OAKWOOD

Mineral Market for Semiconductors in Asia Report

By Bradley, Eva, Evangel, Joshua, Idris, and Ismael

2025

TABLE OF CONTENTS

Executive Summary

The past year saw significant volatility in Asia's semiconductor mineral market, with critical commodity prices and industry fortunes swinging sharply amid global uncertainty. After a boom in 2021–2022, 2023 brought a correction: lithium prices crashed by about 80% from their peak, and rare earth prices remained depressed due to oversupply and sluggish downstream demand. Geopolitical factors – from Russia's war in Ukraine to US-China trade tensions, have introduced new supply risks. Notably, China tightened export controls on gallium and germanium in 2023, underscoring Asia's dominance and the strategic vulnerability in these supply chains. In response, governments and companies are accelerating efforts to "de-risk" and diversify the sourcing of critical minerals away from China.Industry performance in the semiconductor minerals sector was mixed over the last year. Revenue growth stalled or reversed for many upstream players after record gains in the prior year. Global semiconductor sales are forecast to rebound +16% in 2024, but mineral suppliers have lagged this recovery.

Major Asian mineral producers experienced steep profit declines in 2023 as commodity prices fell from historic highs.

Chinese firms, which dominate rare earths and battery metals - saw earnings tumble: the world's largest lithium producers, Ganfeng and Tianqi, both reported ~70–76% drops in net profit, and China's leading rare earth company forecast a ~55% profit decline. Non-Chinese players were not immune; Australia's Lynas Rare Earths posted a 72.8% slump in annual profit amid weak prices and subdued Chinese demand. Share prices reflected these headwinds: many mining stocks corrected sharply, and Albemarle fell ~33% in 2023. As a result, sector valuations reset lower after the prior EV-driven exuberance, underperforming broader equity benchmarks.

Even with these difficulties, the landscape looks better as time goes on. Still-present long-term trends make it so: the secular shift towards electrification of transport, the top-bottom expansion on renewable energy, and the not-very-secret retooling of high manufacturing in Asia all drive mostly structurally positive and upward demand for many minerals right from the semiconductors down to the cell. By some projection, the global value of the rare earth minerals market alone will more than double by 2034. There's a huge amount of public and private investment now aimed at reconstituting domestic chip supply chains, and that translates directly into demand for many of those same domestic chip supply chains, and that translates directly into demand for many of those same "intellect" materials

Even with these difficulties, the landscape looks better as time goes on. Still-present long-term trends make it so: the secular shift towards electrification of transport, the top-bottom expansion on renewable energy, and the not-very-secret retooling of high manufacturing in Asia all drive mostly structurally positive and upward demand for many minerals right from the semiconductors down to the cell. By some projection, the global value of the rare earth minerals market alone will more than double by 2034. There's a huge amount of public and private investment now aimed at reconstituting domestic chip supply chains, and that translates directly into demand for many of those same domestic chip supply chains, and that translates directly into demand for many of those same "intellect" materials

In terms of investment, the sector is a mixed bag of opportunities and risks. On the positive side, apart from the prospects of new tech upcycle, the sector offers chance to buy fundamentally sound companies at discounted prices. The 2023 pullback means that the share price of certain companies is now well below the level that would make them buy in normal times. One potential upside: local supplies in Asia may do well as the region makes a big push for tech self-sufficiency. And firms that are investing in ways to supply new materials, or in recycling technologies, could manage to capture great value in much more regionalised supply chain for parts and minerals.

From an investment perspective, the sector presents a complex mix of opportunities and risks. Potential upsides include the chance to accumulate shares of fundamentally solid companies at discounted valuations following the 2023 pullback. Companies investing in new supply outside China or in recycling technologies may capture outsized value as supply chains regionalise. Additionally, Asia's push for tech self-sufficiency could buoy local suppliers of raw materials. Key risks, however, include ongoing price volatility and policy interventions sudden export bans or tariffs could roil markets. Investors must also consider environmental and regulatory factors, as many governments tighten oversight on mining practices and encourage sustainable sourcing.

Strategic Recommendations

Diversify Supply Exposure: Prioritise investments in companies outside China or in those supported by friendly governments to mitigate geopolitical supply risks.
Monitor Policy and Demand Signals: Stay alert to China's export policies and domestic EV sales trajectory, which directly affect pricing and demand.
Focus on Financially Resilient Leaders: Back companies with strong balance sheets and cost leadership who can withstand downturns.
Long-Term Growth Plays: Gradually increase exposure to critical minerals on price dips, aligned with the long-term electrification trend.
Invest in Innovation and Sustainability: Support companies innovating in recycling or low-impact extraction.
Hedge and Navigate Cycles: Use commodity hedging where possible and monitor performance relative to benchmarks to rebalance effectively.

In summary, the Asian market for semiconductor related minerals endured a challenging year but is poised for recovery and transformation. By balancing short-term caution with a long-term strategic outlook, Oakwood can navigate the current volatility while positioning to capture value from the next phase of growth in this critical sector.

Market Trends

Semiconductor production hinges on a steady supply of critical minerals—such as silicon, gallium, rare earths, and cobalt—that enable the increasingly complex fabrication processes behind advanced microchips. As Asia houses the world's top semiconductor manufacturers (e.g., TSMC, Samsung, SK Hynix), it has emerged not only as a primary consumer but also, via China and others, a vital supplier and refiner of these minerals. This dynamic creates both unparalleled opportunities for growth and profound supply-chain risks for the region.

From a financial viewpoint, the mineral semiconductor link is fuelling extensive capital flows into mining, refining, and technological innovation. Demand growth projections (driven by 5G, AI, automotive chips, etc.) suggest a persistent need for reliable access to these elements. At the same time, geopolitical tensions, resource concentration (especially in China), and export restrictions combine to amplify supply risks. Below, we examine short-term and long-term market trends in Asia, then analyse the regional industry outlook—SupplySide and demand side dynamics—and identify key strategic positioning factors.

Short-Term (Next 5 Years)

Surging Demand amid Geopolitical Friction
Semiconductor Uptick: AI, big data, and 5G networks drive a near-term expansion in chip production volumes. Analysts forecast a rebound and double-digit annual growth in certain chip segments by 2024–2025, after the recent cyclical downturn.

Mineral Bottlenecks: Gallium (for GaN chips) and rare earths (for specialized lasers, magnets) are especially tight due to China's dominant share (gallium ~80–98%, rare earth refining ~90%). Any abrupt export restriction or licensing requirement from China can spur price volatility and disrupt supply.

Export Controls & "Weaponisation" of Minerals

China's Constraints: In 2023–2024, China imposed new licensing rules on gallium, germanium, and other critical metals, partly in retaliation to Western technology sanctions. Prices for these metals spiked, and buyers scrambled to find alternative routes or stockpile.

Resource Nationalism: Indonesia's ban on unrefined nickel ore (and potential restrictions on bauxite) forces downstream investments in smelters and refineries within Southeast Asia, further reshaping shortterm trade flows.

Investment Shifts & Supply Diversification

Friend-Shoring & Joint Ventures: Japan, South Korea, and others invest in Australian, Vietnamese, and African mining projects to reduce reliance on any single supplier.

Local Capacity & Stockpiling: Asian chipmakers (TSMC, Samsung, SK Hynix) increase on-site or regional production of specialty gases (e.g., neon) and chemicals. Governments build or expand strategic reserves of rare earths and other metals to mitigate short-term disruptions.

