

# Taiwanese Fasteners in the Semiconductor Equipment Sector: Development Analysis (Part 1) - Global Market and Products

## Foreword

Taiwan's fastener industry serves as a key foreign exchange earner, with the U.S. as its largest export market. In 2024, exports to the U.S. reached USD 2.04 billion, accounting for nearly half (44.9%) of total exports. However, following President Trump's inauguration in 2025, new tariff policies activated derivative tariffs under Steel and Aluminum Section 232, imposing 50% tariffs on fasteners imported from various countries into the U.S., increasing operational costs and impacting domestic fastener firms.

Taiwan's U.S.-bound fastener exports primarily consist of standard parts, which face intense price competition and high substitutability. Domestic firms must explore potential markets beyond standard products, such as fasteners for drones, automated machinery, new energy vehicles, hydrogen and clean energy equipment, high-end medical devices, and semiconductor equipment. **Leveraging Taiwan's globally most complete semiconductor supply chain, advanced process clusters, and vacuum equipment industry chain, fastener makers can enter the global semiconductor equipment market by enhancing material technology, cleaning processes, surface treatments, and precision inspection capabilities to meet high-end fastener needs for critical modules like exposure, etching, cleaning, and advanced packaging.** Nevertheless, firms require thorough upfront assessments of initial investments, technical barriers, training costs, market size, and ROI. This article provides preliminary analysis on fastener product categories, application environments, material properties, quality requirements, and supply chain structures for semiconductor equipment, offering references for Taiwanese firms.

## Overview of Global Semiconductor Equipment Fasteners

### (1) Semiconductor Equipment Market Grows Rapidly, Creating Steady Incremental Demand for Fasteners:

The global semiconductor manufacturing equipment market reached approximately USD 105-110 billion in 2024 and is projected to grow to USD 175-220 billion by 2030-2034, with a CAGR of about 7-9%. Wafer fabrication equipment plant investments remain high, estimated at USD 110 billion on the front-end equipment by 2025, with further growth expected in 2026.

### (2) Semiconductor Equipment Fasteners as a "High-End Niche Submarket" in Industrial Fasteners:

According to Infinity Market Research, the global industrial fasteners market will reach about USD 88 billion in 2025, with a CAGR of around 4%. The "industrial sealing fasteners" segment for vacuum, sealing, and cleanrooms is valued at USD 410 million in 2025, projected to reach USD 500 million by 2031 with a CAGR of 3.2%, indicating high-spec fasteners as a distinct niche. Public statistics rarely isolate "semiconductor equipment-specific fasteners" by tariff codes. In that case, using estimates by bill of materials (BOM) where fasteners comprise 0.5-1.5% of equipment value, **the 2024 semiconductor equipment output of USD 110 billion suggests an annual fastener market of USD 0.5-1.5 billion—a critical component market that is small in volume but high in technical barriers.**

### (3) Growth Drivers and Cyclical Characteristics:

Semiconductor equipment fasteners are highly correlated with equipment investments. Recent drivers including AI, high-performance computing, automotive electronics, and advanced process expansions boost demand for EUV lithography, epitaxial (EPI) processes, advanced packaging, and testing equipment, thereby increasing needs for vacuum screws and clean fasteners. Compared to general industrial



fasteners, **semiconductor fasteners command higher unit prices but lower volumes, making them less sensitive to economic fluctuations. Supported by equipment upgrades, maintenance packages, and demand for consumables, they exhibit a dual-track structure of "investment cycles + rigid maintenance demand."**

## Characteristics of Fasteners for Semiconductor Equipment

- (1) Overview:** Semiconductor and optoelectronic equipment heavily rely on precision screws and fasteners to ensure structural rigidity, vacuum sealing, and repeatable positioning accuracy. These are key to the "small parts, high yield" principle.
- (2) Application Scope:** Covering semiconductor processes such as wafer fabrication (exposure, etching, cleaning, chemical vapor deposition [CVD], physical vapor deposition [PVD]), advanced packaging, optoelectronic panel machinery, vacuum chambers, carriers, and automation arms. By application scenario, major categories include: Frame/Base Screws, Vacuum Seal Fasteners, PCB Mount, Sensor Fixture, Alignment, Optical Adjustment Screw, Robot/Actuator Mount.
- (3) Core Requirements from Equipment Systems:** High cleanliness, low particle generation, low outgassing, non-magnetic properties, high strength, high temperature/corrosion resistance, vibration resistance, high tightening precision, and long-term reliability.
- (4) Differences in Fastener Requirements by Equipment Segment:** *Table 1* summarizes fastener requirement differences across semiconductor equipment segments.

