The quiet war beneath our electronic chips

Export controls and conflicts are placing compound semiconductor manufacturing at risk

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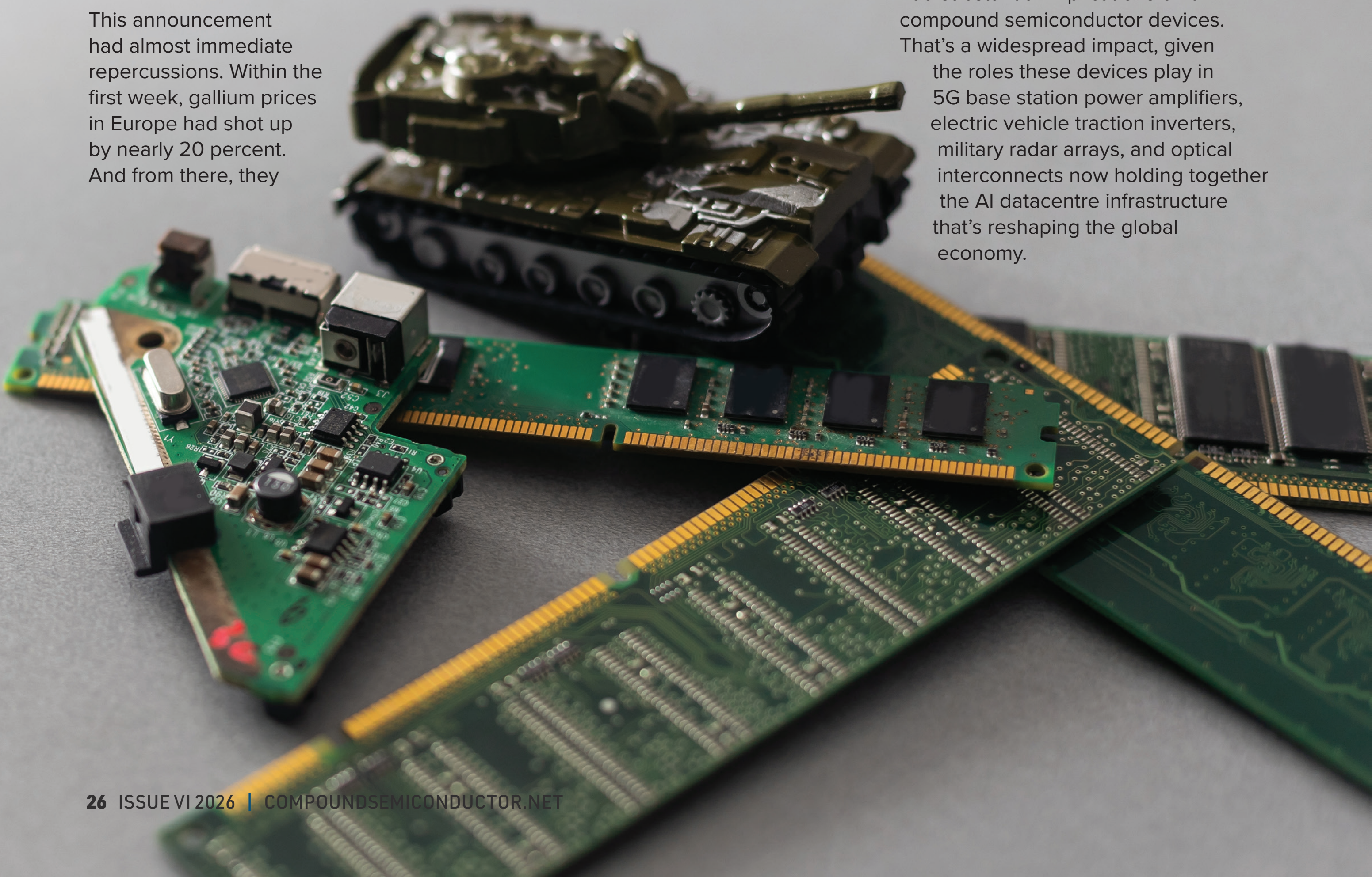
OUR INDUSTRY underwent a profound change on 3rd July 2023. That day, a routine announcement from China's Ministry of Commerce and General Administration of Customs informed exporters of gallium and germanium – and their compounds – that they would now need to apply for licences before shipping. No advance notice. No transition period. No named targets. And the control measures were imminent, imposed from the 1st of August.

