CENJOWS

ISSUE BRIEF
IB/26/25

FROM RESERVES TO RESILIENCE: INDIA - JAPAN SYNERGY IN RARE EARTHS, ADVANCED MATERIALS AND SEMICONDUCTOR SUPPLY CHAINS

DR ULUPI BORAH

www.cenjows.in

CENTRE FOR JOINT WARFARE STUDIES

CENJOWS

FROM RESERVES TO RESILIENCE: INDIA JAPAN SYNERGY IN RARE EARTHS, ADVANCED MATERIALS AND SEMICONDUCTOR SUPPLY CHAINS

Dr Ulupi Borah is a Distinguished Fellow at CENJOWS

Abstract

Rare earth elements (REEs) and critical minerals have emerged as strategic enablers of advanced technologies, underpinning global industries ranging from semiconductors and renewable energy for defence and space systems. The concentration of REE processing in China, accounting for nearly 90 percent of global capacity has created systemic vulnerabilities for nations dependent on high-purity oxides, alloys and advanced materials derived from these minerals. This paper examines the complementarities and challenges in building a resilient semiconductor ecosystem through India Japan collaboration, focusing on the intersection of resource availability, technological capability and strategic policy frameworks.

Keywords: Rare Earth Elements, Critical Minerals, Semiconductors, CMP Pads, Value Chains

Introduction

Rare Earth Elements (REEs) allow vital processes to function, which is why they are frequently described to as the "vitamins of modern industry." Numerous modern devices, including cellphones, computers, hard drives and electric vehicles. In modern defence systems, REEs occupy a place of critical importance.[1] Neodymium and samarium, for instance, are used in high-strength permanent magnets that are essential for the miniaturisation of components in precision-guided munitions, radar systems and advanced communication equipment.[2] Its application is not limited to individual components and goes beyond that. They are used on “Directed Energy Weapons (DEWs)”, including high-powered lasers, which are central to the future trajectory. The role of REEs is immense in terms of their utility in stealth aircraft and submarines. This enhances performance, efficiency and survivability in the advanced radar and missile guidance systems.[3]

However, their supply is extremely concentrated because China owns a large portion of the world's mining, processing and refining capacity. For nations like Japan and India, which depend on guaranteed access to these minerals to maintain their defence-industrial foundation, this poses vulnerabilities. Protecting REE supply networks has become as important for national security as it is for economic resilience as a result of increased global competition.

REEs the Backbone of Advanced Materials

While being minerals, REEs are considered the backbone of a wide range of advanced materials. These advanced materials are used in dual-use technologies. It is crucial to understand how the direct linkage between REEs and advanced materials highlights that minerals are strategic enablers, once transformed through chemical processing and engineering innovation. Advanced materials derived from these REEs not only feed into cutting-edge defence platforms such as stealth aircraft or submarines but also are crucial in the formation of the infrastructure of the global semiconductor ecosystem. “This connection is seen when rare earths like cerium are used in polishing compounds for semiconductor wafers, while others enhance the properties of high-k dielectric materials and specialised glass fibres for communication systems.”[4] Thus, the strategic importance of REEs does not end at the mining stage. It lies in their transformation into advanced materials that underpin the technological edge of modern militaries and semiconductor industries alike.

Dependence of Semiconductor Supply Chain on REEs

The REEs because of their special chemical and physical characteristics, are essential to the semiconductor industry, which form the foundation of modern industries. Due to their functions in electrical conductivity, dielectric characteristics and gas sensing abilities, these elements which include Lanthanides, Yttrium and Scandium are essential for improving the performance of semiconductor devices. For example, Dysprosium improves the high-temperature performance of these magnets, while Neodymium is necessary to produce strong magnets used in semiconductor manufacturing equipment. Similarly, Europium plays a key role in the production of phosphors for electronic device display technology.[5]

Nonetheless, the worldwide supply chain for REEs is highly concentrated, with China producing over 90 percent of the world's supply, despite their vital function. [6] Significant worries over supply chain vulnerabilities have been raised by this concentration, especially by the US, whose semiconductor sector is largely dependent on imported REEs. When China placed export limits on REEs in 2010, the situation grew even more dire, resulting in a lack of supply worldwide and a precipitous rise in prices. This incident brought attention to the dangers of relying solely on one nation for such essential resources which forced the US government and industry participants to look into alternate REE suppliers.[7]

A number of nations, including the US, have responded to these difficulties by funding mining projects in various countries including Australia and Brazil as alternate REE supplies. As a possible way to lessen reliance on primary sources, recycling REEs from end-of-life items has also gained popularity. But despite these initiatives, the US still relies mostly on China for REEs, a situation made worse by a lack of domestic processing capacity. Since China is the only nation with the complete infrastructure for refining these elements into useful commodities, even when they are mined outside of the country, they frequently are required to be brought China for processing.[8]

According to a report from Central News Agency, citing Nikkei, imports from China made up roughly 50 percent of Japan's rare earth metal import volumes in 2018 and increased to 63 percent by 2024 (excluding compounds). [9] Furthermore, according to data by Japan's Ministry of Economy, Trade and Industry (METI), the nation still gets all its heavy rare earths from China. China’s export restrictions on these minerals significantly impact Japan’s access to critical components for semiconductor materials and related advanced manufacturing processes.[10]
Japan was among the first countries to experience the risks of Beijing’s dominance in critical minerals. This became even more evident when China banned the export of several rare earth metals and magnets in early April 2025.[11]

In 2010, after a bitter territorial dispute, China imposed an export restriction on REEs that targeted Tokyo directly, sending it into a panic. Even while the embargo was only in place for around two months, it was sufficient to encourage the fourth-largest economy in the world to alter its supply chain security strategy.[12]
The Japanese government responded by allocating $1.2 billion to reducing its reliance on Chinese REEs.[13] The utilisation of alternative materials, REE recycling and stockpiling and purchasing shares in REE mines in friendly nations like Australia were all supported by this fund.