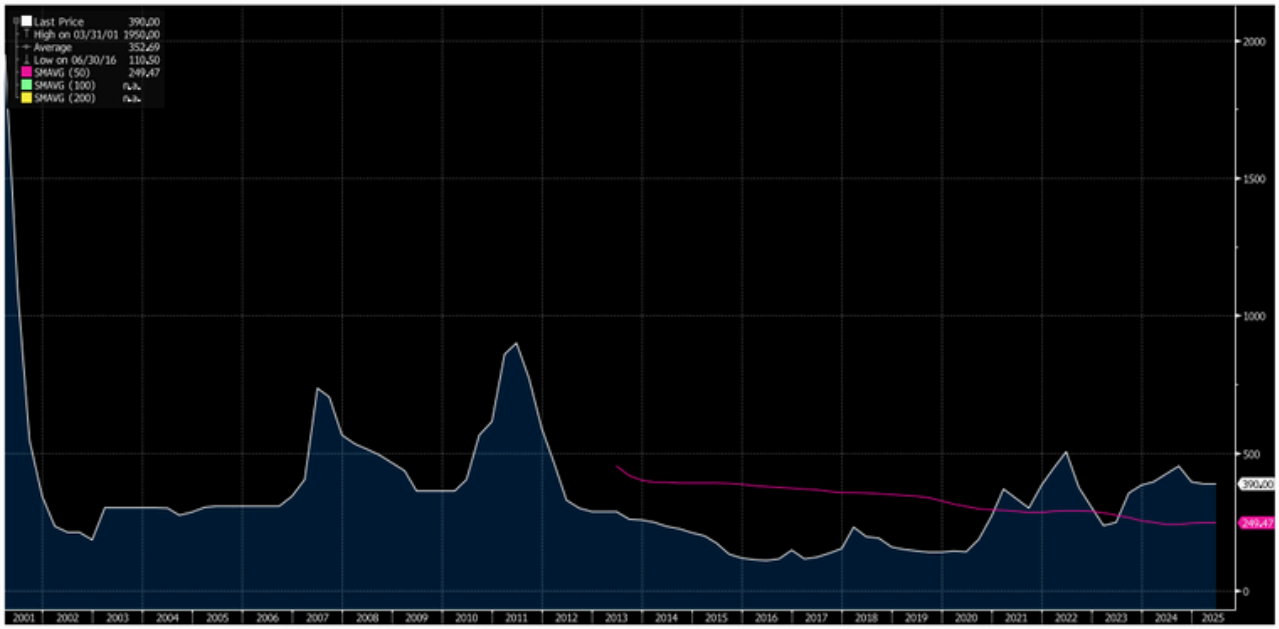
Longer-Term (Next 10 Years)

Shifting Global Fabrication Geography

- **Partial Decoupling**: The U.S. and Europe attempt to expand domestic chipmaking (via CHIPS Acts), while Asia remains the epicenter for advanced production. Demand for minerals will broaden geographically, but Asia still dominates the supply chain.
- **China's Self-Sufficiency Drive**: China invests heavily to internalize every step—from rare earth mining to advanced packaging—aiming to reduce external reliance. If these efforts succeed, it will reinforce China's leverage in critical mineral markets.

Emerging Technologies & Potential Substitutes

- **Wide-Bandgap Semiconductors**: Gallium nitride (GaN) remains crucial for high-power, high-frequency chips, but silicon carbide (SiC) and gallium oxide could substitute in some segments, slightly easing gallium demand growth.
- **Recycling & Efficiency Gains**: Greater recycling of metals from e-waste, improved process yields, and reduced use of neon or cobalt in lithography and interconnects will temper demand. Nonetheless, net consumption is projected to remain high as chip volumes proliferate.



Bifurcated Supply Chains

- Allied Networks: Japan, South Korea, Taiwan, and the U.S. form alliances to develop alternative mineral sources and share stockpiling costs. They might trim China's near-monopoly, but full independence is unlikely in the near term.
- Technological Lock-Ins: If China advances in compound semiconductors or next-gen transistor materials, it may embed these breakthroughs in domestically manufactured chips, sustaining a tech ecosystem that Western competitors find hard to replicate.

Long-Horizon Financial Outcomes

- Sustained Growth in Capital Investments: Funding for new mines, refining plants, and advanced manufacturing could top billions of dollars annually. Equity markets may reward early entrants in Asia's "critical mineral" space, while laggards risk margin squeezes as costs escalate.
- Higher Volatility & Risk Premiums: Investors may demand larger risk premiums for semiconductor-mineral ventures in regions prone to geopolitical strife or regulatory unpredictability (e.g., sudden resource

Industry Outlook

Supply-Side Dynamics

- **Concentration in China**
- China refines a large percentage of key semiconductor minerals (over 90% of heavy rare earths, ~80–98% gallium, ~70% silicon, ~73% cobalt). Such a monopoly position gives Beijing an outsized influence on pricing and export flows.
- **Regional Expansion**
- Southeast Asian nations—especially Indonesia—are capitalizing on resource nationalism (e.g., nickel and bauxite export bans) to secure more value-added refining onshore. Vietnam and India hold untapped rare earth and lithium deposits but face infrastructural and environmental hurdles to scale up.
- **Policy & Stockpiles**
- Governments in Japan, South Korea, and China maintain strategic reserves of critical minerals, while new smelting/refining projects outside China hope to weaken China's market hold. Each of these moves entails high CapEx, long lead times, and environmental compliance costs.

Financial Viewpoint:
Shortfalls or shutdowns in Chinese refining can ripple through chip production globally, prompting short-term commodity price hikes and supply disruption—an immediate hit on manufacturers' cash flow. Over time, new entrants and capacity expansions in Asia ex-China could gradually stabilize supply but will require substantial, sustained funding.

Demand-Side Dynamics

- **Dominant Manufacturing Base**
- Taiwan (TSMC) and South Korea (Samsung, SK Hynix) lead in advanced nodes, consuming large volumes of high-purity silicon wafers, gases (neon, argon), specialty chemicals, and metals (cobalt, tungsten). China, meanwhile, grows capacity in mature nodes, driving additional demand for silicon and rare earth-based manufacturing equipment.
- **Tech-Driven Material Mix**
- Ongoing miniaturization (sub-5nm chips) uses cobalt interconnects and advanced lithography requiring rare gases. Next-gen compound semiconductors (GaN, GaAs) demand higher volumes of gallium and arsenic. Emerging memory (phase-change) may lean on tellurium and indium. As new materials enter the market, their supply constraints become the next bottleneck.

Financial Viewpoint:
Rapid evolutions in chip architecture raise R&D costs for both fabless and integrated device manufacturers. A single new node's bill of materials can shift, magnifying cost volatility in previously minor elements. Semiconductor firms can mitigate margin risks by locking in long-term supply contracts or partial equity stakes in resource firms.

Strategic Positioning of Key Asian Players

Taiwan

- Strength: World-class foundries, top-tier process technology, strong global partnerships.
- Risk: Zero domestic mineral resources; heavily import-dependent. Potential geopolitical flashpoints (Taiwan Strait) threaten supply continuity.
- Strategic Moves: Building partial overseas fab capacity, establishing local neon production, diversifying chemical suppliers.

China

- Strength: Dominant position in mineral refining, massive domestic market, intensifying push for self-reliance.
- Risk: Restricted access to high-end lithography tools and advanced R&D alliances. Economic decoupling could hamper technology inflows.
- Strategic Moves: Leveraging export controls on gallium, rare earths; heavy state-funded expansions in domestic chip manufacturing and materials R&D.

