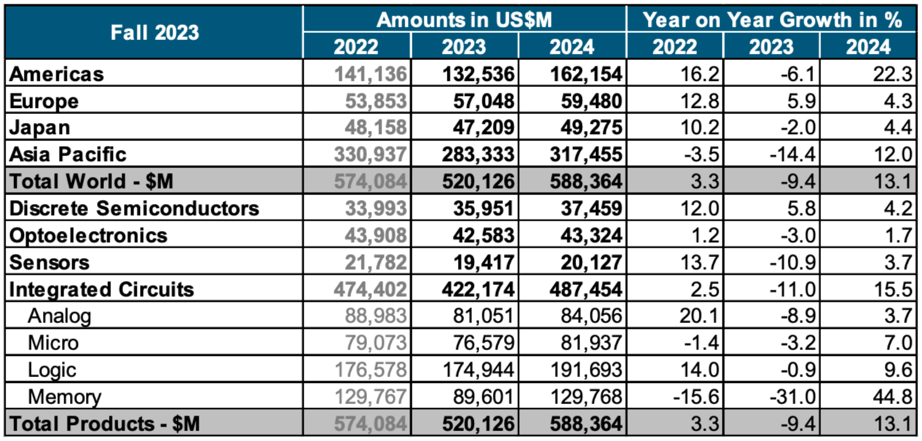
Report Description

The Semiconductor Industry Association (SIA) announced global semiconductor industry sales totaled $526.8 billion in 2023, a decrease of 8.2% compared to the 2022 total of $574.1 billion, which was the industry's highest-ever annual total. Sales picked up during the second half of 2023. In fact, fourth-quarter sales of $146.0 billion were 11.6% more than the total from the fourth quarter of 2022 and 8.4% higher than the total from third quarter of 2023. And global sales for the month of December 2023 were $48.6 billion, an increase of 1.5% compared to November 2023 total. Monthly sales are compiled by the World Semiconductor Trade Statistics (WSTS) organization and represent a three-month moving average. SIA represents 99% of the U.S. semiconductor industry by revenue and nearly two-thirds of non-U.S. chip firms.

On a regional basis, Europe was the only regional market that experienced annual growth in 2023, with sales there increasing 4.0%. Annual sales into all other regional markets decreased in 2023: Japan (-3.1%), the Americas (-5.2%), Asia-Pacific/All Other (-10.1%), and China (-14.0%). Sales for the month of December 2023 increased compared to November 2023 in China (4.7%), the Americas (1.8%), and Asia Pacific/All Other (0.3%), but decreased in Japan (-2.4%) and Europe (-3.9%).

Several semiconductor product segments stood out in 2023. Sales of logic products totaled $178.5 billion in 2023, making it the largest product category by sales. Memory products were second in terms of sales, totaling $92.3 billion. Microcontroller units (MCUs) grew by 11.4% to a total of $27.9 billion. And sales of automotive ICs grew by 23.7% year-over-year to a record total of $42.2 billion.



Fall 2023	Amounts in US$M			Year on Year Growth in %		
	2022	2023	2024	2022	2023	2024
Americas	141,136	**132,536**	**162,154**	16.2	-6.1	22.3
Europe	53,853	**57,048**	**59,480**	12.8	5.9	4.3
Japan	48,158	**47,209**	**49,275**	10.2	-2.0	4.4
Asia Pacific	330,937	**283,333**	**317,455**	-3.5	-14.4	12.0
Total World - $M	574,084	**520,126**	**588,364**	3.3	-9.4	13.1
Discrete Semiconductors	33,993	**35,951**	**37,459**	12.0	5.8	4.2
Optoelectronics	43,908	**42,583**	**43,324**	1.2	-3.0	1.7
Sensors	21,782	**19,417**	**20,127**	13.7	-10.9	3.7
Integrated Circuits	474,402	**422,174**	**487,454**	2.5	-11.0	15.5
Analog	88,983	81,051	84,056	20.1	-8.9	3.7
Micro	79,073	76,579	81,937	-1.4	-3.2	7.0
Logic	176,578	174,944	191,693	14.0	-0.9	9.6
Memory	129,767	89,601	129,768	-15.6	-31.0	44.8
Total Products - $M	574,084	**520,126**	**588,364**	3.3	-9.4	13.1

Global economic slowdowns and capes overspend were catalysts for producing an oversupply of semiconductors and an equipment meltdown in 2023. A significant capacity expansion is underway as current fabs expand and new fabs are planned.

