

# Taiwanese Fasteners in the Semiconductor Equipment Sector: Development Analysis (Part 2) - Domestic Status & Development Strategies

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## Introduction

In the previous article, I provided an initial overview of the global market and product characteristics of fasteners for semiconductor equipment. This market, though a small niche, features high technical barriers, high added value, and strong customer loyalty. Demand is concentrated in Asia, with key technologies and brands dominated by the US, Japan, and Europe. However, Taiwan's fastener industry has long focused on standard parts in the US market. In recent years, influenced by US tariffs on steel and aluminum derivatives and supply chain restructuring, its existing cost and scale advantages have gradually weakened. This has forced industry players to reassess strategies shifting from volume to quality, and from price competition to technological competition. This article comprehensively examines the supply and demand in Taiwan's semiconductor equipment fastener market, characteristics and demand estimates for fasteners in various semiconductor processes, Taiwan's technological gaps and bottlenecks in semiconductor equipment fasteners, and subsequent development and response strategies. It reviews Taiwan's gaps in materials, processes, cleanliness, testing, and quality documentation, proposing countermeasures for Taiwan's fastener industry to enter the semiconductor equipment supply chain as a reference for future industry upgrades and deployment.

## Current Supply and Demand Status of Taiwan's Semiconductor Equipment Fastener Market

### Current Status of Taiwan's Supply Chain and Entry Barriers

Taiwan's fastener industry holds cost and scale advantages in carbon steel and standard parts, but lags behind international leading suppliers in high-end materials, clean processes, and validation capabilities required for semiconductors.

#### 1. Domestic Supplier Types:

- ① **Type 1 (Channels and Agents):** Some domestic manufacturers can supply high-end fasteners, but most are imported brands.
- ② **Type 2 (Local Manufacturing):** A few Taiwanese SMEs have screw processing capabilities, but still need to strengthen cleanliness, vacuum specifications, and inspection documentation systems.

#### 2. Markets of Major Foreign Suppliers:

- ① Suppliers of vacuum-grade fasteners and special materials like Inconel, Hastelloy and Ti: Primarily from US manufacturers, providing vacuum-grade or special material fasteners.
- ② Precision screws, set screws, non-magnetic screws, and vacuum fasteners: Main suppliers from Japan, the US, UK, etc.

#### 3. Price Range per Kilogram:

General semiconductor SUS fasteners are about NTD 1,500–3,000/kg; high-cleanliness/vacuum-grade ones are NTD 3,000–6,000/kg; titanium fasteners exceed NTD 5,000/kg.

### Participation of Taiwan's Fasteners in the Semiconductor Equipment Market

#### 1. Direct Supply to Equipment OEMs (First-Tier Market):

- ✔ **Advantages:** Large purchase volumes from each client, stable specifications, and potential for higher added value.
- ✘ **Challenges:** Must pass strict internal audits and customer certifications, including cleanroom environments, vacuum and particle testing, and complete quality and traceability systems.

#### 2. Maintenance Kits and Consumables Market:

- ① Assemblies include over 100 types of parts, with fasteners comprising only a small portion but serving as high-margin consumables.
- ② Example calculation for a typical maintenance kit: Approximately 15 fastener types per kit × 200 pieces per type × NTD10 to 25 per piece, totaling about NTD 30,000 to 80,000 per kit.
- ③ Converted for M4–M12 fasteners, semiconductor-grade ones range from NTD 2,000 to 6,000/kg depending on grade and use—far higher than general industrial fasteners.

#### 3. Second-Hand Equipment Dealers and Service Providers:

Second-hand equipment dealers bear the audit pressure; fastener manufacturers can first enter the maintenance and equipment refurbishment market as a frontline battleground to accumulate experience with semiconductor specifications.



## Current Status Analysis of Taiwan Fasteners in the Semiconductor Equipment Market:

Although Taiwan is a global semiconductor manufacturing powerhouse, "semiconductor equipment fasteners" currently focus mainly on the "maintenance market" and "specific project demands," without forming a mature industry chain. The current status can be analyzed from supply-side, demand-side, and market entry mode perspectives.