Japan

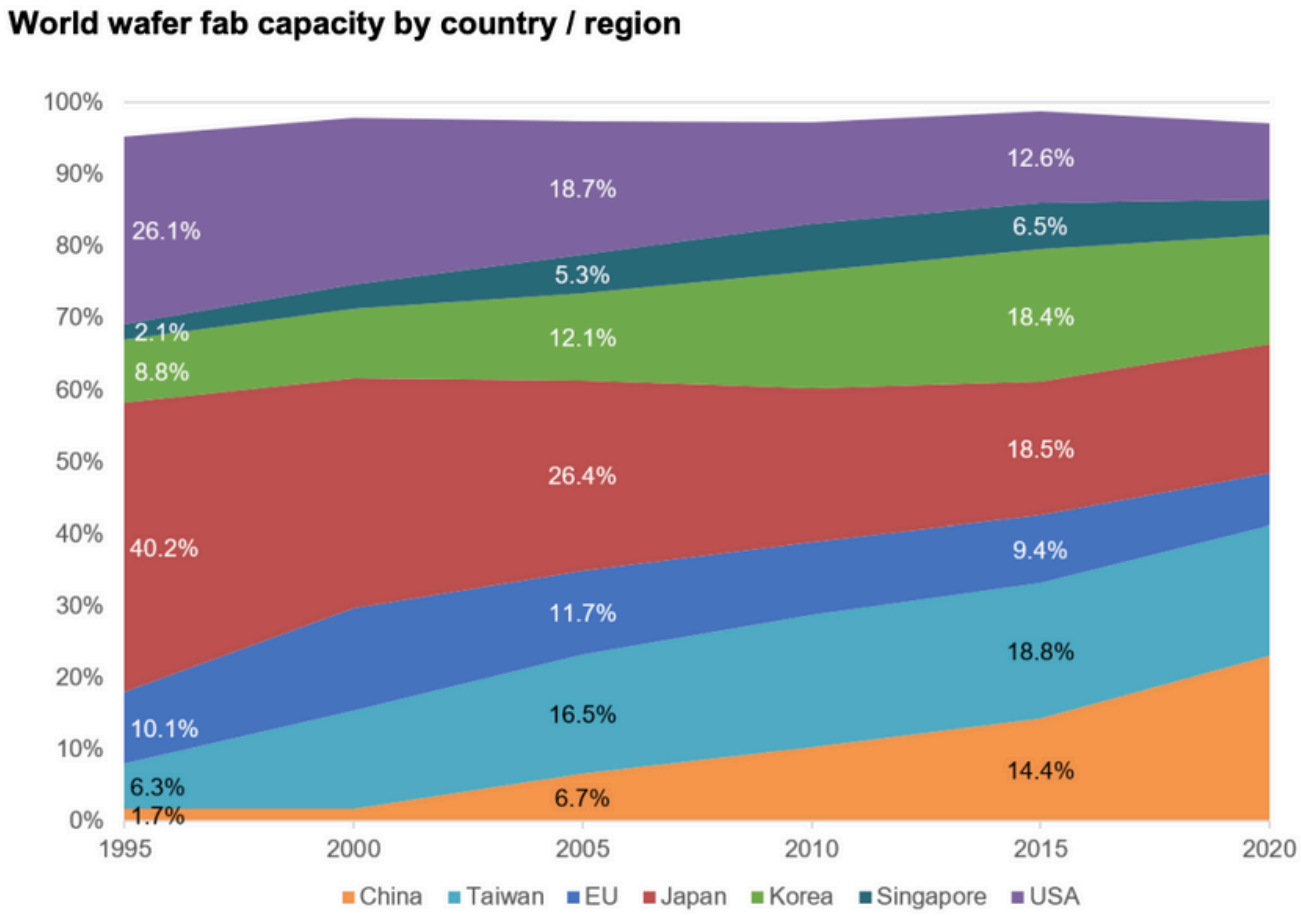
- Strength: Cutting-edge materials and equipment technology (photoresists, silicon wafers), robust R&D.
- Risk: Minimal local mineral reserves. Relies on complex import frameworks for critical metals.
- Strategic Moves: National stockpiling of rare earths, investing in overseas mining (e.g., Lynas in Australia), inviting foreign chipmakers to build domestic fabs.

Emerging Asia (Vietnam, India, Indonesia)

- Strength: Untapped reserves (rare earths, lithium, nickel, cobalt), policy incentives to move up the value chain.
- Risk: Underdeveloped infrastructure, uncertain regulatory environments, limited tech know-how for high-purity processing.
- Strategic Moves: Attract foreign capital and JV partners for refining facilities, leverage resource nationalism to keep value-added steps onshore, reduce raw exports.

South Korea

- Strength: Leading memory chip producers, advanced process nodes, strong global ties (U.S., Japan).
- Risk: Historically vulnerable to supply disruptions (e.g., 2019 Japan-Korea trade row). Limited domestic mineral production.



Growth Opportunities & Bottlenecks

Opportunities

- **Friend-Shoring & Alliances**: Long-term supply contracts among allied nations (Japan–Australia, Korea–Vietnam, Taiwan–U.S.) reduce concentration risk.
- **Resource Development**: Southeastern Asian and Indian resource expansion could open new supply lines—if managed with robust financing and technology transfer.
- **Technological Substitution**: Silicon carbide, gallium oxide, and advanced recycling may mitigate dependence on a few choke-point minerals.
- **Venture Capital & JV Deals**: Growing appetite for upstream investments (mining, refining) from tech giants and financial investors to safeguard future chip output.

Bottlenecks

- **Persistent Concentration**: Despite diversification efforts, China's refining capacity remains a formidable bottleneck for gallium, rare earths, and other byproduct metals.
- **Regulatory & Environmental Hurdles**: Asia's new mine or refinery projects face slow permitting, local opposition, and environmental liabilities—potentially deterring investors.
- **Byproduct Inelasticity**: Elements like gallium, indium, or germanium rely on base metal output (aluminum, zinc). Scaling supply quickly is challenging if primary metal demand is flat.
- **Geopolitical Tensions**: Ongoing U.S.–China standoffs and flashpoints (Taiwan) keep supply disruptions on the table, raising risk premiums.

Financial Implications and Recommendations

- **Proactive Supply Agreements**: Semiconductor firms should formalize *long-term price and volume contracts* with multiple global suppliers to hedge against sudden policy shifts.
- **Upstream Investments**: Direct equity stakes or joint ventures in mining/refining can secure priority allocations. This approach, though capital-intensive, shields manufacturers from abrupt spot price spikes.
- **Strategic Stockpiling**: Maintaining 3–6 months of critical mineral inventory provides a near-term buffer against export bans or logistical snags.
- **R&D for Material Alternatives**: Investing in next-gen materials and recycling technologies can reduce reliance on single points of failure (e.g., gallium or heavy rare earths).
- **Risk Assessment & Insurance**: Firms and investors should factor in higher geopolitical and environmental risks. Political insurance products and sovereign guarantees may become more common in cross-border projects.

Final Note

Viewed from a growth lens, Asia's semiconductor mineral landscape is ripe with high-upside scenarios—demand for chips is skyrocketing, and controlling the raw material supply can deliver commanding margins for those who invest early. Yet, the environment bristles with volatility: price swings, export controls, and supply chain choke points remain ever-present. Stakeholders seeking to ascend to the "1%" tier of influence must adopt robust risk management, innovative R&D, and strategic partnerships. The climb is steep, but those prepared to navigate policy shifts and supply constraints stand to shape the future of the global semiconductor market—and reap the corresponding financial rewards.

Merger & Acquisition Trends in the Semiconductor Mineral Market

Introduction

The semiconductor industry serves as a cornerstone of modern technological development, with its supply chain heavily reliant on critical minerals such as gallium, germanium, silicon, and various rare earth elements. These minerals form the essential building blocks for chip fabrication, enabling advancements in computing, telecommunications, and consumer electronics.
Asia, which has emerged as the nucleus of global semiconductor production, is witnessing a significant surge in merger and acquisition (M&A) activities. These developments are largely driven by companies seeking to secure stable access to raw materials amid escalating geopolitical tensions, ongoing supply chain disruptions, and a rising demand for next-generation chips. This report examines the evolving M&A landscape in the semiconductor mineral sector across Asia, highlights key players and their strategic approaches, and provides a detailed analysis of regional market dynamics and positioning.

Key drivers in M&A activity:

Several major factors are fueling the wave of consolidation in the semiconductor mineral market. Firstly, geopolitical risks and the pursuit of supply chain security have become top priorities, especially after China imposed export restrictions on gallium and germanium. These actions have prompted companies to explore alternative sources through strategic acquisitions.
Secondly, the unrelenting demand for advanced semiconductors, particularly for AI, 5G, and electric vehicles, has led to increased investment in mining and processing operations. Companies are acquiring upstream assets to guarantee access to the high-purity materials necessary for next-generation technologies.

Thirdly, supportive government policies and incentives across Asia are encouraging domestic mining efforts to reduce dependency on foreign sources. These policies include subsidies, tax incentives, and national strategies aimed at boosting semiconductor self-sufficiency.
Finally, vertical integration strategies are gaining traction. Semiconductor manufacturers are acquiring mineral suppliers to ensure long-term supply chain stability, enhance profit margins, and reduce exposure to market volatility.