**Table 1: Fastener Requirement Differences by Semiconductor Equipment Segment**

Segment	Requirements and Materials
Upper Layer (Precision Motion/Optical Modules)	High rigidity, non-magnetic, high-precision positioning; materials are often titanium alloys or high-strength stainless steel.
Middle Layer (Transmission, Pneumatic/Hydraulic, Cooling Systems)	Medium-high strength and corrosion resistance; materials are often high-temperature stainless steel (e.g., A286) or medium-high strength alloy steel (e.g., SCM435).
Lower Layer (Structural Bases and Housings)	Structural support, vibration damping, and maintenance ease; materials primarily are carbon steel and aluminum alloys.

## (5) Classification by Product Type

- 1. Category 1: Bolts, Screws, Nuts, Washers (Including Springs)**
  - ① Application Scenarios: Machine frame/base fixation, PCB and electronic module mounting, optical modules and motion platforms, external vacuum chamber connections, high-temperature zone fixation.
  - ② Primary Materials:
    - A. Stainless Steel (304L, 316L): Corrosion-resistant, high cleanliness; mostly used in vacuum chambers and wet cleaning modules.

- B. Precipitation-Hardened Stainless Steel (e.g., A286): High strength and rigidity; mostly used in transmission structures.
- C. Nickel-Based Alloys (Inconel, Hastelloy): High temperature and corrosion resistance; used in high-temperature process zones.
- D. Aluminum Alloys (6061-T6): Lightweight; mostly used in structural housings and heat dissipation modules.
- E. Titanium (Ti-6Al-4V): Non-magnetic, high rigidity; mostly used in optical and high-precision positioning applications

## 2. Category 2: Stud Bolts/Dowel Pins (Chamber/Flange Fastening)

- ① Application Scenarios: Vacuum chamber flange sealing, high-pressure gas/liquid pipeline fastening, precise positioning (alignment pins); chamber structures requiring heat/pressure/corrosion resistance. Dowel pins and flange studs demand higher precision than standard screws, critically affecting vacuum integrity and chamber leak rates in semiconductor equipment.
- ② Materials: 316L stainless steel (vacuum chambers), precipitation-hardened stainless steel (e.g., A286 for higher preload and thermal cycling resistance), nickel-based alloys (Inconel, Hastelloy for high-temperature and corrosive environments).

## 3. Category 3: Flange Clamps/Complementary Fasteners (Flange Clamp Sets)

- ① Application Scenarios: Quick clamping of vacuum chambers, flange pipeline connections (small-diameter ISO-KF, large-diameter ISO-CLAMP standards), rapid disassembly of PVD/CVD chamber piping, fasteners for modules needing frequent maintenance (to reduce downtime).
- ② Primary Materials: Surface-hardened aluminum (flange bodies for lightweight, low particle generation, and easy assembly/disassembly); stainless steel and nickel-based alloys (bolts for high preload and corrosion resistance; nickel alloys for high-temperature zones).

## (6) Material Categories and Properties

*Table 2* summarizes materials and surface treatments for semiconductor equipment fasteners.

**Table 2: Material Categories and Properties for Semiconductor Equipment Fasteners**

Material	Description
Stainless Steel SUS304/316L	Corrosion-resistant, high cleanliness; used in vacuum chambers and cleaning modules.
High-Strength Steel (e.g., SCM435, A286)	High clamping force and rigidity; used in transmissions and machine bases.
Aluminum Alloy 6061-T6	Lightweight housings and heat dissipation structures.
Titanium Alloy Ti-6Al-4V	Non-magnetic, high strength; suitable for optical modules and advanced vacuum structures.
Special Alloys (Inconel, Hastelloy)	High-temperature, highly corrosive environments, such as high-temperature process zones.
Engineering Plastics (PEEK, PTFE)	Insulation and anti-contamination; used in fluid modules and electronic substrate fixation.

## (7) Surface Treatment/Coating Process Specifications

Table 3 summarizes surface treatment/coating process specifications for semiconductor equipment fasteners.