### ▶▶ 1. Supply-Side Status—

Insufficient materials and cleanliness specifications, and domination by general industrial fasteners: Taiwan fastener manufacturers' strengths are concentrated on general carbon steel screws, construction screws, automotive screws, etc., with mass production capabilities and cost advantages. However, high-end materials and clean processes required for semiconductors remain the weaknesses, preventing Taiwan fastener players from gaining one-time approval from semiconductor equipment suppliers despite having processing capabilities. Typical limitations include:

- ① Lack of processing capabilities for high-end materials like 316L, A286, Inconel, Hastelloy, Ti, etc.
- ② Lack of clean process production lines for ISO Class 5–7 cleaning, vacuum drying, nitrogen sealing, etc.
- ③ Surface treatments mostly being conventional zinc plating or nickel plating, not meeting low outgassing requirements.
- ④ Lack of advanced testing equipment for CMM full inspection, surface roughness, vacuum leak rate, etc.
- ⑤ Not having adopted quality systems such as IATF16949, FAI, CPK, traceability systems, etc.

### ▶▶ 2. Demand-Side Status:

Taiwanese equipment manufacturers have small but diverse and rapidly growing demands. They are gradually expanding into front-end processes (etching, cleaning, thin-film deposition) and advanced packaging equipment. While the demand volumes are not as large as for standard parts, specification levels, added value and customization ratios are high—suitable for upgrading from standard parts. These

approaches can help them reduce initial investment costs, gradually enhance technical capabilities, and accumulate customer documentation and measurement records. Demands include: vacuum chamber studs, flange fasteners, vented screws (degassing screws), high-locking-force screws for high-temperature/high-corrosion environments, high-cleanliness/low-particle fasteners, high-precision set screws and alignment pins, and non-magnetic screws for optical modules.

### ▶▶ 3. Current Entry Modes:

Feasible entry points for Taiwanese manufacturers include "maintenance kits" and "second-hand equipment dealers."

- ① Maintenance Fasteners (Maintenance Kit): Semiconductor equipment maintenance kits often include 10–20 fastener types, about 100 pieces each, with kit values exceeding NTD 1 million. Specifications are fixed and parameters are clear, making them ideal for fastener manufacturers' first-stage entry. Equipment structural overhauls (major overhaul/rebuild) occur every 3–5 years; high-load or critical equipment may require maintenance checks every 1 to 3 years.
- ② Second-Hand Equipment Dealers and Service Providers (Refurbishment): Most semiconductor equipment has an engineering usable life of 10–15 years, extendable to over 20 years for mature processes with proper maintenance. In the refurbishment stage, second-hand dealers are more willing to use Taiwan-made fasteners, with lower audit thresholds. This allows accumulation of processing and inspection experience for semiconductor-grade fasteners before advancing to OEMs.

## Semiconductor Equipment Fastener Demand Volume and Characteristics at Each Stage

Continuing from the previous article, the global semiconductor equipment output value in 2024 was approximately USD 110 billion. Assuming fasteners account for 0.5–1.5% of the equipment's bill of materials (BOM) value, the annual global market value for semiconductor equipment fasteners is about USD 500 million to 1.5 billion—a "small scale but highly technical barrier" critical components market. The following breaks down semiconductor equipment by process stages and estimates fastener quantities required for each equipment type:

### (1) Front-End of Line (FEOL) processes—average fastener quantity per front-end equipment: 1,500–3,000 pieces/unit

Process	Equipment Name	Main Use	Demand (Pieces)/Unit	Characteristics
Wafer Cleaning	Wet Bench / Single Wafer Cleaner	Pre/post-etch Cleaning	800–2,000	Stainless steel, chemical-resistant, corrosion-resistant
Oxidation/Diffusion	Furnace / RTP	Oxidation, Dopant Activation	1,000–2,500	High-temperature fasteners, thermal expansion considerations
Lithography	Stepper / Scanner	Exposure Imaging	2,000–4,000	High precision, low vibration, partial customization
Development/Coating	Coater / Developer	Photoresist Coating, Development	1,200–2,500	Modular structure, quick-release parts
Thin-Film Deposition	CVD / PECVD / ALD	Thin-film Deposition	1,500–3,500	Vacuum, airtight, heat-resistant
Physical Deposition	PVD	Metal Deposition	1,200–3,000	Many vacuum chamber fasteners
Etching	Dry Etcher (RIE/ICP)	Pattern Transfer	1,500–3,500	Airtight + plasma corrosion resistance