A push by the Biden administration to invest $50 billion on domestic manufacturing facilities to improve US self-sufficiency and reduce reliance on Asia has initiated a course that will likely result in oversupply and capacity expansion:

Intel
• Arizona – Fab 42 expansion for 7nm capacity
• Oregon – Fab D1X $3B Mod3 expansion; tools installed Aug. ‘21 to Feb. ‘22
• New Mexico - $3.5B spend for advanced packaging
• Israel - $10B 7nm fab; 2023 production
• Ireland – spent additional $7B from 2019-2021 to expand to 7nm
• Arizona Foundry $20B for 2 fabs (~35k wspm each) starting production in 2023 and 2024
• Malaysia – $7B for advanced packaging fab expansion; 2024 production
TSMC
• Fab 18 – 3nm $20B fab expected to be completed in 2023
• Arizona Fab –$12B over time; 5nm initial phase to produce 20k wspm starting in 1Q24 with equipment installation commencing in 2H2022
• Japan 22 / 28nm fab with Sony; $7B 45k wspm targeting late 2024 production
• 7/6nm & 28nm fab in Kaohsiung, Taiwan for 2024 production for a reported $10B; phase 1 = 40k wspm for 7nm and 6nm with phase 2 for 28nm
Samsung
• Pyeongtaek line 3 (P3) equipment move-in expected to start in April 2022; first 40-50k wspm 176L 3D NAND line, 130k-140k wspm DRAM and 10k-20k wspm 5nm foundry lines in 2H2022
• Pyeongtaek P2 S5-1; 3nm 60k wspm in 2021 & ramp to 120k wspm in 2022
• Pyeongtaek P2 S5-2; 3nm 60k wspm targeted production in 2024
• U.S. $17B 5nm Foundry fab in Texas; expected 2H2024 production (120k wspm est.)
GlobalFoundries
• $4 billion Singapore Module 7H 38k wspm starting wafer production in early-2023; full ramp end of 2023
• $1B Malta New York fab expansion of 12,500 wspm; additional fab to double capacity
• Spending $1.4B to expand capacity in U.S., Singapore, and Germany
SMIC
• 100k wspm 28nm & above fab for $8.87B in Shanghai; timing unknown
• 40k wspm 28nm & above fab in Shenzhen for $2.35B; production starting 2022
UMC
• Fab 12A Phase 6 (P6) $3.5B plan for expansion; scheduled for production in 2Q23
Kioxia / Western Digital
• Fab 7 in Mie Prefecture, Japan; expected production in late 2022 / early 2023
• Kitakami (K2) fab at $18.4B expected completion in early 2023; use of Yokkaichi equip.?
Micron
• DRAM - $7B fab in Japan expected to commence production in 2024
SK Hynix
• $106B fab complex with 800k wspm capacity and 200k EUV – first fab completed in 2025
Nanya
• DRAM - $10.7B 10nm 110k wspm fab expected to be completed in 2023; production in 2024
Powerchip Semi (PSMC)
• $10B 12-inch fab in the Tongluo Science Park; 100k wspm of 1x to 50nm technology will be put into production in stages beginning in 2023
Texas Instruments
• RFAB2 - $850M fab coming online in 2H2022 with equipment over next few years
• LFAB (acquired from Micron) – spend $3B of capex over time with target of coming online in early-2023 – more details in February at capital management call
• North Texas Fab site (option for up to 4 fabs over time) – 1st & 2nd fab construction commencing in 2022 with First fab targeting production in 2025 (70k wspm estimated)

