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Issue Brief

Semiconductor War: Assessing the Strategies and Impact of US Led Technology Decoupling

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Summary

The United States and its allies have taken significant policy measures including sweeping export control regulations to make it hard for China to obtain advanced chips and chip making equipment. China though continues to be an important player in the globalised supply chain. China is directing its efforts towards manufacturing cutting-edge processors as also attempting to become competitive in legacy chip manufacturing. India is also seeking to build a vibrant semiconductor and display design and innovation ecosystem.

Introduction

On 16 September 2022, US National Security Advisor Jake Sullivan announced a change in the US policy of being "only a couple of generations ahead" of China in key technologies to maintaining "as large of a lead as possible".[1] The Biden administration has identified three families of technologies which will be of particular importance over the coming decade and one of them is computing-related technologies, including microelectronics, quantum information systems and artificial intelligence.[2] Preserving the lead and denying the same to the competitors in these arenas are being advanced by the administration as a "national security" issue. The US has also secured the commitment of its allies and partners to choke China's semiconductor industry and "reduce collective reliance on Asia" of EU–US alignment on rare earths. The US efforts to limit the advancements around the world in this field of science and technology is poised to define the geopolitical landscape of the 21st century.

This Brief will examine the strategic motivation behind the US attempts to decouple from China in the field of advanced chip manufacturing and key challenges faced by the US and its allies in these efforts. The Brief will thereafter highlight opportunities and challenges decoupling of China presents for India for its semiconductor ambitions.

Technology Race between US and China

In the history of warfare, the human ability to innovate and employ latest technology have been decisive factors in winning wars. For over a decade now, both the US and China have been racing to develop Artificial Intelligence (AI) and other emerging technologies to gain a competitive edge which will assist to secure even greater power, wealth, status and influence.

In April 2017, the US initiated Project Maven to accelerate AI capabilities that will enable it to digitally identify and track targets using surveillance assets, which will assist in furthering combat efficiency by employing data technology. Maven is one of hundreds of AI initiatives being pursued by the Pentagon. The then-Deputy Defense Secretary Bob Work established the Algorithmic Warfare Cross-Functional Team, which is overseen by the Defense Undersecretary for Intelligence (known as the USDI), under Project Maven.[3] Advanced AI chips are central to this effort.

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[1] **"Remarks by National Security Advisor Jake Sullivan at the Special Competitive Studies Project Global Emerging Technologies Summit"**, *The White House*, 16 September 2022.

[2] The other two families of technologies include biotechnologies and biomanufacturing and clean energy technologies.

[3] Paul Mcleary, **"Pentagon's Big AI Program, Maven, Already Hunts Data in Middle East, Africa"**, *Breaking Defense*, 1 May 2018.

Recognising the importance of AI for warfare, the Chinese government announced US$ 100 billion in semiconductor industry subsidies in 2014. In 2015, China's State Council published *Made in China 2025*,[4] with the objective of manufacturing semiconductors by 2025 and replacing imports with Chinese-made products. China launched these initiatives two years before Project Maven was launched by the US.

In 2017, China went on to release its AI strategy, *China's New Generation Artificial Intelligence Development Plan*. This aspirational document sets out a top-level design blueprint charting the country's approach to developing AI technology and applications, setting broad goals up to 2030.[5] China declassified its AI strategy four years before the US National Security Commission on Artificial Intelligence released its final report.[6] This realisation of the importance of AI and semiconductors provided the necessary impetus to the Chinese government to make self-reliance in chip manufacturing a national priority.

No Chip, No AI

Advancements in AI are greatly dependent on high-end semiconductor chips. AI, especially deep learning, requires vast amounts of computational power to process and analyse data. In 2018, OpenAI found that the amount of computational power used to train the largest AI models had doubled every 3.4 months since 2012.[7] Without high-end chips, such as Graphics Processing Units (GPUs) and specialised AI accelerators like Tensor Processing Units (TPUs), training deep neural networks would be significantly slower or even infeasible. Another crucial advantage of high-end chips is their scalability. Since they are scalable, they can be used in clusters to build powerful supercomputers or large-scale AI infrastructure. This feature helps in training AI models on vast datasets.