Big M&A deals in the semiconductor minerals from 2020-2025:

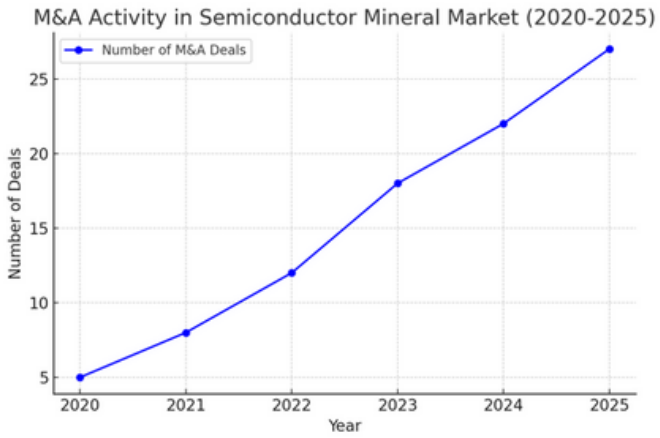
Acquiring Company	Target	Deal Value (USD)	Objective
SK Hynix (South Korea)	Australian Rare Earths Ltd.	$1.5B	Secure rare earth supply
TSMC (Taiwan)	Indonesian Mining Firm	$1.2B	Expand access to raw materials
Sumitomo Metal Mining (Japan)	Philippine Nickel Mines	$950M	Secure nickel for semiconductor production
GlobalFoundries (Singapore)	Malaysian Silicon Refinery	$750M	Ensure steady silicon supply

Key Recent M&A Developments

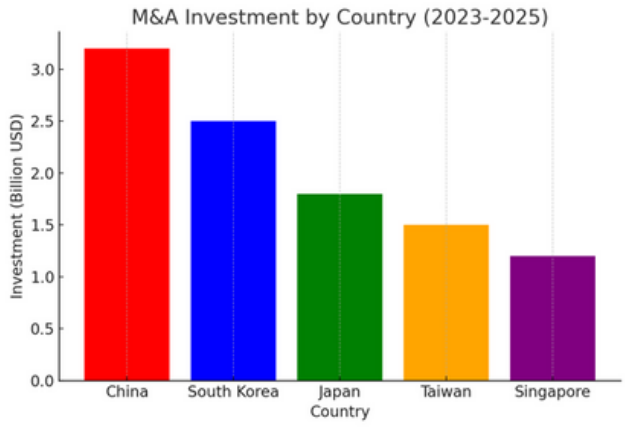
-Recent merger and acquisition activity in Asia reflects the region's strategic push to secure essential mineral resources amid rising geopolitical uncertainty and growing semiconductor demand. In 2024, China led the region in deal volume, reporting 31 semiconductor-related M&A transactions, many of which focused on analog chips and semiconductor materials. Among these, seven acquiring companies specialized in key segments such as power management, signal chains, and power integrated circuits (ICs), indicating a targeted effort to enhance domestic technological capabilities. In Japan, Resonac Holdings—formed through the merger of Hitachi Chemical and Showa Denko—announced plans in February 2025 to pursue additional acquisitions following a successful phase of restructuring and debt reduction, signaling a renewed growth trajectory. Meanwhile, India is making strategic moves to secure upstream lithium supplies essential for both semiconductor and electric vehicle production. In March 2025, four Indian state-owned enterprises—Khanij Bidesh India Ltd (KABIL), Coal India, Oil India, and ONGC Videsh—entered negotiations with Chilean mining giant SQM to acquire a 20% stake in its Mount Holland and Andover lithium projects in Western Australia for approximately $600 million. These cross-border deals underscore Asia's growing emphasis on mineral independence and vertical integration to support its semiconductor ambitions.

Appendix: Graphs & Figures

M&A Activity in Semiconductor Mineral Market (2020-2025)



M&A Investment by Country in Semiconductor Minerals (2023-2025)



Key Semiconductor Companies Engaging in M&A

-Several leading semiconductor companies across Asia are actively involved in mergers, acquisitions, and strategic investments to strengthen their positions in the mineral supply chain. Shin-Etsu Chemical Co., Ltd., a top producer of semiconductor materials, has demonstrated strong financial performance and long-term vision. In April 2024, the company committed approximately $560 million to construct a new lithography materials plant in Japan by 2026, reflecting its strategy to enhance domestic production capacity and reduce supply vulnerabilities. Sumco Corporation, another major Japanese firm specializing in silicon wafers, plays an essential role in the semiconductor value chain by focusing on producing high-quality wafers that meet the stringent specifications of advanced chipmakers. Samsung Electronics, headquartered in South Korea, continues to invest aggressively in research and development to maintain its technological leadership. In November 2024, it held a groundbreaking "tool-in" ceremony for a new semiconductor R&D complex at its Giheung campus, planning an investment of KRW 20 trillion to drive innovation through 2030. Taiwan's TSMC, the world's largest semiconductor foundry, also remains a central player, expanding its global footprint with massive investments in advanced process nodes and fabrication plants across Taiwan, Japan, and the United States. With a 2023 revenue of approximately $74 billion, TSMC is consolidating its leadership in cutting-edge chip production and maintaining strategic control over critical parts of the semiconductor ecosystem.

Strategic Comparisons and Competitive Advantages

Shin-Etsu Chemical Co., Ltd. maintains its competitive edge through substantial capital investments aimed at expanding production capacity and responding to the increasing global demand for semiconductor materials. This strategic approach includes building new manufacturing facilities and enhancing existing ones. Sumco Corporation, by contrast, focuses its efforts on the high-quality production of silicon wafers tailored to the specific requirements of chipmakers. This specialization has allowed the company to secure a strong position in the global silicon wafer market. Samsung Electronics employs a strategy centered around heavy investment in research and development, which fuels continuous innovation in semiconductor technologies. By expanding R&D infrastructure and scaling up production capabilities, Samsung aims to stay ahead in an intensely competitive field. Meanwhile, TSMC sets itself apart through its leadership in cutting-edge process technologies, such as 3nm and 2nm nodes. The company's high R&D spending, exclusive partnerships with major technology firms, and aggressive global expansion have solidified its role as a dominant force in semiconductor manufacturing. In 2024, TSMC announced over $40 billion in investments dedicated to new fabrication plants, underscoring its commitment to supporting the next wave of innovation in AI and high-performance computing.

Segmentation by company size

- The Asian semiconductor mineral market comprises a wide range of players categorized by company size, each contributing uniquely to the industry's dynamics. Large enterprises such as JX Advanced Metals, Sumitomo Chemical, and Shin-Etsu Chemical dominate their respective domains. JX Advanced Metals controls approximately 60% of the global market for sputtering targets, a crucial material in semiconductor manufacturing. Sumitomo Chemical leads in producing high-purity chemicals and silicon wafers, supplying top-tier semiconductor manufacturers worldwide. Shin-Etsu Chemical continues to be a global powerhouse in the silicon wafer industry, serving major foundries like TSMC and Samsung. Medium-sized enterprises also play a pivotal role; LG Chem, a South Korean firm, is expanding its portfolio of specialty chemicals and electronic materials, while Showa Denko is recognized for its production of chemical mechanical planarization (CMP) slurries used in wafer processing. ASE Group contributes through its expertise in semiconductor packaging and testing—essential steps in the chip production process. Smaller enterprises such as Topco Scientific and Ferrotec Holdings are vital for addressing niche market demands. Topco Scientific, based in Taiwan, specializes in chemical supplies and environmental services tailored to semiconductor manufacturing, whereas Japan's Ferrotec Holdings focuses on producing silicon wafers and vacuum components, reinforcing the industry's depth and diversity.

Segmentation by Regional Presence

Regional presence plays a critical role in shaping the semiconductor mineral market across Asia. Japan stands out as a leading supplier of semiconductor materials, including photoresists, high-purity gases, and specialty chemicals. Companies such as Shin-Etsu Chemical and Sumco collectively control more than half of the global silicon wafer supply, reflecting Japan's dominance in upstream semiconductor materials. The Japanese government has also introduced initiatives to bolster domestic production and reduce reliance on imports. In Taiwan, the semiconductor industry is anchored by global foundries like TSMC and UMC, supported by a dense network of material suppliers such as GlobalWafers. Taiwan continues to invest heavily in strengthening local supply chains to achieve greater semiconductor self-sufficiency. South Korea is home to key semiconductor giants such as Samsung Electronics and SK Hynix, supported by robust chemical supply firms like LG Chem and SK Siltron. Government subsidies have been instrumental in strengthening the country's domestic material infrastructure. Meanwhile, China represents a rapidly expanding player in the semiconductor materials space, with increasing investment in rare earth elements and local production capacity. .

Segmentation by Market Niche

The semiconductor mineral market in Asia is also segmented by niche, reflecting the diverse material needs of the industry. High-purity chemicals are indispensable in semiconductor manufacturing processes such as lithography and wafer cleaning. Companies like JSR Corporation and TOK lead innovation in this segment, while Showa Denko and BASF provide critical materials such as CMP slurries, etchants, and solvents. In the silicon wafer niche, which serves as the foundation for all semiconductor devices, leading suppliers like Shin-Etsu Chemical, Sumco, and GlobalWafers continue to invest in research and development aimed at producing larger, more defect-free wafers compatible with advanced process nodes. The rare earth elements market is another vital niche, particularly for semiconductor doping processes. China dominates this segment, controlling over 80% of the global supply and home to leading firms such as China Northern Rare Earth Group. This dominance makes rare earths both a strategic asset and a geopolitical lever in the semiconductor supply chain.