There were five major pillars in the package:

- To encourage equipment investment and technological development in order to minimise the consumption of REEs.[14]
- To create technologies that make use of substitute materials.[15]
- To encourage REEs recycling by funding the construction of recycling facilities and the creation of more effective recycling technologies.[16]
- To build mines and purchase shares in rare earth mines in Australia and other countries. Government-affiliated organisations' ability to offer loan guarantees and equity investments for these kinds of operations was greatly enhanced.[17]
- Begin building rare earth stockpiles alongside establishing a strong policy framework to ensure secure reserves of essential minerals.[18]

Nonetheless, REEs such as Scandium and Yttrium are vital to high-tech sectors like consumer electronics, robotics, renewable energy, electric vehicles (EVs) and semiconductors. As a result, Japan remains the world's leading importer of these metals.[19]

Japan's strategic domination in this vital supply chain was further cemented in 2024, when it accounted for 56.86 percent of all imports of rare earth elements worldwide. Japan imported USD 339.61 million worth of rare-earth metals between January and December 2024, an increase of 13.18 percent over the same period the year before.[20] This rebound highlights Japan's ongoing need for these vital minerals and comes after the price-driven market downturn of 2023.[21]

Japan’s Edge in Advanced Materials

At the same time, Japan renowned for its advanced materials, remains substantially dependent on REEs and other critical minerals, particularly for its semiconductor industry. While Japan’s semiconductor ecosystem may no longer include leading-edge chip fabrication, the country continues to exert remarkable influence over the upstream domain of advanced materials, a position built on its strategic use of REEs and critical minerals.

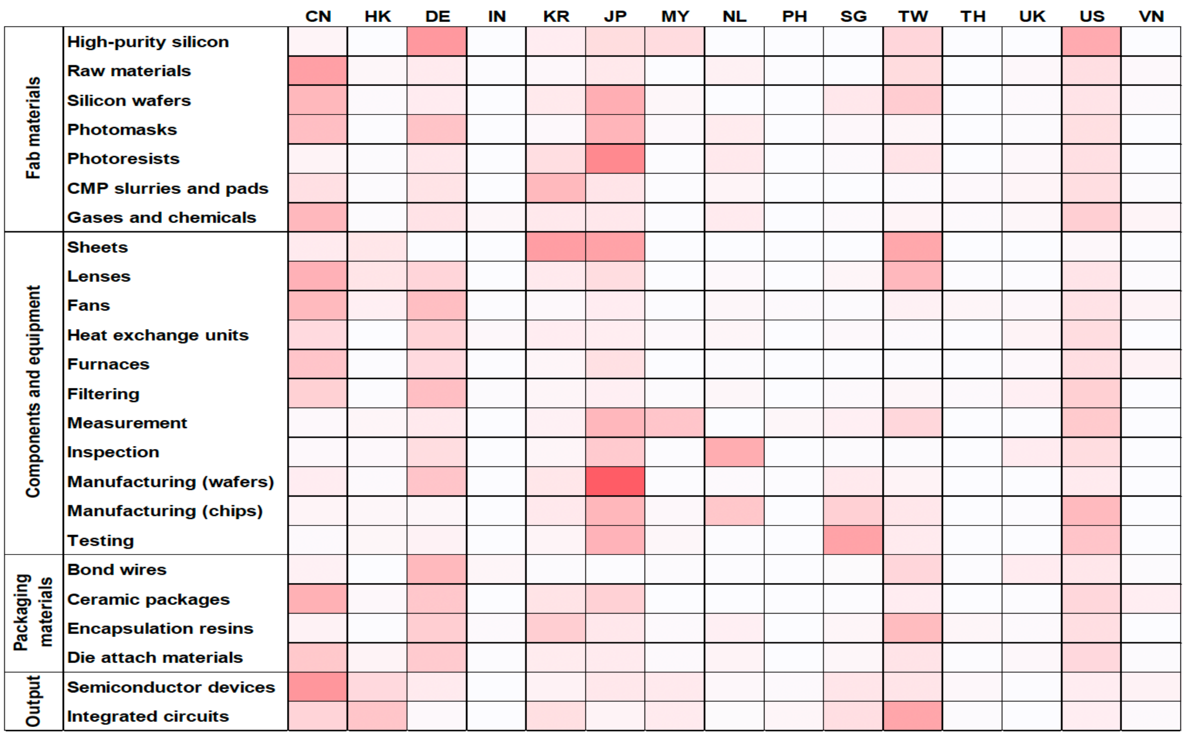

Table 1: Export Mapping of the Global Semiconductor Value Chain. Country short forms: CN = China, HK = Hong Kong (China), DE = Germany, IN = India, JP = Japan, KR = Korea, MY = Malaysia, NL = Netherlands, PH = Philippines, SG = Singapore, TW = Taiwan (province of China), TH = Thailand, UK = United Kingdom, US = United States of America, VN = Vietnam. Source: ASEAN+3 Macroeconomic Research Office.[22]

Table 1 shows the export mapping of different countries across the global semiconductor value chain, with darker pink shades indicating a larger share of global exports in each category. In terms of manufacturing (wafers), Japan is shown in the darkest shade of pink indicating that it is the largest exporter of it.

