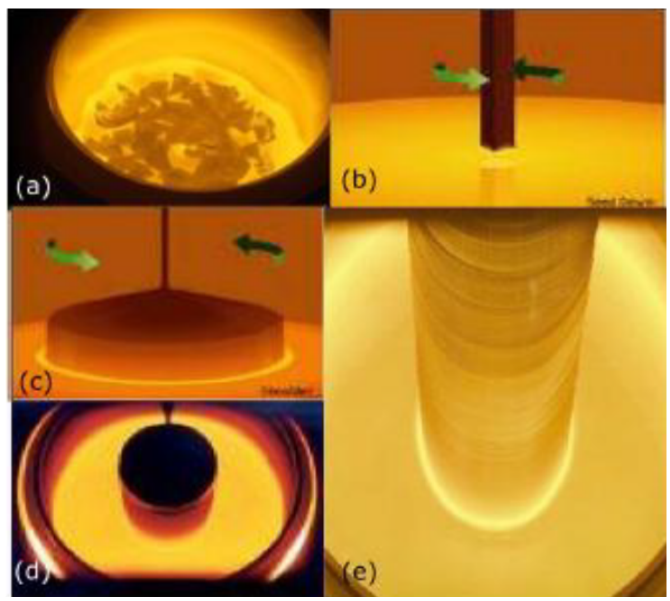


Source: www.researchgate.net

Once the monosilicon crystal is grown, it is of a purity and crystal quality sufficient for downstream semiconductor and wafer processing. In short, monosilicon crystal growth is where the final chip parameters are initially defined. For this reason, crystal preparation and growth is the beginning of the semiconductor wafer manufacturing process.

The Czochralski Method





Source: www.tf.uni-kiel.de

Source: www.researchgate.net

From Semiconductor Ingot to Semiconductor Wafer:

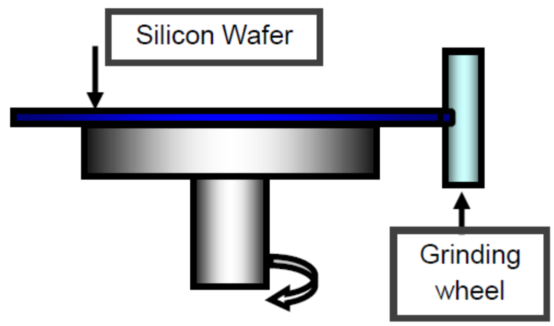
After crystal growth, the 'wafering' processes commence to transform the ingot into the final physical dimensions, surface finish, and cleanliness of a semiconductor wafer. Wafering begins with grinding the ingot axially, removing excess material, and aligning the sides of the ingot perfectly with the internal crystal lattice orientation. Once aligned, the ground 'rod' is x-rayed and a small notch is ground along the length of the rod to locate the customer's desired crystal axis. This orientation is critical for the fab, as it will impact carrier mobility, a key fab-designed characteristic. Next, the 'tops' and 'tails' are cropped and the ingot is cut into segments of manageable length. These segments go through a subsequent x-ray process before being sliced into individual wafers. This second x-ray process ensures the surface of the wafer is also aligned with the internal crystal lattice.

Modifying and Refining the Semiconductor Wafer:

After slicing, the wafers are a dull gray color and possess a rough surface. The subsequent 'refining' steps bring the surface features into a near perfect match of the wafer's internal crystal structure. This begins with the edge grind process. After slicing, the edge is square, sharp, and fragile. By grinding a bevel on the edge, stress concentrators are eliminated and the wafer becomes significantly more durable, which is why this step takes place so early in the overall process. Like crystal axis orientation, the wafer edge characteristics are customer defined, and the fab's lithography and cleaning steps are tuned to specific wafer edge shape features. Next, the wafers go through either a double side grind or lap process that removes much of the surface damage caused by slicing, improves flatness, and brings the thickness closer to the customer specification. The wafers then undergo a lasermark step to scribe unique identifiers on each individual wafer. This is a key feature as every single die in the fab must be traceable back to each piece of equipment that was used to form the wafer from which the die was made. This concludes what is known as the 'modifications' processes.