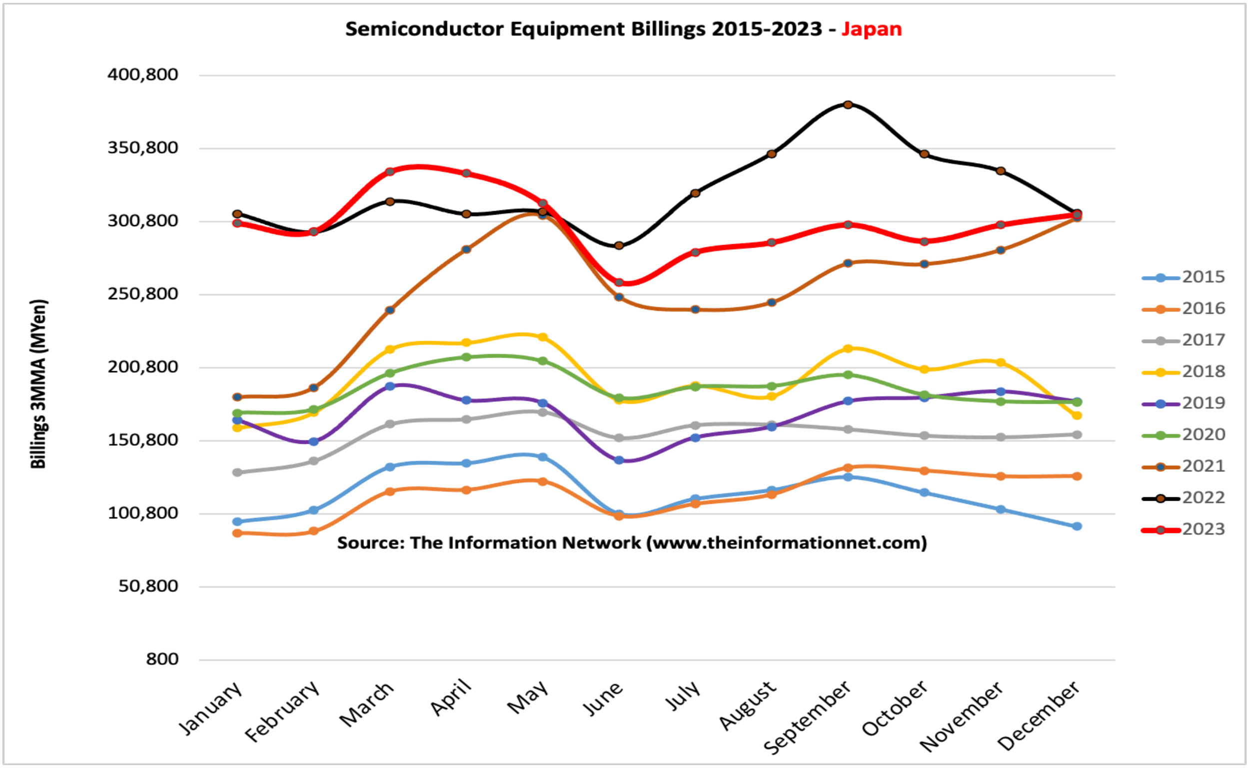
Wafer Front End equipment spend between 2020 and 2024 by device end product is shown below

WFE SPEND BY END APPLICATION ($ MILLION)

	2020	2021	2022	2023	2024
Wafer Fab Equipment ($M)	61,137	87,167	97,278	74,613	69,987
	20.1%	42.6%	11.6%	-23.3%	-6.2%
Memory	29,600	43,584	42,988	23,594	25,534
YoY	29.5%	47.2%	-1.4%	-45.1%	8.2%
DRAM	13,450	22,875	22,758	13,612	14,464
YoY	31.2%	70.1%	-0.5%	-40.2%	6.3%
NAND	16,150	20,708	20,230	9,982	11,071
YoY	28.2%	28.2%	-2.3%	-50.7%	10.9%
Foundry	23,181	31,894	36,125	34,080	27,443
YoY	27.7%	37.6%	13.3%	-5.7%	-19.5%
Logic	8,355	11,689	18,166	16,939	17,009
YoY	-15.6%	39.9%	55.4%	-6.8%	0.4%

SOURCE: THE INFORMATION NETWORK

Below we show the situation for equipment billings in 2023 compared to the previous six years for Japanese equipment companies.