Japan Leading in Chemical Mechanical Planarization (CMP) for Semiconductor Manufacturing

Chemical Mechanical Planarization (CMP) is one of the most indispensable steps in semiconductor manufacturing, ensuring wafer surfaces are perfectly flat for the stacking of multiple circuit layers. CMP uses a combination of mechanical abrasion and chemical action to polish away uneven surfaces, making it critical for modern chip designs that rely on dozens of layered structures.[23] The materials used in CMP, such as CMP pads, slurries, abrasives, pad conditioners and polishing consumables are considered part of the category of advanced materials. Without CMP, subsequent lithography steps are impaired due to surface topography issues, wafers must be extremely flat for multi-layer deposition and patterning.

While exact percentages vary by node, CMP is known to be one of the more expensive steps in front-end processing. Some industry sources estimate CMP (including pads, slurry, pad conditioning) can account for up to 10-15 percent or more of total wafer fabrication costs, depending on how many planarization steps a process flow uses. The global CMP materials market (slurries, pads, conditioners, etc.) was USD 4.46 billion in 2024, expected to reach USD 6.59 billion by 2030, growing at 6.7 percent Compound Annual Growth (CAGR).[24] The CMP pad market specifically is forecast to grow from USD 970 million in 2023 to USD 2.80 billion by 2032 (CAGR 7.1 percent).[25] CMP equipment (tools, pad conditioners, etc) is also substantial, for example, CMP equipment market was USD 2.35 billion in 2024 and expected to reach USD 3.68 billion by 2033, at a CAGR 5.1 percent.[26]

Japan is the clear leader in CMP consumables and pad technologies. Companies such as Resonac (formerly Showa Denko and Hitachi Chemical) and Fujimi supply high-purity slurries and abrasives that are used worldwide for defect-free planarization. [27] Resonac advertises CMP slurry products tailored for dielectric and metal polishing with low defectivity while Fujimi provides multiple slurry product lines, including ceria-based abrasives for oxide CMP, that are widely adopted by top fabs.[28]

Toho Koki Seisakusho has solidified its position as one of the global leaders in CMP pad processing machines, particularly pad-groove machines and inspection tools, offering highly precise manufacturing of abrasive resin plates used in CMP of semiconductor wafers.[29] The company's business description explicitly states that it manufactures and sells CMP pad groove processing machines and conducts contract processing for pad surface and groove processing as well as pad inspection machines. This product line is a core component of its semiconductor-materials business.[30]

At the India SEMICON 2025 trade exhibition, Toho Koki's exhibitor profile stated that China relies on external sources CMP pad processing machines. Toho remains a significant contributor of these CMP pads to the Chinese market. This underscores Beijing's dependence on Japanese suppliers for a critical stage of wafer planarization. Although companies like Hwatsing Technology are developing CMP tools domestically, their market penetration remains narrow, and they have yet to achieve the quality and reliability offered by Japan. [31]

Tokyo's Lead in Photoresist

Japan controls a commanding share of the global photoresist market. These are materials that define the patterns etched onto silicon wafers during lithography. They enable nanometre-scale resolution, making them indispensable for the most advanced semiconductor nodes (7 nm, 5 nm, 3 nm and below). Japan is a global powerhouse in the photoresist market, with several Japanese companies dominating both the technological and revenue leadership in this crucial advanced material. Key players such as JSR, Tokyo Ohka Kogyo (TOK), Shin-Etsu Chemical, Fujifilm and Sumitomo

Chemical are repeatedly cited among the top firms in reports on semiconductor photoresist materials.[32] As of 2024, JSR, Tokyo Ohka Kogyo (TOK) and Shin-Etsu together supply over 50 percent of the world's photoresists, with stronger dominance in advanced ArF immersion and next-gen EUV resist sectors.[33]

These resists are chemically complex and often integrate or rely on rare-earth derived or related advanced chemistries, underpinning their performance. Though not all resist components are rare earths, the broader semiconductor workflow (wafer prep, mask coatings, optics) is often enabled by REE-derived materials, further cementing Japan's upstream control.

The global IC photoresist market was valued at approximately USD 2.436 billion in 2023 and it is projected to grow to nearly USD 4.478 billion by 2032, at a CAGR of roughly 7.0 percent.[34] Japan plays a significant role in that market, given its strong R&D leadership and its long history of supplying high-performance photoresists.

In Japan itself, the photoresist market was estimated to be USD 277.34 million in 2024, with forecasts placing its value at about USD 497.45 million by 2035, growing at a CAGR of 5.45 percent.[35] This reflects not only domestic demand but also Japan's role as a key supplier internationally.