Process	Equipment Name	Main Use	Demand (Pieces)/Unit	Characteristics
Ion Implantation	Ion Implanter	Impurity Doping	2,000–4,000	Heavy structure, anti-vibration
Planarization	CMP	Surface Planarization	1,000–2,500	High-humidity environment, rust-proof
Inspection/Measurement	CD-SEM / Overlay / Inspection	Dimension/defect Measurement	800–1,800	High precision, low thermal drift

(2) Back-End of Line (BEOL) processes (within wafer fabs)—  
average fastener quantity per back-end equipment: 1,200–2,500 pieces/unit

Process	Equipment Name	Main Use	Demand (Pieces)/Unit	Characteristics
Metallization	Electroplating	Copper Electroplating	1,200–2,500	Chemical-resistant
Dielectric Deposition	PECVD / Spin-On	ILD Deposition	1,200–2,800	Similar to FEOL
Etching	Via / Trench Etcher	Vias/Trenches	1,500–3,000	High sealing requirements
CMP	Cu CMP	Metal Planarization	1,000–2,300	Rust-proof, anti-vibration
Inspection	E-beam / AOI	Metal Layer Inspection	800–1,800	Precision structure

(3) Back-End Assembly & Test (primarily in packaging plants)—  
Average fastener quantity per packaging equipment: 800–2,000 pieces/unit

Process	Equipment Name	Main Use	Demand (Pieces)/Unit	Characteristics
Wafer Dicing	Dicing Saw	Singulation into dies	500–1,200	Small/medium equipment
Die Attach	Die Bonder	Die fixation to substrate	800–2,000	High precision
Wire Bonding	Wire Bonder	Die electrical connection	700–1,800	Lightweight
Encapsulation	Molding Press	Die structure protection	1,200–3,000	High-pressure structure
Testing	Test Handler / Tester	Functionality/yield verification	1,000–2,500	Modular

## Taiwan's Current Technological Gaps and Bottlenecks in Semiconductor Equipment Fasteners

### ►► (1) Material Technology Shortfalls— Lack of High-Performance Metal Processing Capabilities:

Primary materials for semiconductor equipment fasteners, such as A286, Inconel 718, Hastelloy C-276, and Ti-6Al-4V, have extremely low processing rates among Taiwan fastener manufacturers. Most lack capabilities in tooling, heat treatment, forging, and CNC machining. Required attributes include: non-magnetic properties, low outgassing, high-temperature processing, high strength, and corrosion resistance.

### ►► (3) Insufficient Precision (Thread, Concentricity, and Roughness Capabilities Need Upgrade):

Semiconductor fasteners require tolerances of  $\pm 0.01$ – $0.02$  mm, surface roughness  $R_a \leq 0.8 \mu\text{m}$ , and ISO 6H or JIS Grade 2 thread precision. While Taiwanese manufacturers have excellent processing capabilities, mass-producing such precision fasteners while maintaining yield remains challenging.

### ►► (5) Gaps in Documentation and Quality Management System:

Semiconductor equipment fastener supply chains demand extensive documentation. Most fastener manufacturers operate under general mechanical industry standards, failing to meet semiconductor clients' requirements. This includes: complete FAI (First Article Inspection), batch traceability, complex process capability index (CPK), material test report (MTR), surface treatment records, and packaging records.

### ►► (2) Lagging Surface Treatment and Clean Processes:

Taiwanese manufacturers generally lack maturity in low outgassing technology. Semiconductor equipment fasteners must not delaminate, must avoid particle generation, have oil/grease-free surfaces with no residues, and produce no chemical gases under high vacuum. Specific surface treatment technologies are needed, such as passivation, DLC, TiN, PEEK coating, etc., combined with ultrapure water cleaning, ultrasonic degreasing, vacuum baking, and ISO Class 5–7 packaging.

### ►► (4) Inadequate Testing Capabilities (Lack of Vacuum Leak Rate and Particle Testing Equipment):

Semiconductor equipment fasteners require extensive testing items, mostly available only in research institutions rather than fastener manufacturers, who rarely invest independently. Thus, complete test reports cannot be provided to customers. Required testing includes: leak detection, outgassing tests, particle generation tests, material spectral analysis, and CMM high-precision dimensional measurement.