High-end chips come with sufficient memory and memory bandwidth to handle data-intensive workloads, such as natural language processing and computer vision, efficiently. High-end chips are also energy efficient. Energy efficiency of advanced semiconductor chips prevent the batteries from draining out quickly, a crucial requirement for both data centre operations and terminal devices.

High-end semiconductor chips, therefore, are the backbone of AI development and deployment. They are indispensable to AI ecosystem and have a direct bearing on

[4] **"Roadmap of Major Technical Domains for Made in China 2025"**, Center for Security and Emerging Technology.

[5] **"Full Translation: China's 'New Generation Artificial Intelligence Development Plan' (2017)"**, Stanford University, 1 August 2017.

[6] Caitlin Lee, **"Winning the Tech Cold War"**, *The RAND Blog*, 17 August 2023.

[7] Karen Hao, **"The Computing Power Needed to Train AI is Now Rising Seven Times Faster than Ever Before"**, *MIT Technology Review*, 11 November 2019.

advancements of weapon platforms and surveillance systems. The chips provide the necessary computational power, energy efficiency, and specialised hardware to make AI applications and research feasible and efficient. Even as AI continues to advance, the role of high-end chips will remain central to its development.

US Efforts to Slow Down Chinese Chip Industry

The advancements in science and technology will define the geopolitical landscape of the 21st century including new military and intelligence capabilities that will shape national security. The US has, therefore, made preserving technological edge a national imperative.

The Trump administration pursued an aggressive policy of trade war and sanctions against China which the current Biden administration has moderated, and is working to identify areas of cooperation. This notwithstanding, the US is determined to limit flow of technology to China—notably semiconductors—and invest in technology innovation at home. In August 2022, President Biden signed the CHIPS and Science Act, an Executive Order on Advancing Biotechnology and Biomanufacturing Innovation, and the Inflation Reduction Act. The CHIPS Act aims to invest US$ 52 billion to restore US leadership in semiconductor manufacturing and R&D and reduce over-reliance on foreign-produced chips.[8]

In pursuance of its policy to build a cutting-edge semiconductor industry, the US administration invited applications for funds from the Chips Act with a caveat that the companies that received funding must also not "knowingly engage in any joint research or technology licensing effort with a foreign entity of concern that involves sensitive technologies or products".[9] The administration has also barred private equity and venture capital firms from making investments in China in quantum computing and advanced semiconductors.[10]

In addition to measures enumerated above which help US companies, the administration has taken measures to slow China's chip-making industry by imposing sweeping export control regulations in October 2022 that will make it hard for China to obtain advanced chips and chip making equipment. On 7 October 2022, the US government promulgated export controls policy on AI and semiconductor technologies to China. The Biden administration's export controls aim to stop China from achieving self-reliance in chip manufacturing.

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[8] **"Remarks by National Security Advisor Jake Sullivan at the Special Competitive Studies Project Global Emerging Technologies Summit"**, no. 1.

[9] **"Chipmakers Receiving US Federal Funds Barred from Expanding in China for 10 years"**, *Financial Times*, 28 February 2023.

[10] Ana Swanson, Alan Rappeport and Keith Bradsher, **"U.S. Commerce Secretary Faces a Wide Range of Issues in China"**, *The New York Times*, 27 August 2023.

The new policy of denial includes items of 5G and below the 5G level, including 4G items, Wi-Fi 6 and 7, artificial intelligence, and high-performance computing and cloud items.[11] The policy also restricts export of equipment and materials needed to produce chips with anything smaller than a 16-nanometer process node—restricting China from purchasing capabilities to build microchips that were cutting-edge in 2014.[12] The US export control policy is firmly focused on retaining control over AI chip designs, electronic design automation software, semiconductor manufacturing equipment and equipment components.[13]

Roughly a year after the export controls were first launched to counter the use of the chips for military applications that include the development of hypersonic missiles and AI, the US on 17 October 2023 updated and broadened its export controls to stop China from acquiring advanced computer chips and the equipment to manufacture them. The updates also introduce new requirements that make it more difficult for China to manufacture advanced chips abroad. The list of manufacturing equipment that falls under the export controls has also been expanded.[14]

US Partners Impose Technology Control on China

The export controls policy on AI and semiconductor technologies to China announced by the US on 7 October 2022 was a "major diplomatic gamble". These export controls were designed after consultation with key US allies, but the US originally implemented them unilaterally.[15] In late January 2023, the US, Japan and the Netherlands reached a landmark agreement on semiconductor technology export controls to China.