Leadership in Other Diverse Domains

Another key area of Japan's leadership is in EUV mask blanks, the substrates for photomasks used in extreme ultraviolet (EUV) lithography. Companies such as Hoya and AGC Inc. are among the global leaders in producing high-precision EUV mask blanks.[36] These blanks must meet extremely tight specifications for substrate quality, smoothness, reflectivity and defect density so that circuit patterns can be transferred with minimal distortion. Japan dominates much of this market; for example, Hoya Corporation is noted to lead in the development of products for EUV lithography and mask blanks in its business segment.[37]

Japan also leads in mask and photomask technology, which includes the production of patterned photomasks and their supporting blanks. Photomasks are essential for defining circuit pattern geometry on wafers.[38] Japanese firms supplying these photomask blanks and optical masks must meet extreme standards for defectivity (imperfections can lead to yield loss), alignment and stability over repeated exposure.[39] Hoya, AGC, Toppan and other Japanese firms continue to be cited as among the top players in global EUV mask blank markets, with high importance placed on R&D and quality control in this space.[40]

The Untapped Reserves of India

India is among the richest nations in terms of REEs and critical mineral reserves, yet it remains significantly under-utilised in terms of production and value-chain capture. India holds the world's third-largest, rare-earth reserves, estimated at about 6.9 million metric tons of rare earth oxides (REO).[41] These reserves are scattered across multiple states, including Andhra Pradesh, Odisha, Kerala and Tamil Nadu and include both light and some heavier rare earths. Despite this abundance, India produces less than 1 percent of the world's REE minerals.[42]

Rare Earth Element	Places Found in India	Uses
Neodymium (Nd)	Odisha (Bastar belt), Andhra Pradesh, Rajasthan	High-strength permanent magnets for wind turbines, EV motors, precision-guided systems.
Lanthanum (La)	Kerala (monazite sands), Tamil Nadu	Optical lenses, battery electrodes, catalysts, night vision devices.
Dysprosium (Dy)	Coastal Kerala, Odisha (monazite deposits)	Heat-resistant magnets in missiles, naval propulsion, electronics.
Cerium (Ce)	Odisha, Jharkhand, Chhattisgarh	Catalysts for automotive exhaust systems, glass polishing, alloy additives.
Praseodymium (Pr)	Kerala, Andhra Pradesh	Magnets, aircraft engines, carbon arc lighting, alloys.
Samarium (Sm)	Tamil Nadu, Kerala	Samarium–cobalt magnets, nuclear reactors, defense guidance systems.
Yttrium (Y)	Andhra Pradesh, Jharkhand	Phosphors in LEDs and displays, superconductors, radar systems.
Gadolinium (Gd)	Kerala (monazite), Tamil Nadu	MRI contrast agents, data storage, neutron shielding in reactors.

Table 2: Rare Earth Elements in India. Source: Author's Analysis

The table 2 lists major REEs found in India, their locations of occurrence and their key industrial, technological and strategic uses.

One of the central constraints for India is that it does not yet have sufficient domestic capability in the extraction, separation, purification and downstream manufacturing technologies required to convert its mineral wealth into advanced materials. The extraction of monazite, a key REE-bearing mineral, is complicated by high thorium content, which is radioactive and subject to heavy regulation under India's Atomic Energy regulatory regime. These regulatory, environmental and policy hurdles slow down or limit the commercialization of many REE processing projects.[43]

Besides regulatory challenges, there is a technology gap. India lacks the industrial scale refining and separation infrastructure that can isolate REEs to the purity required for uses in electronics, magnets, optical materials, and semiconductor inputs.[44] Although there are some facilities (for example in Odisha and Kerala) and state-owned entities like Indian Rare Earths Limited (IREL), much of the metallurgical or chemical processing needed to produce usable rare earth oxides (and further, rare earth metals or alloys) must be imported or depends on overseas expertise.[45]

This gap translates into a strategic weakness. While India is rich in the raw material base, it cannot yet transform that into a significant share of the advanced materials value chain, magnets, specialised chemicals, electronic components, without more advanced purification and separation technologies.[46] India also lacks domestic magnet production, forcing it to import nearly all rare earth magnets used for EVs, wind turbines, medical devices and other manufactured goods. [47]

The Significance of these REEs in Semiconductors and Advanced Materials

Cerium oxide is a key ingredient in CMP slurries, which are indispensable for polishing wafers at nanometre scales. Without high-purity ceria, advanced chip manufacturing becomes far more costly or less reliable. Most of these REEs feed into the semiconductor ecosystem. Neodymium and dysprosium, although primarily used in magnets, also support semiconductor lithography equipment, robotics in fabs, and precision tools.[48]

So, while India has the reserves, its inability to process these REEs into high-purity oxides or alloys means it cannot yet supply critical semiconductor materials. At the same time, semiconductor supply chains are extremely sensitive to disruptions in REE supply. China dominates global processing and refining of REEs, including those used in semiconductor manufacturing. India's lack of separation and purification technology keeps it dependent on imports for downstream materials like photoresist[49] inputs, CMP slurries and REE-stabilised optics.

If India invests in extraction and purification capacity, it could channel its third-largest global reserves of REEs into building an advanced materials base for semiconductors. This would make India not just a supplier of raw monazite sands but a partner for Japan, the US and Europe in producing CMP slurries, EUV optics, sputtering targets and rare-earth-stabilised specialty alloys. This is precisely where India and Japan collaboration is emerging, Japan has the know-how in processing, while India has the reserves. Together, they could strengthen supply chain resilience for the semiconductor industry.