Conclusion

The semiconductor mineral market in Asia is undergoing a significant transformation, influenced by geopolitical developments, technological demands, and strategic realignments. As nations and corporations strive for resilience and competitive advantage, merger and acquisition activities have become a central tool for securing access to critical resources.
This intensifying competition has led to a reshaping of global supply chains, with companies increasingly pursuing vertical integration, cross-border partnerships, and long-term investments in mining and refining operations. The role of government policy cannot be understated—public sector support is catalyzing domestic capacity-building, especially in Japan, India, and South Korea.

Looking ahead, the semiconductor mineral market is poised for continued consolidation and innovation. Companies that successfully integrate upstream assets, embrace sustainability, and invest in technological capabilities will be best positioned to thrive in an era of digital acceleration. As Asia consolidates its leadership role in the global semiconductor ecosystem, strategic foresight and coordinated policy responses will determine which players emerge as true industry leaders in the next decade.

Regulatory Environment and Changes: Mineral Market for Semiconductors in Asia (Q2 2024 - Q1 2025) -

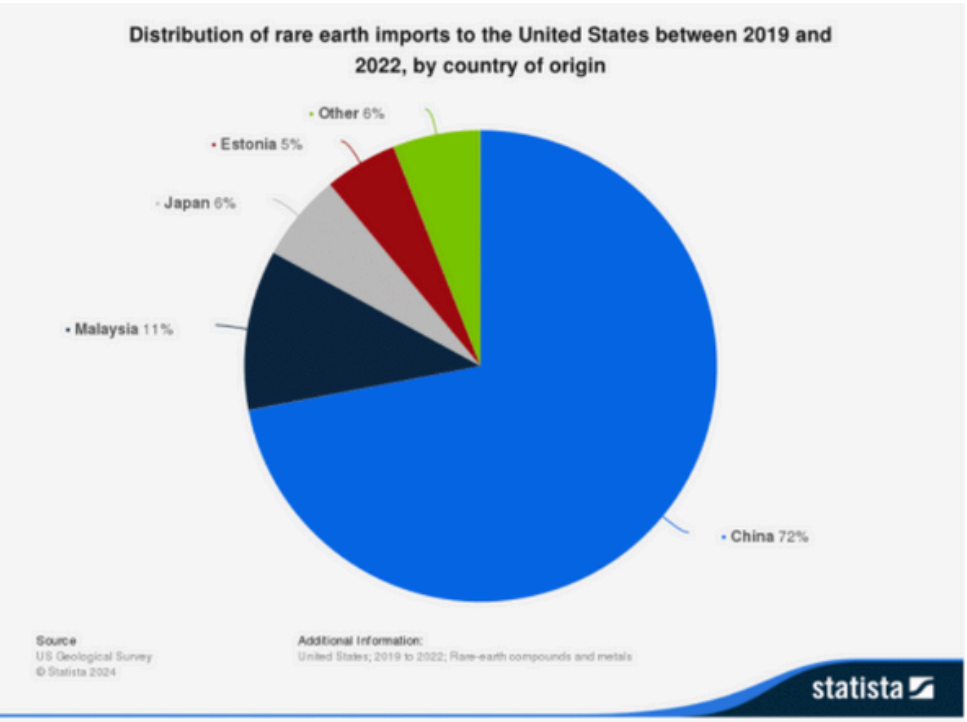
The semiconductor industry's reliance on critical minerals has placed Asia's regulatory landscape at the epicentre of geopolitical competition, environmental sustainability imperatives, and domestic industrial policy over the past year. Between Q2 2024 and Q1 2025, countries such as China, Indonesia, and Vietnam introduced extensive reforms aimed at securing their positions in the global supply chain for minerals vital to advanced chip manufacturing. These reforms embody three interconnected priorities: enhancing supply chain resilience, advancing environmental sustainability, and fostering domestic industrial growth.

Geopolitical Dynamics: US-China Semiconductor Decoupling

China has increasingly leveraged mineral export restrictions as a countermeasure to U.S. semiconductor sanctions, escalating tensions in the global supply chain. In December 2024, the Ministry of Commerce expanded export bans on gallium, germanium, antimony, and now super hard metals under the Export Control Law (ECL) mandating stricter end-user disclosures and checks designating these materials to not be permitted to be exported specifically to the United States. These minerals are critical for semiconductor manufacturing, with China dominating global production. It controls 98% of global gallium refining, which is essential for high-performance AI chips, 68% of germanium production, used in fibre optics and infrared systems and over 50% of antimony output, crucial for military uses, batteries and microelectronics. Geopolitically, this move is widely seen as retaliation for U.S. sanctions on Chinese semiconductor technologies exacerbating trade tensions between the two largest economies, with some US zinc firms arguing diversifying supply of germanium and gallium is possible at the cost of extensive infrastructure investment which may not be economically feasible, it is estimated this supply chain disruption could sot the U.S. a "$3.4 billion decrease in GDP" and rise of costs for semiconductor industries.

China's export restrictions on critical minerals, including gallium, germanium, and antimony, have disrupted supply chains across Asia, particularly in semiconductor manufacturing hubs such as Japan, South Korea and Vietnam. While the ban explicitly targets the United States, its ripple effects have strained regional reliant on these materials. Chinas dominates global production, with the restrictions of gallium causing price increases up by over 100% and germanium by 27% since the initial curbs in August 2023. The U.S., meanwhile, faces significant economic impacts from these disruptions. A study by Gruzer estimates that diversifying gallium and germanium supply chains would require extensive infrastructure investments, potentially resulting in a $3.4 billion decrease in GDP while increasing costs for semiconductor manufacturers.

In response to China's export controls, the Biden administration expanded its own restrictions on semiconductor-related technologies. The Bureau of Industry and Security (BIS) announced an Interim Final Rule in September 2024, adding controls on advanced chipmaking tools such as extreme ultraviolet lithography machines. Additionally, over 140 Chinese entities were added to the U.S. Entity List in December 2024 to prevent technology diversion. While these measures align with the goals of the CHIPS Act to bolster domestic semiconductor manufacturing capacity, they have exposed vulnerabilities in critical mineral supply chains that remain heavily reliant on imports from Asia.



Source: US Geological Survey Statista 2024

Recent developments in the semiconductor industry reflect intensifying geopolitical tensions and strategic shifts. In Q1 2025, the U.S. introduced its "Outbound Investment Final Rule," restricting American investments in Chinese sectors like semiconductors, quantum computing, and AI, aiming to curb China's technological advancements. amsung reported a 20% decline in AI chip sales due to U.S. export restrictions on China, impacting its high-bandwidth memory (HBM) chips.

Despite these challenges, global semiconductor sales are forecasted to grow by 9.5% this year, driven by demand for AI, healthcare, and defence applications. Taiwan's TSMC continues its overseas expansion with significant investments in the U.S., Japan, and Europe to diversify manufacturing and reduce reliance on China amid geopolitical pressures. hese shifts highlight the industry's resilience as it adapts to trade restrictions while navigating supply chain disruptions and innovation demands.

Domestic Policy Overhauls in Key Asian Markets

Indonesia’s recent amendments to its mining laws represent a transformative shift in how the country manages its vast mineral resources. The fourth amendment to the Law on Mineral and Coal Mining (Minerba), passed in February 2025, emphasises domestic mineral processing and utilisation over raw exports. This policy aims to bolster Indonesia’s green industrialisation agenda, particularly in sectors such as electric vehicle (EV) batteries and solar panels. A key feature of this amendment is the prioritisation of small businesses and religious organisations for access to mining areas, enabling broader participation in the mineral processing industry. Additionally, companies in the production phase are now required to prioritise domestic sales of minerals, a move designed to support Indonesia’s burgeoning renewable energy sector. These reforms align with Indonesia’s strategic goal of becoming a global leader in nickel-based EV battery production, leveraging its position as the world’s largest producer of nickel. The success of these policies is evident in the July 2024 launch of Southeast Asia’s first lithium-ion battery plant in West Java, a $1 billion investment by Hyundai Motor Group and LG Energy Solution. This facility is expected to expand further with an additional $2 billion investment, showcasing Indonesia’s ability to attract foreign capital through its domestic-centric mineral policies. However, challenges persist. Centralised licensing under the Ministry of Energy has raised concerns about bureaucratic delays that could hinder project approvals. Furthermore, export restrictions on nickel have driven global prices up by 18% year-on-year, creating cost pressures for industries reliant on this critical material.