Refining the Wafer

Source: www.semicon.edu.vn



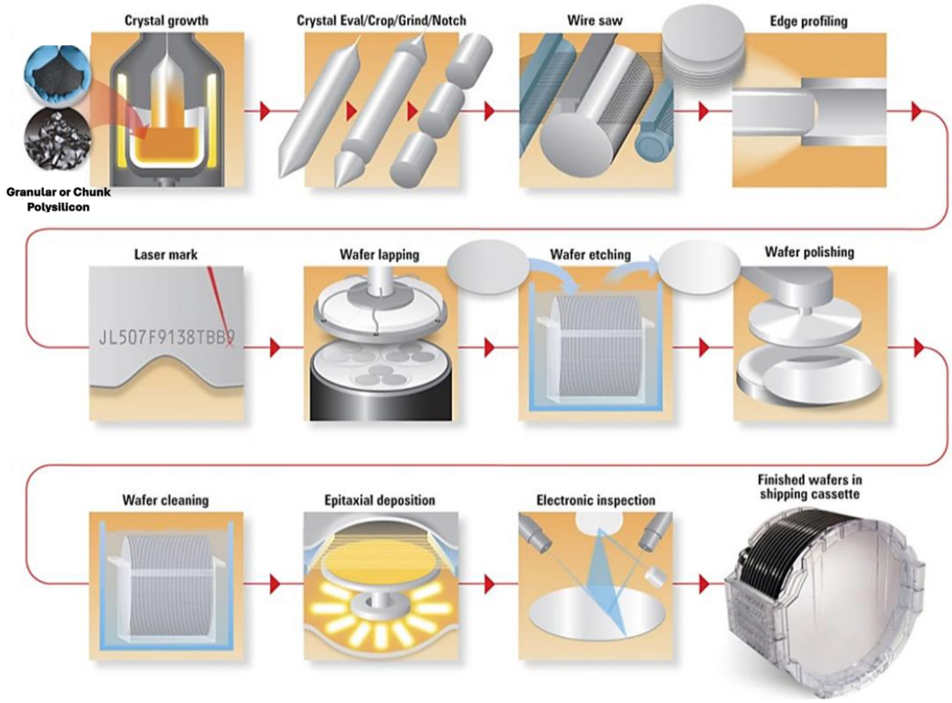
Source: www.globalwafers.com

Polishing, the next refinement stage, begins with a chemical etching process that removes internal stress, improves surface damage, and brings the wafer closer to the final thickness target. After etching, the wafers proceed to a double sided polish step that eliminates surface damage, improves flatness, and brings the wafers to a mirror finish surface condition. This is followed by edge polishing to accomplish the same outcome on the edge of the wafer. At this point the wafers have a mirror-like polished surface and the back of the wafer has now reached a finished state. As a final step, the front surface is then polished one last time to further reduce surface roughness.

Cleaning and Inspection:

Once fully polished, the wafers then go through a final cleaning process, which makes them ready to be fully characterized and sufficiently pure to enter a semiconductor fab. The characterization process involves two primary aspects, flatness and surface inspection. During inspection thousands of data points are collected on each wafer and shared with the customer to ensure the wafers meet customer expectations. This data also enables the client to correlate fab performance to incoming wafer characteristics.

Semiconductor Wafer Manufacturing at a Glance

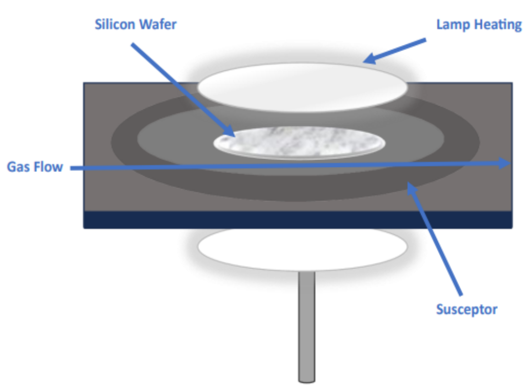


Source: www.memc.com

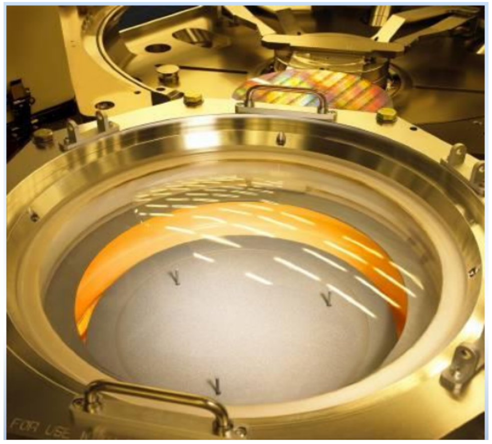
Further Processing Depends on Application:

For some chip segments like memory, clean and inspected wafers are ready to be sent to the customer fab as 'polished wafers.' At this point, the polished wafers proceed to a 'holding' step where all upstream inspection information- all the way back to crystal formation- is assembled and analyzed to confirm it meets customer requirements. If acceptable, the wafers undergo a vaccuum packaging process and are double bagged to maintain their pristine condition during transport. The packaged product is given unique labels to assign to the specific customer and part number to which they were designed.

Epitaxy Production



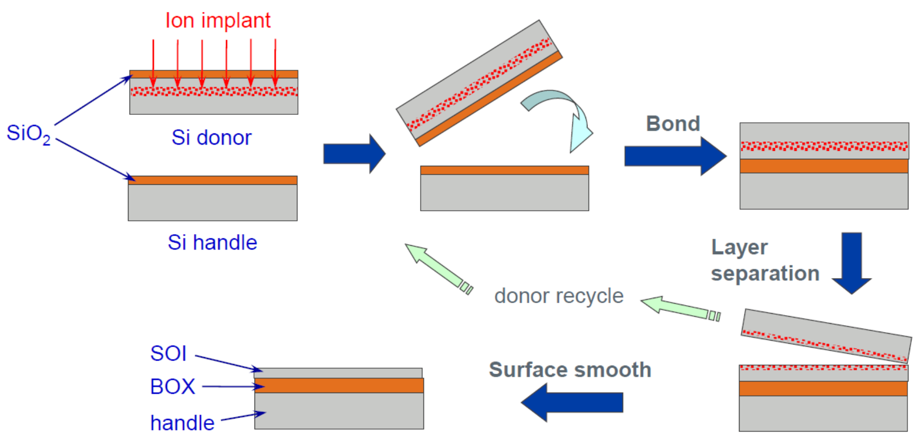
Source: GlobiTech



Source: www.nccavs-usergroups.avs.org

For other market segments, like logic and power, the wafer process includes additional customer-defined downstream layering, the most common being the epitaxy process. Epitaxy immediately follows the final cleaning process and involves depositing a perfect monocrystalline layer of silicon on top of the finished polished wafer. Depending on the fab's chip design, this 'epi' layer is often of a different resistivity or even dopant than the polished wafer. Other applications such as radio frequency (RF) semiconductors require wafers produced with more extensive and intricate processing such as the Silicon-on-Insulator (SOI) wafer. SOI wafers require an oxide layer underneath the silicon device layer. Epitaxy is not possible on an oxide layer, so specialized implant, bonding, and cleaving steps are required. Other customers require specialized backside layers to assist in impurity isolation or backside 'sealing'.

Silicon on Insulator



Source: Veendrick, H.J.M. (2017). Manufacture of MOS Devices. In: Nanometer CMOS ICs. Springer, Cham.

After epi, SOI or other additional processing, these wafers, like polished wafers, are vacuum packed, double bagged, and transported to the customer's fab, where they will undergo additional steps in the semiconductor manufacturing process.

Wafer Manufacture:

It is important to note that in addition to the major steps described above, there are several internal steps for process control, cleaning, inspection, and characterization. While not all of these steps have a major impact on the physical characteristics of the wafer itself, they are critical to maintain the process and certify to the customer that the final wafer meets their demands.

Manufacturing semiconductor wafers is a highly technical and IP-intensive process that takes years to perfect. Wafer manufacturers utilize much of the same expensive and specialized equipment and materials that final chip manufacturers do, including automation tools, polishers, cleanroom design, cleanlines, metrology equipment, specialized chemical gases, and dopants. By the time a wafer is delivered to the chip fab floor, it is already embued with defining semiconductive characteristics specific to the chip's final application.