This announcement had almost immediate repercussions. Within the first week, gallium prices in Europe had shot up by nearly 20 percent. And from there, they continued to climb. By mid-August 2023, the spot price for gallium had spiked by roughly 50 percent from its June baseline; and the trend continued, with Rotterdam gallium prices climbing by nearly 150 percent from the pre-control time to May 2025. Similarly, by the end of 2024, the year-over-year germanium prices had rocketed by nearly 90 percent in Europe.

This is what supply chain weaponisation looks like. It's not an embargo announced with fanfare, but a licensing regime tightened incrementally – from cautious signal, to export ban, to extraterritorial jurisdiction clause – until the supply chain of an entire technology class is effectively held hostage.

As we are sure you can figure out, these restrictions on germanium, gallium and their compounds – and since 4 February, 2025, you can add indium into that mix – have had substantial implications on all compound semiconductor devices. That's a widespread impact, given the roles these devices play in 5G base station power amplifiers, electric vehicle traction inverters, military radar arrays, and optical interconnects now holding together the AI datacentre infrastructure that's reshaping the global economy.



Compound Semiconductor Supply Chain Resilience Risk Matrix

Materials	Conflicts	Export Controls	Sanctions	Natural Disasters	Energy Crises	Concentration Risk	Average Risk
Gallium	Critical	Critical	High	Low	Medium	Critical	4.0
Germanium	High	Critical	High	Low	Medium	Critical	3.8
Rare-earths	High	Critical	Critical	Low	Low	Critical	3.8
Indium	Medium	High	Medium	Low	Medium	High	3.2
Arsine/ Phosphine	Medium	Medium	High	Medium	Medium	Medium	3.2
Sapphire Substrate	Medium	Medium	Medium	Low	Low	Medium	2.7

Risk Scores: Authors' analysis using CSIS, SEMI, USGS, SIA/BCG data

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A supply chain unlike silicon

Compound semiconductor supply chains are short, steep, and extraordinarily concentrated. While silicon chips are made from one of the most abundant elements on Earth, compound semiconductors are markedly different: they are built from binary and ternary combinations of elements that are scarce, geographically concentrated, and in most cases extracted as byproducts of entirely different industrial processes. Due to scarcity and accessibility, these elements are defined as critical minerals. This underscores their strategic importance.

Production of gallium involves recovery from residues of aluminium smelting. Germanium comes from zinc refining and coal fly ash, and indium is a byproduct of zinc production. In other words, for the three most important metals in our industry, there's no primary mine; so simply mining more is not an option when prices rise. It is also worth noting that China produces approximately 98 percent of the world's low-purity gallium – not because it holds a monopoly on deposits, but because it has built an unmatched refining infrastructure over three decades, largely beneath the radar of Western industrial policy.

From raw material to finished devices, the compound semiconductor supply chain traverses four layers: raw materials and process gases; substrate and epitaxial growth; device fabrication; and end-use sectors. An illustration of this interconnectedness is trimethylgallium, the organometallic precursor that carries gallium into MOCVD reactors for GaN and GaAs epitaxy. It is synthesised from Chinese-refined gallium metal and supplied through key regions, including the US, China, Europe, Japan, South Korea, and India.

Disruption vectors

The compound semiconductor supply chain faces four threats: export controls, war and geopolitical conflict, energy supply crises, and climate and water risk.