Semiconductor Equipment Billings 2015-2023 - Japan

Source: The Information Network (www.theinformationnet.com)

Industry Trends

The increased use of semiconductors has been accompanied by an increase in their complexity. Due to the creation of new applications and markets for semiconductors, suppliers and manufacturers are faced with an increasing demand for new products that provide greater functionality and higher performance at lower prices. As a result, many new complex materials, structures and processes are being introduced into semiconductor manufacturing ecosystem.

Such materials include, among others, copper, low-k and high-k dielectrics, silicon-on-insulator, silicon-germanium, III-V, strained silicon and raised source/drain. Manufacturers have transitioned in the past years toward 300 mm silicon wafers (from 200 mm silicon wafers). While 300 mm wafers can yield up to twice as many integrated circuits than 200 mm wafers, they also create new manufacturing challenges. For example, because 300 mm wafers can bend or bow more than twice than the 200 mm wafers, they are more susceptible to damage. The larger area of 300 mm wafers also makes it more difficult to maintain film uniformity across the entire wafer.

Semiconductors also continue to move toward smaller feature sizes and more complex structures such as 3D FinFET transistors, GAA (Gate All Around), 3D-NAND and emerging memory structures. The growing complexity of semiconductor devices increase the complexity and the costs of the semiconductor manufacturing process, which has also been a driver for the growing demand for metrology systems.

The ever-increasing level of complexity and the decrease in feature sizes has also significantly increased the cost and performance requirements of semiconductor fabrication equipment. The cost of wafer fabrication equipment has also increased due to the higher levels of automation being utilized by manufacturers. Thus, semiconductor manufacturers must increase their investment in capital equipment in order to sustain technological leadership, to expand manufacturing capacity and maintain profitability.

Many of the manufacturing steps involve the controlled application or removal of layers of materials to or from the wafer. The application of materials to the wafer, known as deposition, involves the layering of extremely thin films of electrically insulating, conducting or semi-conducting materials. These layers can range from one-thousandth to less than one-hundred-thousandth of a millimeter in thickness and create electrically active regions on the wafer and its surface.

A wide range of materials and deposition processes are used to build up thin film layers on wafers to achieve specific performance characteristics. One of the principal methods of thin film layer deposition is chemical vapor deposition (CVD). In CVD, a chemical is introduced into the chamber where the wafer is being processed and is deposited using heat and a chemical reaction to form a layer of solid material on the surface of the silicon wafer.

Although CVD equipment represents the largest equipment type, there are more segments in the thin-layer deposition equipment market as epitaxy, physical vapor deposition (PVD) and atomic layer deposition (ALD). Currently the ALD represents the fastest growing equipment category. Metrology systems monitor the thickness and uniformity of thin film layers during the deposition process.

For the photolithography process to work properly, the thickness of the photoresist must be precise and uniform. In addition, to control the photolithography process, the film thickness, reflectivity, overlay registration and critical dimensions are all measured and verified. The exposed photoresist is developed when it is subjected to a chemical solution. The developed wafer is then exposed to another chemical solution, or plasma, that etches away any areas not covered by the photoresist to create the structure of the integrated circuit. Semiconductor manufacturers use metrology systems to verify the removal of material through the etch process and the critical dimensions of the structures created.

A number of technical and operational trends within the semiconductor manufacturing industry are strengthening the need for more effective process control solutions. These trends include:

- Development of Smaller Semiconductor Features. There has been a push for smaller, more efficient chips continues, with leading manufacturers moving towards 5nm, 3nm, and even 2nm process nodes.

- Transition to 3D Device Structures. Foundries are adopting 3D FinFET transistors. In 2019 the leading logic processes in production were Intel’s 10nm process, Samsung’s 7nm process and TSMC’s 7nm optical process (7FF). At the end of 2019, Samsung and TSMC both began risk production of 5nm processes and both processes were in production in 2020.

- Memory makers are moving to 300-layer 3D NAND and vertical structures for next generation NAND technology. These trends will require process control with metrology solutions capable of measuring critical dimensions in these 3D structures that are currently supported only by optical metrology technology.