Vietnam has also taken significant steps to reform its mineral management framework with the passage of its Law on Geology and Minerals in November 2024, set to take effect on 1 July 2025. This legislation introduces a categorisation system that divides minerals into four groups based on their strategic importance. Rare earth elements (REEs), classified as Group I minerals, are subject to stricter exploitation limits and sustainability requirements. Vietnam holds the world's second-largest reserves of REEs after China and plans to quadruple output by 2030. The law also mandates circular economy practices, requiring companies to adopt recycling technologies for mineral waste. A notable feature of Vietnam's new legislation is its emphasis on state-led exploration projects for strategic minerals. Certain areas have been reserved exclusively for state-controlled initiatives or intergovernmental agreements, ensuring that critical resources are managed sustainably and strategically. Foreign investors face challenges complying with these regulations due to stringent environmental audits and licensing requirements. Despite these hurdles, Vietnam's legal framework positions it as a viable alternative to China for rare earth supply chains.

Critical Mineral Reliance and Strategic Resource Regulations

China's dominance in processing critical minerals such as cobalt, lithium, and rare earth elements, controlling over 60% of global refining capacity, has exposed vulnerabilities in supply chains essential for advanced chip production. In response, countries across Asia have introduced regulatory frameworks to diversify supply sources, enhance domestic processing capabilities, and reduce dependency on Chinese exports. For example, India's ₹34,300 crore ($4 billion) National Critical Mineral Mission, launched in mid-2024, focuses on exploration, mining, benefaction, and recycling while expediting approvals for strategically important projects. Indonesia has amended its Mineral and Coal Mining Law , prioritising nickel processing facilities critical for semiconductor production. Vietnam's national chip strategy includes mineral sourcing provisions supported by targeted tax incentives and streamlined regulations under its Law on Investment, , with additional updates in 2024 to attract foreign investment into domestic mineral processing facilities.

The development of alternative sources for these critical minerals continues to face significant challenges. Lengthy permitting processes and stringent environmental requirements create substantial lead times for new projects. For instance, Malaysia and Vietnam have implemented comprehensive Environmental Impact Assessment requirements targeting mining operations for semiconductor-critical minerals to address ecological concerns such as water pollution and habitat destruction. These measures align with global Environmental, Social, and Governance standards but also increase compliance costs for mining operators and semiconductor manufacturers. Malaysia's National Semiconductor Strategy includes provisions for sustainable mineral sourcing alongside advanced mineral processing technologies to mitigate these challenges. Meanwhile, Indonesia has sought to balance expedited approvals with environmental oversight through its previous Omnibus Law on Job Creation , which streamlines licensing processes while maintaining environmental safeguards. In late 2024, Indonesia also introduced a new regulation under Government Regulation to further incentivise investment in nickel refining facilities essential for semiconductor production. ASEAN countries have responded by leveraging trade agreements like the Regional Comprehensive Economic Partnership to diversify export markets and reduce dependence on China. Additionally, several countries are establishing strategic reserves of critical minerals to buffer against supply disruptions. India's National Critical Mineral Mission includes stockpiling provisions aimed at ensuring long-term supply stability for domestic semiconductor manufacturers. Malaysia is exploring advanced recycling technologies under its Environmental Quality Act (1974) to recover rare earth elements from electronic waste while reducing reliance on newly mined resources.

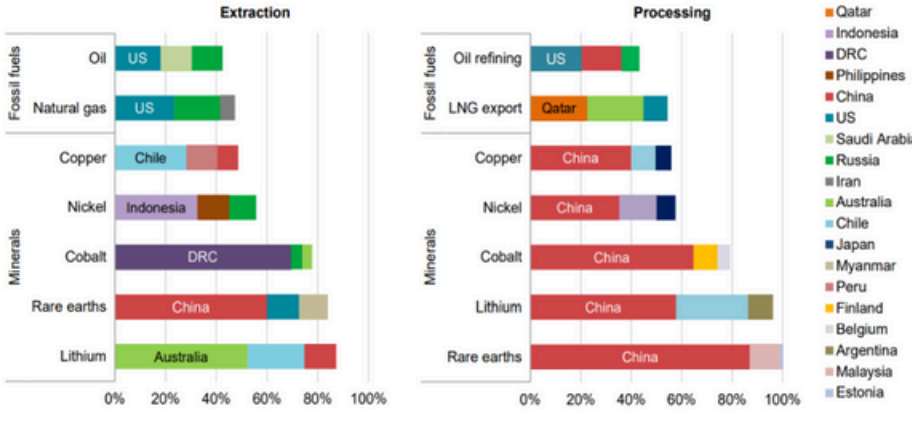
SWOT Analysis

Strengths

Silicon, gallium, arsenide and indium are some of the most important minerals required in the production process of semi-conductors. These minerals play important roles in the production process of microchips and transistors. Since the invention of the microchip in 1958, the number of transistors per wafer in a microchip has grown by a factor of 10 million and as a result of this a 100,000-fold increase in processor speed has occurred, with a significant decrease in costs of roughly 45% per year. With these rapid growths in the industry and in areas such as transistor density this can lead to microchips performing more complex tasks at a better speed whilst being able to fit more transistors per wafer. This can prove to be extremely beneficial because as density decreases microchips reduce power consumption and become overall more energy efficient. Due to the superior electrical properties of gallium, it has become well suited for high frequency applications such as satellite communications and wireless technology. With China being the largest manufacturer of gallium there is a significantly high level of semiconductors such as gallium arsenide (GaAs) being produced. When it comes to rare earth elements (REEs) China produces roughly 60% of the worlds REEs allowing them to solidify themselves in the production process and creating a reliance of the semiconductor industry on them.

When it comes to the mineral market for semiconductors, countries such as South Korea, Japan and China have put in place policies like tax incentives and subsidies to support mining these minerals and the development of the supply chain. An example of this occurred in December 2024 in which China declared an official ban of gallium and germanium being exported to the United States. This can be perceived a strength as it keeps control over main supply chains whilst also reinforcing Asias mineral market in terms of strength by displaying the ability to disrupt markets. By taking actions like this incentivisation can take place when it comes to investing in research and development and improving mining infrastructure. When looking at figure 1 China has a superior position in the processing of REEs mainly in the materials that are crucial to semiconductor production. This can lead to long term stability within the market which acts as a competitive advantage for countries such as China as it also forces competitors to find an alternative source or find their own means of production.

Figure 1: Share of top five countries in critical element extraction and processing (not limited to REE), 2019



Source: IEA (2021)

When it comes to governance multiple Asian mineral suppliers are based in areas with inconsistent regulation and weak governance. One of the main suppliers of REEs is based in Myanmar specifically in heavy rare earth elements (HREEs) which play important roles in the development of more advanced semiconductors. However, when it comes to getting these elements there is a lack of government control with illegal groups smuggling REEs across the border into China and creating more instability within the region.

It was reported on October 23rd, 2024, that an armed group took control of a mining hub within Myanmar which led to disruptions in the channels of supply which caused questioning over the authenticity of the materials being supplied globally. Furthermore, as a result of this situation companies who are behind the sourcing of these materials for semiconductor production are under more constraint to take better measures to provide a more ethical and sustainable approach. Fundamentally, a mixture of poor governance, environmental damage and illegal activities integrated in the supply chain question the overall integrity of the mineral market within Asia.

Opportunities

A key opportunity that should be considered is with the expansion of artificial intelligence and electric vehicles there is going to be a surge in demand for minerals required to produce semiconductors to match with the advancements in technology. Moreover, in Japan due to their limited amount of REEs they have implemented recycling programs to recover REEs from electronic waste such as different forms of data storage such as disk drives. Towards the end of 2023 Japan adopted these recycling techniques for REEs and as a result of this they were able to increase recovery of REEs from electronic waste by roughly 20%. These new methods that were implemented included more efficient chemical treatments which play large roles in reducing environmental damage but also providing an alternative approach to mining operations which cause significant controversy. With this new method of recovering REEs, opportunities for partnership with recycling technology firms and semiconductor manufacturers open providing a more environmentally focused method as an alternative to mining.

India and Indonesia have been investing in research and development in increase quality in extraction methods and processing equipment to counter their underutilisation of REEs. Their goal is to be able to produce and refine their own REEs to a high standard so that they can manufacture their own semiconductors. India have focused on setting up supply chains to reduce their dependency on imports coming from China. Governments are starting to recognise the importance of developing their own self-sufficiency. The Indonesian government has carried out policies to utilise their high amounts of materials such as nickel alongside other REEs. Some of these include adding restrictions on the export of certain mineral ores and implementing subsidies to encourage domestic processing of these ores. By taking this action Indonesia doesn't have to rely on processing their minerals in China who already dominates the mineral processing industry. This can lead to improvements in a stronger infrastructure but also more job creation. Indian Rare Earths Limited (IREL) is now projected to increase their level of output of rare earth oxide by 20% at the end of 2024. This government action can help strengthen REE supply chains between India and the United States giving the US an alternative supplier of these key materials used in semiconductor production after the ban China imposed on these exports.