National Critical Mineral Mission of India

In order to create a strong foundation for independence in the critical mineral industry, the Indian government started the National Critical Mineral Mission (NCMM) in 2025. The Geological Survey of India (GSI) has been assigned 1,200 exploration projects to carry out between 2024–2025 and 2030–2031 as part of this program.[50]

Its core objectives are:

- To guarantee the availability of minerals from both domestic and foreign sources in order to safeguard India's vital mineral supply chain.[51]
- Enhance technological, financial and regulatory ecosystems to promote innovation, skill development and worldwide competitiveness in mineral exploration, mining, beneficiation, processing, and recycling would strengthen the value chains.[52]

"The total outlay approved for NCMM over seven years (FY 2024-25 to FY 2030-31) is INR 34,300 crore (USD 4.1 billion)."[53] The government portion would cover INR 16,300 crore (USD 1.9 billion) and would initiate activities including exploration, regulatory support, setting up processing or beneficiation infrastructure, recycling schemes and so on.[54]

The Public Sector Undertaking (PSU) contribution of INR 18,000 crore (USD 2.16 billion) comes from state-run companies such as Khanij Bidesh India Limited (KABIL), Indian Rare Earths Limited (IREL), Coal India Limited (CIL), Steel Authority of India Limited (SAIL), ONGC Videsh Limited (OVL), and possibly others. They are expected to initiate projects involving the acquisition of assets in foreign nations, creation of downstream value-chain etc.[55]

Collaboration with the like-minded countries remains one of the crucial pillars of NCMM. Since New Delhi aspires to possess mineral assets abroad, NCMM encourages both the public and private sectors to initiate exploration in overseas nations. Apart from Australia, India's focus remains in strengthening its collaboration with Japan in this sector. This is mostly through having access to Japan's advanced technologies for separation and exploration which would be aimed at boosting the critical minerals value chain of both countries. This could even strengthen the Indo-Pacific Economic Security pillar.

The Technological Edge of Tokyo and the Untapped Reserves of India

Tokyo and New Delhi have been working together in this sector since 2012 when Japan signed an agreement to import 4,100 tons of rare earths a year from India.[56] REEs and critical minerals including Cobalt, Lithium, Copper, Nickel etc., are extremely significant for the development of industries, achieving clean energy and economic security. Hence, Tokyo and New Delhi have already initiated collaboration at the industry level. The trading division of the Japanese company Toyota Group, Toyota Tsusho engaged with Indian Rare Earths Limited (IREL) in 2012 itself.[57] Toyotsu Rare Earths India, a subsidiary of Toyota Tsusho, was made possible by this partnership. It filters and processes thousands of tons of Indian rare earth oxides before exporting them to Japan.

Such endeavours provide India with value-added industrial capacity while assisting Japan's industries (automotive, electronics and defence) in securing a supply of rare metals of magnet-grade.[58]

One of the most ambitious projects is Japan's effort to mine rare-earth-rich muds from the deep seabed near Minamitorishima (Minami-Torishima Island). It is expected that by 2026, test mining for pilot extraction would be begin.[59]

There are several Japanese companies who are global leaders in this field. Shin Etsu Chemical has been engaged in separation of REEs since 1961. They are known for using the solvent extraction method which remain extremely crucial for high purity of the REEs. These highly purified extractions are essential for advanced magnets, semiconductors etc.[60] Apart from Shin Etsu Chemical, the contribution of JX Advanced Metals and Hitachi is noteworthy. JX Advanced Metals is known for its lead in high-purity metals and sputtering targets of semiconductors. Meanwhile, Hitachi is known for its recycling technologies including the development of machinery used to separate and collect magnets.[61]

The lead Japan has in these technologies and its strategic foresight, makes it the only country outside China in terms of processing of REEs. At the same time, New Delhi has underutilised reserves mostly due to the lack of advanced separation technologies.

This technological asymmetry creates a natural synergy between the two countries. India can provide the scale of reserves, while Japan contributes the expertise to transform these raw resources into high-purity oxides and alloys indispensable for semiconductors, clean energy and advanced defence applications.[62]

Collaboration under frameworks such as the NCMM would therefore allow India not only to move up the REE value chain but also to reduce dependency on Chinese imports, while offering Japan secure access to mineral feedstock.[63] "Such a partnership would blend India's resource base with Japan's processing know-how, positioning both countries as critical players in shaping resilient and diversified global supply chains."[64]

Collaboration in REEs: Building a Resilient Supply Chain for Semiconductors

REEs such as neodymium, dysprosium, cerium and yttrium are the hidden enablers of modern technology, powering everything including high-efficiency magnets to other advanced materials.[65] Yet, while India stands third globally in reserves, it lacks the sophisticated technology for separation, purification and conversion into high-purity oxides and alloys. Japan, by contrast, despite its limited natural endowment, has become a global leader in processing and refining through innovations pioneered by firms such as Shin-Etsu Chemical, Hitachi, and JX Advanced Metals. This asymmetry creates a natural complementarity while India brings the resource scale and Japan contributes the technology required to transform these resources into advanced materials critical for the semiconductor ecosystem.

From the perspective of semiconductor supply chains, such collaboration directly strengthens resilience. "Today, nearly 90 percent of global REE processing is concentrated in China, leaving the rest of the world exposed to supply disruptions, export restrictions and geopolitical risks."[66] India's reserves, if effectively harnessed with Japanese know-how, could diversify this concentration, providing alternative flows of high-purity ceria. Since, New Delhi is focused on strengthening the ecosystem of semiconductors through its India Semiconductor Mission (ISM),[67] collaboration with Japan in this sector will enable India to reduce its reliance on other countries and mitigate vulnerabilities in the supply chain.

Areas Requiring Alignment

Although India Japan has various areas of convergence but there are several factors which could hinder their effective collaboration. Some of them have been discussed in the following paragraphs:

- **Gaps in Technology:** It is seen that transferring Japanese technologies to India for extraction is not a very smooth and easy process. The complexities arise because Japan remain cautious about its intellectual property along with the high cost of R&D. Since, New Delhi is aspiring to move beyond licensed production towards collaboration which would involve more co-development in IP and R&D, there should be more emphasis on government to government backed mechanism especially for IP sharing.