- Transition to 3D Integration Technology. Three-dimensional (3D) integration of active devices, directly connecting multiple IC chips, offers many benefits, including power efficiency, performance enhancements, significant product miniaturization, and cost reduction. It provides an additional way to extend Moore's law beyond spending ever-increasing efforts to shrink feature sizes. A critical element in enabling 3D integration is the Through-Silicon Via (TSV); TSV provides the high-bandwidth interconnection between stacked chips. The TSV process is beginning to enter production. In the case of TSV, since multiple chips are connected, the process has to achieve and maintain very high yield levels in order to be economically viable. TSV metrology solutions are required to closely monitor and measure depth, side-wall slope, top and bottom diameter (CD), and bottom curvature.

- There has been a shift towards SiC and GaN materials marks a significant trend in power electronics and RF applications. These materials offer superior performance in terms of efficiency, heat resistance, and power handling, especially at high voltages and frequencies. This makes them particularly suited for applications in electric vehicles, renewable energy systems, and 5G networks, where these characteristics can lead to more efficient, compact, and reliable systems.

- Increasing Use of Extreme Ultraviolet (EUV) lithography. Lithography. The industry's relentless pursuit of Moore's Law is driving the development of advanced process nodes, now approaching 3nm and looking towards 2nm technologies. Extreme Ultraviolet (EUV) lithography plays a pivotal role in this evolution, enabling the creation of smaller, more complex circuits by allowing for finer feature patterning without the need for complex multi-patterning techniques. This leap in lithography technology is essential for maintaining the pace of semiconductor miniaturization and performance gains.

- New Materials. Since 2012, as features on technology nodes continued to shrink and 3D transistors (FinFET design) were introduced, an increasing number of critical process steps came to rely on the deposition of high-quality dielectric films with exacting thickness, feature coverage, stress, electrical and mechanical requirements.

- Growing of Foundry Manufacturing. As a result of the rising investment needed for semiconductor process development and production as well as the proliferation of different types of semiconductors, semiconductor manufacturing is increasingly being outsourced to large semiconductor contract manufacturers, or foundries. A foundry typically runs several different processes and makes hundreds to thousands of different semiconductor product types in one facility, making the maintenance of a constant high production yield and overall equipment efficiency more difficult to achieve. This trend of shifting to foundries for manufacturing needs has progressed even further during recent years. The challenges associated with foundry in the following years relate to aspects such as: shortening the time to market, reducing costs and monitoring process complexity.

- Advanced Memory Manufacturing. As a result of recent years progress, the NAND market is entering a critical transition phase as NAND technology shifts from traditional 2D planar structures to 3D structures where 2D NAND flash is reaching its practical limit for cost-per-bit reductions and thus major cost reductions in the future will come from the shifting to 3D NAND structures.

- ALD is being incorporated into the volume manufacturing process. We believe that the ALD end-market will still continue to grow as the multi-patterning market will still exist, and ALD demand will be further expanded by new critical layers and applications, with the emergence of EUV continuing to extend chip makers' roadmap (increasing the range of material and device architecture available.

Report Coverage

This 325-page report analyzes and forecasts the semiconductor market for 24 different equipment types, including market shares for 2023 by type:

- AMHS (Automated Material Handling Systems) Market
- CMP (Chemical Mechanical Planarization) Market
- Clean Market
  - Plasma Strip
  - Spray Processors
  - Wet Stations
- Deposition Market
  - ALD
  - Epitaxy
  - MOCVD
  - LPCVD (non-tube)
  - LPCVD (tube)
  - PECVD
  - PVD
- Ion Implantation Market
- Lithography Market
  - Direct-Write E-Beam Lithography
  - Mask-Making Lithography
  - Steppers
- Oxidation/Diffusion Market
- Photoresist Processing (Track) Market
- RTP Market
- Plasma Etch Market
  - Dielectric
  - Conductor
- Process Control Market
  - Lithography Metrology
  - Thin-Film Metrology
  - Wafer Inspection and Defect Review

The report in pdf format profiles 6 U.S., 11 European, and 26 Asian equipment companies.

An Excel File accompanies the report and covers Market Shares of each company by each equipment type between 2012 and 2023.

Driving forces of technology and geopolitics are analyzed and forecast by semiconductor type including China markets.