Threats

A threat to be considered is with a current steep rise in technological advancements alternative materials are likely to emerge which can act as a replacement for the conventional REEs. In essence, materials such as graphene have good thermal and electrical properties which can make it a reliable substitute for other materials in the production process of semiconductors. As a result of this manufacturers of semiconductors to create a new form of production incorporating new materials to replace old ones the mineral market could take a fall in demand. Furthermore, incentivisation to invest in the traditional mineral market for REEs can decrease and move to substitutes.

Another part of this threat is the removal of Asias dominance over the material industry with the rise of substitutes, and if substitutes such as graphene and silicon carbide prove to improve efficiency of new semiconductors the initial REEs can end up facing significant decline in industrial power in terms of leverage. This acts as a threat to countries within Asia who have heavily invested in the infrastructure of mineral processing as challenges in efficiency of resources may occur.

Another threat is the high volatility of mineral prices. This is due to the fact that when a new minerals demand increases the costs also increase accordingly. However, a threat can come into play especially if a new material proves to be more efficient which can cause the initial materials demand to drop. This cycle of a materials demand skyrocketing to then plummeting due to a more efficient and cost-effective material replacing it can complicate long term goals for either producers or consumers. Furthermore, mining companies who invest in improving infrastructure for mining a certain material only for the demand of it to drop, this could also lead to costs increasing for manufacturers of semiconductors as with a new scarcity of high demand materials higher costs will come naturally coupled with high demand for the materials. Sudden regulations that can be put in place can affect the volatility of price as export restrictions or imposition of tariffs can force companies to change strategy, e.g. Indonesia restricting the exportation of raw materials to encourage more domestic processing.

Industry Disruptors

As of recently the largest industry disrupter is forced diversification. Countries are aiming to reduce their reliance on suppliers in Asia. Some of these countries include the United States and some countries within the European Union are searching for alternative suppliers to diversify their supply chain. India and other countries within southeast Asia have started to invest in mining infrastructure and mineral processing to mitigate the risk of relying only on China. By taking these actions countries can secure access to critical minerals in the long run which can lead to incentivisation of technological developments due to the improved availability of minerals. The US and the EU are also encouraging investments into more advanced recycling technology for REE recovery and more improved processing facilities which will improve the overall supply chain but will also lead to the erosion of Chinas dominance within this industry. Another industry disruptor is the introduction of more environmentally friendly mineral extraction processes and more sustainable technology. Companies are trying to reduce their carbon footprint when it comes to mining whilst aiming to increase the output of the amount of minerals from ores mined. By taking these measures companies within India and other countries who are adopting domestic mining methods can improve their ESG ratings. As a result of these measures more traditional industry leaders within China can be affected the most. Furthermore, governments are offering support for more sustainable practices when it comes to production to increase the rate of conversion to sustainable technology and the replacement of original supply chains. When it comes to using these technologies, costs can be reduced since newer recycling methods are reusing mineral processes whilst also trying to minimise waste production. With the emergence of these environmentally friendly initiatives and forced diversification being put into action, Countries such as China are going to lose a majority of consumers since countries are starting their own and more efficient production processes leaving China with near to nothing.

Another part of this threat is the removal of Asias dominance over the material industry with the rise of substitutes, and if substitutes such as graphene and silicon carbide prove to improve efficiency of new semiconductors the initial REEs can end up facing significant decline in industrial power in terms of leverage. This acts as a threat to countries within Asia who have heavily invested in the infrastructure of mineral processing as challenges in efficiency of resources may occur.

Another threat is the high volatility of mineral prices. This is due to the fact that when a new minerals demand increases the costs also increase accordingly. However, a threat can come into play especially if a new material proves to be more efficient which can cause the initial materials demand to drop. This cycle of a materials demand skyrocketing to then plummeting due to a more efficient and cost-effective material replacing it can complicate long term goals for either producers or consumers. Furthermore, mining companies who invest in improving infrastructure for mining a certain material only for the demand of it to drop, this could also lead to costs increasing for manufacturers of semiconductors as with a new scarcity of high demand materials higher costs will come naturally coupled with high demand for the materials. Sudden regulations that can be put in place can affect the volatility of price as export restrictions or imposition of tariffs can force companies to change strategy, e.g. Indonesia restricting the exportation of raw materials to encourage more domestic processing.

Industry Disruptors

As of recently the largest industry disrupter is forced diversification. Countries are aiming to reduce their reliance on suppliers in Asia. Some of these countries include the United States and some countries within the European Union are searching for alternative suppliers to diversify their supply chain. India and other countries within southeast Asia have started to invest in mining infrastructure and mineral processing to mitigate the risk of relying only on China. By taking these actions countries can secure access to critical minerals in the long run which can lead to incentivisation of technological developments due to the improved availability of minerals. The US and the EU are also encouraging investments into more advanced recycling technology for REE recovery and more improved processing facilities which will improve the overall supply chain but will also lead to the erosion of Chinas dominance within this industry. Another industry disruptor is the introduction of more environmentally friendly mineral extraction processes and more sustainable technology. Companies are trying to reduce their carbon footprint when it comes to mining whilst aiming to increase the output of the amount of minerals from ores mined. By taking these measures companies within India and other countries who are adopting domestic mining methods can improve their ESG ratings. As a result of these measures more traditional industry leaders within China can be affected the most. Furthermore, governments are offering support for more sustainable practices when it comes to production to increase the rate of conversion to sustainable technology and the replacement of original supply chains. When it comes to using these technologies, costs can be reduced since newer recycling methods are reusing mineral processes whilst also trying to minimise waste production. With the emergence of these environmentally friendly initiatives and forced diversification being put into action, Countries such as China are going to lose a majority of consumers since countries are starting their own and more efficient production processes leaving China with near to nothing.

Investment opportunities

Over the past 12 months the market for semiconductors has taken off, with in 2024 an expected growth of 19% and sales of $627 billion dollars. One thing driving this increase been the growing demand for AI chips. Another key driver of growth in demand for semiconductors has been the rise in demand for electric cars something which moving forward is continued to grow even more. This has demand for electric vehicles has rising Electric vehicles and automatic cars with a self-drive function place a significant demand on the semiconductor market. In 2021, it was reported that the automotive segment accounted for 10% of the semiconductor market. With the rise in demand for AI and appliances that make life easier its predicted that the demand for these vehicles will rise alongside it which will then increase the demand for semiconductors moving into the future.

Asia and the US currently dominate the market for semiconductors by having strong manufacturing hubs. Asia particularly, is fore fronting innovation into the creation of semiconductor market. For instance, companies such as TSMC, Samsung and intel are leading innovations like energy efficient chips for 5g data. Southeast Asia is also benefiting from said this boom in demand for semiconductors. TSMC is a key leader in semiconductor manufacturing. What makes them standout in comparison to their competitors is the commitment to research and development. By constantly investing in research and development they have been able to develop cutting edge chips which power things like smart phones to high-power computers. In a space were staying ahead of the market and differencing from competitors and meeting consumer needs is important to survive moving into the future they present a good opportunity for investment.

With the rise in focus in being more environmentally conscious the production of semiconductor manufacturing is likely to shift towards a net zero future being greener and more sustainable. Currently, the environmental implications of producing semiconductors I large with the manufacturing of advanced 3nm chips N3 predicted to consume up to 7.7 billion kilowatt-hours annually. Additionally, the world's largest chip maker, TSMC, in Taiwan used 6% of the islands power in 2021. With the growing demand for chips and semiconductors, companies are starting to switch to investing in greener ways of manufacturing.

Risks: Rise in competitors in Europe

One risk for the market of semiconductor market in Asia is the rising competition from other places around the world. At the forefront of chip manufacturing and producing, has been Asia and the US. Due to growing demand other countries have also begun investing in to manufacturing as well. It has been reported that the Newport Wafer Fab (NWF), now known as Vishay Newport, facility in Wales is £250 million to start making silicon carbide semiconductors. The facility in South Wales is now Britain's largest production plant since being acquired by the Vishay Intertechnology. Part of the fund is being invested by the UK government with funds being used to develop a semiconductor material which has a faster battery charging and can withstand longer driving differences. A rise in production from companies outside of Asia could pose a potential risk. In market which is driven by innovation to stand out from competitors' differentiation is imperative.