- **A Capital-Intensive Process:** Investment in this sector requires billions of dollars mostly to develop specialised infrastructure and advanced equipment. Under the IREL of India, there are very limited facilities and struggles to meet with the semiconductor-grade requirements. The Japanese companies may show apprehension regarding return of investment (ROI) hindering long-term agreements for stronger policy frameworks.

- **Coordination Between Government and Industry**: Collaboration in this domain requires significant integration "between governments, PSUs and private firms. India's NCMM"[68] encourages exploration and asset acquisition, while Japan's "ESA, 2022 designates REEs as critical items. However, differences in institutional approaches, decision-making speeds and industry participation often delay joint projects." [69]

- **Focus not Aligned:** Both India and Japan are also separately engaging with the U.S., Australia and EU in critical minerals frameworks (QUAD, IPEF, EU-India TTC, etc.). Sometimes, these overlapping commitments dilute focus, funding or urgency for bilateral India-Japan initiatives.

- **Vietnam and Thailand Attracting Japan's Investments:** Japan's Vietnam and Thailand seem to attract Japan with their cost-competitive labour, and strategic geographic locations within ASEAN, making them ideal for supply chain diversification under the "China+1" strategy.[70] Both countries have become central to Japan's push for expanding semiconductors, electronics and electric vehicle (EV) ecosystem. Meanwhile, India continues to grapple with infrastructure gaps and slower project clearances. These hurdles raise costs and risks for Japanese firms, discouraging large-scale investments in sectors such as automobiles, semiconductors and electronics, where Japan has heavily engaged with Southeast Asia. Moreover, India's absence from major regional trade agreements reduces its appeal as a hub for supply chain diversification under Japan's "China+1" strategy.
  Nonetheless, India's vast market, abundant resource base and new incentive schemes like the Production-Linked Incentive (PLI), [71] position it as a promising destination. It is expected that with these evolving initiatives New Delhi could soon match or even surpass the predictability and ease offered by Vietnam and Thailand for Japanese investors.

Recommendations

To mitigate the challenges, certain areas have been highlighted where Tokyo and New Delhi can collaborate, as outlined in the following points:

- **Reduce the Reliance on China:** Both India and Japan remain highly exposed to China's dominance in the rare earth supply chain, particularly in processing and downstream applications. A joint India Japan initiative should prioritise diversification of sourcing by leveraging India's reserves and Japan's advanced purification technologies. This would reduce dependency on China, safeguard critical sectors like automobiles and semiconductors and protect against economic coercion similar to the rare earth embargo Japan experienced during the Senkaku conflict.[72]

- **Focus on Creation of Upstream Value Chain:** The upstream value chain has its own advantages and the focus of both the countries should be to develop it which includes minerals, materials, machine tools etc. apart from the downstream manufacturing. Co-development could be taken more on a serious note especially in terms of alloys and magnet production. It is believed that by doing so they would be able to gain genuine geo-economic leverage.

- **Institutionalise Economic Security Cooperation:** Japan's Economic Security Promotion Act (ESA), enacted in May 2022, aims to protect national interests by strengthening supply chain resilience, securing critical infrastructure and fostering advanced technology development to reduce vulnerability to external coercion.[73] India could explore harmonising its NCMM with Japan's ESA priorities, creating joint protocols for protecting critical minerals and technologies. Such institutionalisation will deepen resilience, embed transparency and facilitate trust-based technology transfers between the two nations.

- **Expand Joint Research and Innovation Platforms:** To move beyond resource-export and import dynamics, India and Japan must focus on co-development of advanced technologies in REE recycling, substitution and sustainable processing. Japan's proven expertise in recycling (Hitachi's dry-process recovery of Nd and Dy, Shin-Etsu's solvent extraction) could be linked with India's NCMM and IIT-based research initiatives.

- **India Japan Joint Investment in Third Countries:** In order to reduce their dependence on third countries, the two countries could make joint investments in third countries. These joint ventures could be in Africa, Latin America, Southeast Asia and Australia too.

- **Creation of a Robust Supply Chain:** New Delhi and Tokyo have been vulnerable to the critical supply chain of China. Nonetheless, it cannot be denied that China remains heavily dependent on Australia for Lithium. On those lines, Japan and India should emphasise on creating a critical minerals supply chain to reduce their vulnerability and compel Beijing to become dependent on them in turn.

Conclusion

REEs remain extremely crucial to create advanced materials which have become the backbone of emerging technologies like semiconductors. They will be at the heart of global geo-economic and geo-strategic competition. Hence, the nations have become aware that securing a resilient access to these REEs will enable them to hold control in determining the global trajectory of power and innovation. While speaking about New Delhi and Tokyo, this collaboration is not merely about mitigating the challenges but have the capability to redefine the narrative of critical minerals.