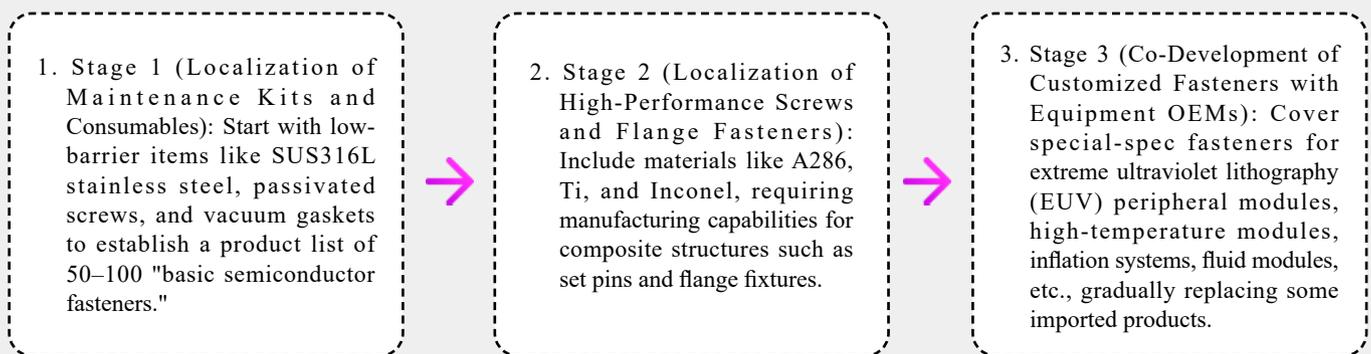


Future Strategies for Taiwan's Development of Semiconductor Equipment Fasteners

**(1) Technical Aspects: Simultaneous Development of 3 Major Technology Platforms**

1. High-Performance Materials Technology Platform: Assist manufacturers in adopting forging, heat treatment, and CNC processing for high-end materials like titanium, Inconel, and A286. Introduce tooling and parameter databases, creating a "High-Performance Fastener Processing Manual" tailored to each factory's characteristics and processes.
2. Clean Process Platform: Establish clean process equipment such as ultrasonic cleaning, circulating ultrapure water, high-vacuum drying, and nitrogen-sealed packaging. Research institutions should provide "fastener cleanliness testing" and "particle testing" services to reduce manufacturers' investment costs.
3. Reliability and Vacuum Testing Platform: Offer services like leak detection, outgassing testing, and surface roughness testing. Develop "Semiconductor Fastener Reliability Standards" and testing procedures.

**(2) Industry Aspects: Three-Stage Localization Model from Standard to Precision Parts**



**(3) Supply Chain Aspects:**

Build bridges between the fastener industry and equipment manufacturers. Government-led "Semiconductor Equipment Fastener Matching Program" to facilitate collaboration between fastener makers and Taiwanese semiconductor equipment firms. Encourage fastener manufacturers to join the Semiconductor Equipment and Materials International (SEMI) association and co-develop standard products with Taiwanese and international equipment makers. Additionally, create a reliable "Qualified Fastener Supplier List" for Taiwanese equipment manufacturers' reference.

**(4) Policy Aspects:**

Establish comprehensive audit guidance, technical subsidies, and R&D investment regulations and systems. The government can assess incentives for guiding fastener manufacturers to adopt "semiconductor audit systems." Leverage Article 10 (R&D expenditure investment tax credits) and Article 12 (doubled R&D expenditure incentives) of the Industrial Innovation Ordinance to support fastener manufacturers' R&D and material technology upgrades. Also, consider promoting dedicated projects for semiconductor fastener localization.

**Conclusion**

Although semiconductor equipment fasteners represent a small global niche market, their high technical barriers, stable demand, and high added value make them a key target for Taiwan's fastener industry to advance toward precision manufacturing and internationalization. If Taiwan can address critical gaps in high-performance materials, clean processes, vacuum testing, and system documentation—through government-introduced technology platforms, localization programs, and international matching mechanisms—it has the potential to form a competitive "semiconductor fastener supply chain" within 3–5 years. However, the global market for semiconductor equipment fasteners (USD 500 million–1.5 billion annually) is still a small fraction of total global fastener demand (about USD 90 billion). With high upfront costs, numerous technical hurdles, and the need to address current pressures from US tariffs, exchange rates, material costs, and rising operational expenses, short-term profitability gaps remain. Manufacturers entering this field should conduct thorough preliminary assessments to minimize entry risks. ■

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