Tariffs/ Geopolitical tensions

With presidents' trump re-election in November of 2024, geopolitical tensions between the US and China have risen. Most recently, on the 2nd of April 2025, a 'universal' tariff of 10% was put in place by the US. Some countries, like China had tariffs of 34% placed on their imports. The semiconductor market in Asia likely to feel a hit with key manufacturing regions being in Taiwan, China and South Korea. The price for both chips and AI processors is expected to rise due to this cost.

The Taiwanese company chip manufacturer TSMC is looking at establishing plants in the US, so in the future tariffs can be avoided. In the long run it will be beneficial, it will take a while for the plant to be at optimalcapacity.

The US is also set to suffer themselves with xAI building two data centres in the US which is each is costing 100 of millions of dollars. I's expected that the one data centre alone is including 200,000 AI processors with plans to expand to over a million. Because of the tariffs on the chips from Taiwan, it will make the plans significantly more costly. This could potentially lead to companies backing out of investing in the project due to the higher costs.

The extent doesn't just fall on the countries who have been hit with the hardest tariffs the universal tariff of 10% means that all inputs are due to rise. The semiconductor market is heavily reliant on a global supply chain with raw materials being imported from an array of different countries. Now with countries reciprocating tariffs back which the US has put in place this effect will be heighted. As China is facing some of the heaviest tariffs, companies may seek out chips from other locations because of the higher prices. Due to how competitive the market is around chips, especially for the use of AI, most likely business in Asia for semiconductors will fall.

Looking into the future, the constant implementing tariffs and countries creates uncertainty within the semiconductor market. It's risky to now invest with the risk of volatility in prices and potential changes in the supply chain. Many companies may move investment out of countries who are specifically affected by the tariffs. Asia again has been hit hard especially, so may find a slowdown in business.

Summary of Findings

Moving forward the market for semiconductors in Asia is uncertain. Tariffs and geopolitical tensions are causing slowdowns in production and hence supply is lower. However, despite potential supply shortages the demand for semiconductors is increasing and will be higher as we move into the future. Because of this price of semiconductors are set to be high. Countries who mainly produce in Asia will have to come up with creative solutions to overcome tariffs and uncertainties in the market, in a market where innovation is key, companies who can come up with creative solutions to overcome the challenges of the market are set to succeed

References

[1] https://cset.georgetown.edu/publication/china-rare-earth-export-ban/

[2] https://www.reuters.com/markets/commodities/china-bans-exports-gallium-germanium-antimony-us-2024-12-03/

[3] https://bisi.org.uk/reports/escalating-trade-war-chinas-ban-on-rare-mineral-exports-to-the-us

[4] https://www.fastmarkets.com/insights/markets-largely-adjusted-to-chinas-germanium-gallium-graphite-export-controls-one-year-on/

[5] https://projectblue.com/blue/news-analysis/960/germanium-prices-soar-amid-stockpiling-activities

[6] https://www.tradepractitioner.com/2024/09/bis-issues-rule-on-implementation-of-export-controls-on-several-advanced-technologies/

[7] https://www.csis.org/analysis/understanding-biden-administrations-updated-export-controls

[8] https://bisi.org.uk/reports/escalating-trade-war-chinas-ban-on-rare-mineral-exports-to-the-us

[9] https://www.semiconductors.org/chip-supply-chain-investments/

[10] https://pubs.usgs.gov/publication/ofr20241057

[11] https://www.aseanbriefing.com/news/indonesias-mining-law-amendments-boosting-the-domestic-mineral-market/

[12] https://indonesiabusinesspost.com/3610/capitol-influence-and-lobbying/house-passes-revised-mining-law-to-strengthen-governance-boost-industrialization

[13] https://www.thailand-business-news.com/markets/commodities/197777-indonesias-mining-law-revisions-strengthening-the-domestic-mineral-industry

[14] https://en.vietnamplus.vn/geology-and-mineral-law-to-take-effect-on-july-1-post309749.vnp

[15] https://theinvestor.vn/vietnams-new-regulations-in-energy-mineral-and-construction-sectors-d14230.html

[16] https://ven.congthuong.vn/new-law-to-enhance-state-management-of-mineral-resources-56380.html

[17] https://www.mondaq.com/water/1585852/vietnams-new-law-on-geology-and-mineral-resources

[18] https://www.mining.com/which-critical-minerals-will-be-crucial-for-the-ai-boom/

[19] https://www2.deloitte.com/us/en/insights/industry/technology/technology-media-telecom-outlooks/semiconductor-industry-outlook.html

[20] https://www.metatechinsights.com/industry-insights/semiconductor-market-1365

[21] https://international-adviser.com/the-semiconductor-industry-a-regional-approach-to-investing/

[22] https://semiconductormarkets.com/emerging-semiconductor-markets-to-watch-in-asia-pacific/

[23] https://earth.org/semiconductors/

[24] https://www.msn.com/en-us/money/other/newport-wafer-fab-rebooted-with-250m-silicon-carbide-investment/ar-AA1BLAv7

[25] https://anysilicon.com/the-impact-of-trumps-liberation-day-tariffs-on-the-semiconductor-industry/

[26] https://nationalinterest.org/blog/techland-when-great-power-competition-meets-digital-world/critical-materials-can-make-or-break

[27] https://www.csis.org/analysis/what-chinas-ban-rare-earths-processing-technology-exports-means#:~:text=They%20are%20also%20used%20in,other%20countries%20and%20processing%20them.

[28] https://www.regulations.gov/comment/BIS-2021-0011-0080

[29] https://www.stimson.org/2025/chinas-germanium-and-gallium-export-restrictions-consequences-for-the-united-states/#:~:text=China's%20new%20ban%20on%20germanium,through%20trade%20via%20third%20countries.

[30] https://www.oxfordenergy.org/wpcms/wp-content/uploads/2023/06/CE7-Chinas-rare-earths-dominance-and-policy-responses.pdf

[31] https://trendsresearch.org/insight/critical-minerals-and-the-u-s-china-trade-war/?srsltid=AfmBOopzCwH33QTJO3KfnEbS4Z9GZGffjHTNUlcptnfySgVWAaRuZVdm

[32] Rare earth mining may be key to our renewable energy future. But at what cost?

[33] Armed group says it takes control of Myanmar rare earth mining hub | Reuters

[34] https://www.reuters.com/markets/commodities/western-rare-earths-supply-chain-springs-into-gear-2024-06-17/

[35] https://www.mining.com/web/indias-rare-earths-miner-eyes-400-expansion-for-clean-energy/

[36] https://www.csis.org/blogs/new-perspectives-asia/strengthening-us-india-rare-earth-elements-cooperation

[37] https://www.iea.org/reports/global-critical-minerals-outlook-2024/outlook-for-key-minerals

[38] https://www.business-standard.com/world-news/anything-but-china-us-tech-companies-supply-chain-shift-away-trump-125021700365_1.html

[39] https://www.iea.org/reports/global-critical-minerals-outlook-2024/market-review

[40] https://www.asiafinancial.com/chinas-critical-minerals-blockade-risks-global-chip-shortage

[41] https://www.ft.com/content/2b26db14-c677-42c1-808d-5366d0de751b

[42] https://www.fortunebusinessinsights.com/semiconductor-material-market-110088.

[43] https://www.reuters.com/markets/commodities/congo-conflict-is-double-trouble-global-tin-market-2025-03-19/.

[44] https://www.koreatimes.co.kr/business/companies/20221215/korea-heavily-dependent-on-china-for-battery-minerals-supply-report

[45] https://apnews.com/article/china-us-gallium-critical-tech-ban-711fdfcb7c09e0e0e6374192fd2e24fa.

[46] https://www.mordorintelligence.com/industry-reports/asia-pacific-semiconductor-materials-market

[47] https://www.spglobal.com/market-intelligence/en/news-insights/research/the-shifting-global-semiconductor-landscape-in-asiapacific

[48] https://www.globenewswire.com/news-release/2024/12/09/2993702/0/en/Advanced-Semiconductor-Materials-Market-to-Reach-USD-140-38-Billion-by-2032-Driven-by-5G-AI-and-EV-Innovations-Research-by-SNS-Insider.html

[49] https://www.tsmc.com.

[50] https://www.ft.com/content/cace5b0f-e08c-4cb9-aac5-c3117d5a93bc.