References

[1] Stanford Advanced Materials, (2025), "Advanced Materials", URL: https://www.stanfordmaterials.com/rare-earths-in-electronics.html?
[2] Ibid
[3] Klean Industries, "2025", "How Rare Earths Power U.S. Defense – Infographic & Analysis", [Online:web], Accessed:5 September 2025, URL: https://kleanindustries.com/insights/market-analysis-reports/rare-earths-u-s-defense-critical-minerals/?
[4] AEM, (2025), "How to Use Cerium Oxide in High-Precision Industries and Why It Matters", URL: https://www.aemree.com/news/how-to-use-cerium-oxide.html
[5] Shubham Rajendra Ekatpure, (2022), "Rare Earth Elements for Semiconductor Manufacturing: Global Supply Chain and Dominance", Journal of Marketing & Supply Chain Management DOI:10.47363/JMSCM/2022(1)E109, URL: https://www.researchgate.net/publication/384211713_Rare_Earth_Elements_for_Semiconductor_Manufacturing_Global_Supply_Chain_and_Dominance
[6] Ibid
[7] Ibid
[8] Ibid
[9] Trend Force News, (2024), "Japan Reportedly Develops Tech to Cut Heavy Rare Earth Use Amid Dependence on China", URL: https://www.trendforce.com/news/2025/06/24/news-japan-reportedly-develops-tech-to-cut-heavy-rare-earth-use-amid-dependence-on-china/?
[10] Ibid
[11] Sam Meredith and Dylan Butts, (2025), "A lesson for the West? Japan was better prepared than most for China's rare-earth mineral squeeze", CNBC, URL: https://www.cnbc.com/2025/06/20/rare-earths-japan-more-prepared-than-most-for-chinas-mineral-squeeze.html
[12] Ibid
[13] Ryan C. Berg Henry Ziemer, and Emiliano Polo Anaya, (2024), "Mineral Demands for Resilient Semiconductor Supply Chains", Centre for Strategic and International Studies, URL: https://www.csis.org/analysis/mineral-demands-resilient-semiconductor-supply-chains?
[14] Tatsuya Terazawa, (2023), "How Japan solved its rare earth minerals dependency issue", World Economic Forum, URL: https://www.weforum.org/stories/2023/10/japan-rare-earth-minerals/?
[15] Ibid
[16] Ibid
[17] Ibid
[18] Ibid
[19] GTAIC, (2025), "Japan's Rare-Earth Metals Market in 2024", URL: https://gtaic.ai/market-reports/japan-rare-earth-metals-market?
[20] Ibid
[21] Ibid
[22] ASEAN+3 Macroeconomic Research Office, (2024), "AMRO's 2024 Annual Consultation Report on Japan", Pg: 77, URL: https://amro-asia.org/wp-content/uploads/2025/04/1.-AMRO-2024-Japan-ACR_for-publication_corrected-font-size-footnote-77.pdf
[23]Cadence PCB Solutions, (2025), "The Planarization Process for Semiconductor Manufacturing", URL: https://resources.pcb.cadence.com/blog/2023-the-planarization-process-for-semiconductor-manufacturing
[24] 360iResearch, (2024) "CMP Materials for Semiconductor Market by Type (Polishing Pads, Slurries), Application (Analog Devices, Logic Chips, Memory Chips), Distribution Channel, End-User - Global Forecast 2025-2030"
[25] Raksha Sharma, (2025), "CMP Pads Market", URL: http://dataintelo.com/report/cmp-pads-market?
[26] Global Growth Insights, (2025), "CMP Materials for Semiconductor Market by Type (Polishing Pads, Slurries), Application (Analog Devices, Logic Chips, Memory Chips), Distribution Channel, End-User - Global Forecast 2025-2030", URL: https://www.globalgrowthinsights.com/market-reports/cmp-equipment-market-115415?

[27] Resonac, (2025), “CMP Slurry”, URL: https://www.resonac.com/products/semi-frontend-process/75?
[28] Ibid
[29] TOHO, (2025), “Manufacture and sale of next generation semi-conductor substrate planarization machines (CARE equipment)”, URL: https://tohokoki.jp/toppage-en/service-en/?
[30] Ibid
[31] Toho Koki Seisakusho Co. (2025), “CMP Pads”, Semicon India 2025, URL: https://expo.semi.org/india2025/Public/eBooth.aspx?BoothID=656305&Task=Products&utm_