On 9 March 2023, the Netherlands government put export restrictions on the country's most advanced microchip technology. The Dutch government has already forbidden sales of its most advanced semiconductor machinery, called extreme ultraviolet lithography systems (EUV), to China. But the US has encouraged the Dutch to also limit a slightly less advanced system, called deep ultraviolet

[11] Karen Freifeld, Alexandra Alper and Stephen Nellis, **"U.S. Stops Granting Export Licenses for China's Huawei - Sources"**, *Reuters*, 30 January 2023.

[12] "Process node" determine how densely designers can pack circuits onto their chips. Roughly speaking, the smaller the process node, the more powerful the chip. See Sihao Huang and Bill Drexel, **"China Goes on the Offensive in the Chip War What the United States Should Do to Keep Its Lead"**, *Foreign Affairs*, 11 October 2023.

[13] Gregory C. Allen, **"Choking Off China's Access to the Future of AI"**, *CSIS*, 11 October 2022.

[14] Josh Boak, **"The Commerce Department Updates its Policies to Stop China from Getting Advanced Computer Chips"**, *AP*, 17 October 2022.

[15] Gregory C. Allen, **"Clues to the U.S.-Dutch-Japanese Semiconductor Export Controls Deal are Hiding in Plain Sight"**, *CSIS*, 1 March 2023.

lithography (DUV).[16] This was followed by the announcement by the Japanese government on 31 March 2023, that it will supplement the Wassenaar Arrangement and impose export controls on 23 types of semiconductor manufacturing equipment which were not subject to prior restrictions, including all Deep Ultraviolet (DUV) Immersion Lithography systems.[17]

On 30 June 2023, the Dutch government announced new restrictions on exports of some semiconductor equipment, boosting the US-led drive to curb supplies of high-tech components to China. ASML (ASML.AS), a Dutch company that is a key equipment supplier to computer chip makers, would require a licence to export its second most advanced DUV lithography systems, which are used to help print the circuitry of chips. ASML's 2000 series "and subsequent" models would come under the ambit of new licencing policy which also include its most advanced EUV machines. ASML has been restricted from selling DUV and EUV machines without a licence under the Wassenaar Arrangement.

Japan along with the Netherlands agreed to join the US in restricting exports to China of equipment that could be used to manufacture sub-14 nanometre chips. Japanese companies Tokyo Electron and Screen make around a fifth of the world's chipmaking tools, while Shin-Etsu Chemical Co Ltd (4063.T) and Sumco Corp (3436.T) produce most silicone wafers. The Japanese government, with effect from July 2023, imposed export controls on six categories of equipment used in chip manufacturing, including cleaning, deposition, lithography and etching.[18] With the revision of a trade ministry ordinance under the foreign exchange law, Japan added 23 chip-manufacturing items that require approval for export.[19]

China's Expanding Capabilities and Challenges

The semiconductor industry is one of the world's most globalised industries. A factor which has contributed to globalisation of this industry has been the unification of the mobile communication standards. This has led to the development of the globalised supply chain, of which China is an important player. Integrated circuit chips are indispensable to mobile communication devices. Globalised supply chain of popular iPhone abundantly demonstrates the challenges the US and its Western partners will face to decouple from China. The chips used in the phone are designed

[16] Ana Swanson, **"Netherlands and Japan Said to Join U.S. in Curbing Chip Technology Sent to China"**, *The New York Times*, 28 January 2023.

[17] Wei Shaojun, **"Japan's Proposed Semiconductor Export Controls Will Cause Unnecessary Damage"**, *Global Times*, 1 May 2023.

[18] Tim Kelly and Miho Uranaka, **"Japan Restricts Chipmaking Equipment Exports as it Aligns with US China Curbs"**, *Reuters*, 31 March 2023.