**Table 3: Surface Treatment/Coating Process Specifications for Semiconductor Equipment Fasteners**

Surface Treatment/Coating	Description
Nickel Plating	Electrolytic process deposits uniform nickel layer on fastener surface, enhancing corrosion barrier, reducing oxidation in vacuum environments, and improving friction stability with minimal wear/debris.
Passivation	Oxidizes or passivates stainless steel surface to form stable Cr <sub>2</sub> O <sub>3</sub> protective layer, boosting corrosion resistance and reducing free iron on surface.
DLC Coating	Deposits amorphous carbon film from carbon-containing gas; offers high hardness, low friction, wear resistance, and corrosion resistance. Achieves low outgassing and low particle shedding in ultra-high vacuum; used on internal vacuum chamber shields and transport mechanism sliding surfaces.
TiN Coating	PVD (magnetron sputtering, arc discharge) forms titanium nitride thin film on metal surface; provides high hardness, wear resistance, and conductivity. Used on shielding component fasteners in vacuum chambers to suppress metal wear and particle generation.
Black Chrome	Chromium plating with additives creates gray-black appearance; combines conductivity, high corrosion resistance, and UV resistance. Common on instrument exteriors, optical frames, medical devices, and automotive parts.
PEEK Coating	Sprays PEEK powder + fusion or solution-coats film on metal surface; offers high temperature resistance, mechanical strength, chemical resistance, and low outgassing.
Low Outgassing	Minimal volatile release (organics, solvents, small molecules) from fastener materials under vacuum/heating, reducing contamination on optical lenses, wafers, and detectors.
Low Particle Generation	Semiconductor fabs require "low outgassing + low particle" for lubricants, seals, and transport parts to prevent secondary contamination inside equipment.

## (8) Process and Inspection Requirements

Table 4 summarizes process and inspection requirements for semiconductor equipment fasteners.

**Table 4: Process and Inspection Requirements for Semiconductor Equipment Fasteners**

Process and Inspection	Requirements
Thread Precision	Beyond ISO 6H/JIS Grade 2, semiconductor fasteners require enhanced pitch deviation control, polishing, vacuum cleaning, precision rolling, deburring/no burr tails (to avoid particles).
Dimensional Tolerance	Typically $\pm 0.01$ to $\pm 0.02$ mm; surface roughness $R_a \leq 0.8 \mu m$ .
Cleanliness Requirements	Ultrasonic degreasing + pure water rinse + vacuum drying, with vacuum or nitrogen-sealed packaging; corresponds to ISO Class 5-7 cleanrooms (low particles, low outgassing, preventing nickel plating flaking).
Inspection Items	Appearance & dimensions (CMM 3-axis full/spot inspection), material (spectroscopy/XRF analysis), torque testing, surface roughness, etc.

## Conclusion

In summary, while the global semiconductor equipment fastener market is a small niche, its stringent requirements for high vacuum, low contamination, non-magnetic properties, and high material strength create technical barriers far exceeding general industrial fasteners. It grows steadily with equipment investments and cleanroom expansions, exhibiting "low volume, high price, high loyalty" traits. The US, Japan, and Europe control major brands and advanced materials, while Asia is the largest demand source—forming a supply-demand regional mismatch that creates entry opportunities for Taiwan. For Taiwan's fastener industry, this market aligns with the shift from standard to precision parts. By bolstering materials, clean processes, and vacuum inspection capabilities, opportunities exist in maintenance markets, localized regional supply, and custom specials products. The next article will focus on Taiwan's current status in developing semiconductor equipment fasteners, industry gaps, and concrete strategies, proposing technical, industrial, and policy pathways for Taiwan's deployment. □

## Global Competitive Landscape Analysis of Potential Customers for Semiconductor Equipment Fasteners

- Suppliers Highly Concentrated in the US, Japan, Europe, with Tight Links to Semiconductor Equipment Clusters**
  - USA:** Major suppliers focus on fasteners and O-rings (elastomeric seals) for high vacuum/ultra-high vacuum (HV/UHV) systems, targeting "cleanliness critical sectors" like semiconductors, vacuum coating, energy, and defense.
  - Japan:** Major suppliers tap in via "Special Screws," covering vacuum screws, low-outgassing screws, clean screws, titanium screws, etc., serving semiconductor equipment, flat panel displays (FPD), medical, and food machinery industries with mature brand strength.
  - Europe:** Vacuum component companies provide complementary vacuum screws and chamber parts, closely tied to European high-vacuum equipment and research markets.
- Market Characteristics: Diverse Product Lines but High Brand Loyalty**

**1. High-end fasteners**, though of the "components" category, involve vacuum reliability, particle control, and maintenance efficiency, leading equipment giants to exhibit high loyalty to suppliers. Once certified, they often stick to the same brand or item for a very long time.

**2. Global mainstream suppliers adopt a "standard + customization" dual-track**, offering catalogued standard vacuum screws and flange fasteners, while accepting equipment makers' custom designs for head shapes, lengths, materials, and surface treatments.

**3. Demand is Concentrated in Asia, but High-End Supply Chains are Still Led by the US, Japan, and Europe**

Semiconductor equipment investments are clearly concentrated in Asia (Taiwan, South Korea, China, Japan), accounting for over two-thirds of the global equipment market. However, high-end fastener brands and technology remain dominated by the US, Japanese, and European firms, creating a "demand in Asia-Pacific, brands in USA/Japan/Europe" structure.