[32] Markets and Markets, (2025), “Photoresist & Photoresist Ancillaries Companies”, URL: https://www.marketsandmarkets.com/ResearchInsight/photoresist-market.asp?
[33] Mireya Solis and Mathiehttps://www.brookings.edu/articles/the-renaissance-of-the-japanese-semiconductor-industry/?
[34] Semiconductor Insight, (2025), “Global IC Photoresist Market Trends, Business Strategies 2025-2032”, URL: https://semiconductorinsight.com/report/global-ic-photoresist-market/?
[35] Spherical Insights, (2025), “Japan Photoresists Market Size, Share, and COVID-19 Impact Analysis, By Product Type (Positive Photoresists and Negative Photoresists), By Application (Semiconductors & ICs, LCDs, Printed Circuit Boards, and Others), and Japan Photoresists Market Insights, Industry Trend, Forecasts to 2035”, URL: https://www.sphericalinsights.com/reports/japan-photoresists-market
[36] Hoya, (2025), “Information Technology”, URL: https://www.hoya.com/en/business/informationtechnology/
[37] Ibid
[38] Ibid
[39] KD Market Insights, (2025), “EUV Mask Blanks Market”, URL: https://www.kdmarketinsights.com/reports/euv-mask-blanks-market/7679?
[40] Ibid
[41] Rare Earth Exchanges, (2025), “India’s Rare Earth Paradox: Rich in Reserves, Missing in Production”, URL: https://rareearthexchanges.com/news/indias-rare-earth-paradox-rich-in-reserves-missing-in-production/?
[42] Ibid
[43] Ibid
[44] Nexdigm, (2025), “India Rare Earth Elements (REEs) Market Outlook to 2030”, URL: https://www.nexdigm.com/market-research/report-store/india-rare-earth-elements-market-report/?
[45] Ibid
[46] Neha Arora and Aditi Shah, (2025), “Exclusive: India moves to conserve its Rare Earths, seeks halt to Japan Experts”, Reuters, URL: https://www.reuters.com/world/india/india-moves-conserve-its-rare-earths-seeks-halt-japan-exports-sources-say-2025-06-13/?
[47] Ibid
[48] Alan Patterson, (2025), “China’s Rare Earth Controls May Impact Chip Industry by 2026” EE Times, URL: https://www.eetimes.com/chinas-rare-earth-controls-may-impact-chip-industry-by-2026/
[49] ZAUBA, (2025), “Photoresist Imports Under HS Code 37079090”, URL: https://www.zauba.com/import-photoresist/hs-code-37079090-hs-code.html?
[50] Ministry of Mines, (2025), “National Critical Mineral Mission Powering India’s Clean Energy Future”, Government of India, URL: https://www.pib.gov.in/PressReleasePage.aspx?PRID=2120525&utm_
[51] Ibid
[52] Ibid
[53] Sauhard Kaushal, (2025), “Developing all Stages of Critical Mineral Value Chain: Crucial for Viksit Bharat”, RIS, URL: https://ris.org.in/en/node/4093?
[54] International Energy Agency, (2025), “National Critical Mineral Mission”, URL: https://www.iea.org/policies/25735-national-critical-mineral-mission?
[55] Sauhard Kaushal, (2025), “Developing all Stages of Critical Mineral Value Chain: Crucial for Viksit Bharat”, RIS, URL: https://ris.org.in/en/node/4093?

[56] Chisaki Watanabe and Ichiro Suzuki, (2012), “Japan Signs Deal with India on Rare Earth Production, Supply”, URL: https://www.bloomberg.com/news/articles/2012-11-16/japan-signs-deal-with-india-on-rare-earth-production-supply

[57] Anindita Sinh, (2025), “Economic Security in the Indo-Pacific: India-Japan Cooperation on Critical Minerals”, Centre for Social and Economic Progress, URL: https://csep.org/blog/economic-security-in-the-indo-pacific-india-japan-cooperation-in-critical-minerals/

[58] Ibid

[59] Yuka Obayushi, (2025), “Japan to begin test mining rare-earth mud from seabed in early 2026”, Reuters, URL: https://www.reuters.com/markets/asia/japan-begin-test-mining-rare-earth-mud-seabed-early-2026-2025-07-04/?

[60] Trend Force, (2024), “Japan Reportedly Develops Tech to Cut Heavy Rare Earth Use Amid Dependence on China”, URL: https://www.trendforce.com/news/2025/06/24/news-japan-reportedly-develops-tech-to-cut-heavy-rare-earth-use-amid-dependence-on-china/

[61] Hitachi, (2010), “Hitachi Develops Recycling Technologies for Rare Earth Metals”, URL: https://www.hitachi.com/New/cnews/101206.html

[62] Neha Arora and Aditi Shah, (2025), “Exclusive: India moves to conserve its Rare Earths, seeks halt to Japan Experts”, Reuters, URL: https://www.reuters.com/world/india/india-moves-conserve-its-rare-earths-seeks-halt-japan-exports-sources-say-2025-06-13/?

[63] Ibid

[64] Ibid

[65] Every CSR Report, (2013), “Rare Earth Elements: The Global Supply Chain”, URL: https://www.everycrsreport.com/reports/R41347.html?

[66] Alvin Camba, (2025), “A Federal Critical Mineral Processing Initiative: Securing U.S. Mineral Independence from China”, War on Rocks, URL: https://warontherocks.com/2025/04/a-federal-critical-mineral-processing-initiative-securing-u-s-mineral-independence-from-china/?

[67] India Semiconductor Mission, (2025), “Semicon India”, Government of India, URL: https://ism.gov.in/

[68] Ministry of Mines, (2025), “National Critical Mineral Mission Powering India’s Clean Energy Future”, Government of India, URL: https://www.pib.gov.in/PressReleasePage.aspx?PRID=2120525&utm_

[69] Kazuto Suzuki, (2023), “How Will the Economic Security Law Change Japan’s Sci-Tech Policy?”, The Tokyo Foundation, URL: https://www.tokyofoundation.org/research/detail.php?id=943&utm

[70] Pritesh Samuel, (2022), “Vietnam’s Diversification of Trade and the China Plus One Strategy”, Vietnam Briefing, URL: https://www.vietnam-briefing.com/news/vietnams-diversification-of-trade-and-the-china-plus-one-strategy.html/

[71] Sudhanshu Singh, (2025), “India’s PLI Schemes Clears 806 Projects, Drives US$20 Billion in Investment”, India Briefing, URL: https://www.india-briefing.com/news/indias-pli-schemes-bring-in-us21-billion-in-investment-in-2025-38796.html/

[72] World Economic Forum, (2023), “How Japan solved its rare earth minerals dependency issue”, URL: https://www.weforum.org/stories/2023/10/japan-rare-earth-minerals/?

[73] Kazuto Suzuki, (2023), “How Will the Economic Security Law Change Japan’s Sci-Tech Policy?”, The Tokyo Foundation, URL: https://www.tokyofoundation.org/research/detail.php?id=943&utm