Export controls account for the most acute near-term threat. In December 2024, China prohibited exports of gallium, germanium and antimony to the US, a direct retaliation of US semiconductor export restrictions. For China, critical mineral supply control is a strategic leverage. Following a US-China trade truce in November 2025, these controls have been suspended under a licensing regime until November 2026. However, the ban on military end-uses remains fully in place, with Beijing retaining the complete legal architecture to reimpose restrictions at any point. The controls are paused, not resolved. Meanwhile, the extra-territorial provisions introduced in December 2024 – extending Chinese legal authority to third-country re-exporters – have not been rescinded. Trans-shipment routes via Germany, Belgium and Japan remain closed in law, even as direct trade partially resumes. The structural dependency ensuring that the ban would be effective has not been reduced. China also bans imports of some Nvidia chips from the US, supporting local production of advanced AI chips, in line to develop a full end-to-end advanced semiconductor supply chain.

War and geopolitical conflict introduce a different risk profile: a faster onset, and a more indiscriminate cascade. The 2022 Russian invasion of Ukraine immediately disrupted neon and krypton supply. Prior to the conflict, Ukraine supplied roughly half of global semiconductor-grade neon – this is one of the critical gases used in high-end lithography tools, and while it is primarily employed in the silicon industry, it is starting to impact compound semiconductor manufacturing.

Another potential disrupter is an energy supply crisis. Restrictions in electricity and gas threaten and directly impact the sustainability of substrate epitaxial growth, wafer production and device fabrication. This occurs, due to the energy intensiveness of these processes – and our industry must take this fragility seriously.

Climate and water risk is the least visible, but most structurally embedded vector. Recurrent drought conditions in Taiwan have had implications for compound semiconductor fab operations, addressed by emergency water-trucking. Epitaxial growth processes are particularly water-intensive, causing water management to become a strategic variable alongside geopolitical risk.

What can be done?

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For companies, the priority is to move from reactive procurement to structural resilience. Chipmakers should be dual-qualifying every critical input across at least two geopolitically distinct suppliers (if possible) – a process that takes 12-24 months and must begin before a crisis, not during one. Alongside this move, there must be a redesign of inventory strategy: as a 90-day gallium buffer proved insufficient by late 2023, a 180-day reserve for non-substitutable inputs is now a reasonable baseline.

It's also crucial to invest in renewable substrates, critical material and rare-earth recycling: companies generating gallium-bearing epi polish waste are sitting on a recovery opportunity that reduces cost exposure and geopolitical dependency simultaneously, and can directly contribute to the circular economy.

For policy makers and nations, there are four important opportunities to exploit, forming part of modern industrial strategy and national security. One of these four is the strategic on-shoring and scale up gallium, indium and germanium (and antimony) refining capacity. Another prudent move is the mandatory supply chain disclosure of critical mineral and rare earth inputs in semiconductor manufacturing: requiring fabs to report Tier 1 and Tier 2 input geographies, which would transform visibility for both industry and government. A third objective is to derisk, through the substitution of materials and reshoring semiconductor manufacturing to a stable, sustainable eco-system. And last but by no means least, there's a need for design security, resilience and circularity, for the photonics, electronics and semiconductor manufacturing supply chains.

The decade ahead

Due to recent events, the semiconductor industry is undergoing a fundamental transformation from a model that's been optimised for global efficiency to one that must prioritise resilience and security. The four levers to succeed in this quest are strategic stockpiling, geographic diversification of processing, recycling investment and material substitution R&D. All are underinvested relative to the strategic exposure they address. The US CHIPS Act, the EU Chips Joint Undertaking, the EU/UK/USGS Critical Raw Materials Act, the UK Semiconductor Strategy, and the allied-nation supply agreements represent a real, if belated, beginning.

But the pace must accelerate. So far, our industry's responses to supply chain shocks have been reactive, although long-term resiliency strategies are gaining speed. However, the next shock may provide no warning.

We live in turbulent times, where structural changes in the global world order are fast and frantic. Over the last few years, supply chains have become increasingly uncertain, as an evenly-poised battlefield outcome. The compound semiconductor industry's ability to recognise that fact – and act on it with the urgency the situation dictates – will define the technology security landscape of the 2030s.