[19] **"Japan's Export Curbs on Chip-making Equipment to China Take Effect"**, *The Japan Times*, 23 July 2023.

in the US, produced in Taiwan, packaged in Southeast Asian countries, and assembled with other components from Japan, South Korea, Europe and China to form a complete phone.[20]

China has been investing huge sums of money to further its semiconductor ambitions. The China Integrated Circuit Industry Investment Fund, also known as the 'Big Fund', has launched three funds till date. The first two funds were launched in 2014 and 2019, which according to government reports, raised 138.7 billion yuan (US$ 19 billion) and 200 billion yuan (US$ 27 billion) respectively. In September 2023, the Chinese government announced that it aims to raise about 300 billion yuan (US$ 41 billion).[21]

Over the last decade, huge sums of money have flowed into the semiconductor industry with little oversight leading to corruption. In 2021 and 2022, China undertook an anti-corruption drive in its semiconductor funds, punishing individuals for graft and wasteful spending. The Central Commission for Discipline Inspection (CCDI), the CCP's anti-graft agency, has probed several senior officials and former officials at SINO-IC Capital, the sole manager for the 'Big Fund'.

Despite ongoing anti-graft investigation, SINO-IC Capital is expected to remain one of the managers for the third fund, a sign of both desperation and importance attached to semiconductor industry by the Chinese decision-makers. The desperation arises from the fact that despite some successes, like the Semiconductor Manufacturing International Corporation (SMIC), 'Big Fund' investments have failed to meaningfully reduce China's reliance on imported technology.[22]

To frustrate US led effort to decouple the country from advanced chip technology, China is directing its resources and efforts towards manufacturing cutting-edge processors as also attempting to become competitive in legacy chip manufacturing. In August 2023, when US Commerce Secretary Gina Raimondo was visiting the country, Huawei released Mate 60 Pro, a phone featuring an unexpectedly advanced processor. The processor was made on a 7-nanometer process node, a capability that US export controls seek to deny.

It is quite likely that the chip designing for Mate 60 Pro has been done in-house by Huawei's Hisilicon, which can design advanced chips, especially for smartphones. However, the fabrication of the chip, in all possibility, has been undertaken by SIMIC

[20] Wei Shaojun, **"Japan's Proposed Semiconductor Export Controls Will Cause Unnecessary Damage"**, no. 17.

[21] See Julie Zhu, Kevin Huang, Yelin Mo and Roxanne Liu, **"China to Launch $40 Billion State Fund to Boost Chip Industry"**, *Reuters*, 5 September 2023.

[22] Dan Macklin, **"What's Driving China's Chip Sector Crackdown?"**, *The Diplomat*, 29 August 2022.

using US equipment without such a license.[23] It has also been reported that several Taiwanese technology companies are helping Huawei Technologies Co. build infrastructure for an under-the-radar network of chip plants across southern China.[24]

The term 'legacy chip' is a misnomer. It refers to semiconductor produced on older process nodes with less dense circuitry. Except in the most advanced computer processors, these chips are used in highly advanced applications, such as state-of-the-art microwave integrated circuits and electric vehicles. Chinese dominance in legacy chip ecosystem will provide the country with levers wherein it can exercise control over essential services such as energy infrastructure, automotive industry, emergency response systems to even everyday consumer electronics.

China has been able to achieve reasonable success in fabricating equipment for assembly and testing chips. However, its biggest challenge is fabrication of equipment for advanced manufacturing nodes. Despite all its efforts, it is appreciated that China is unlikely to perfect EUV lithography, the advanced technology needed to wield process nodes under 5 nanometers (the state of the art in 2020), for some time to come.[25]

Opportunities and Challenges for India

India's capabilities in large-scale semiconductor manufacturing are almost non-existent. India had announced semiconductor policies on two previous occasions—in 2007 and then in 2013. The governmental initiatives failed for a variety of reasons. In 2007, it was felt that the government delayed the passage of the semiconductor policy and the financial initiatives provided were also considered inadequate. The government's efforts in 2013–14 also failed to make a dent in India's semiconductor manufacturing ecosystem.[26]

In March 2022, the government announced India Semiconductor Mission (ISM) with a vision to build a vibrant semiconductor and display design and innovation ecosystem to enable India's emergence as a global hub for electronics manufacturing and design. A total outlay of INR 76,000 crore has been announced for the development of semiconductor and display manufacturing in the country. The

[23] Mercy A. Kuo, **"The State of China's Semiconductor Industry"**, *The Diplomat*, 2 October 2023.

[24] **"Key Taiwan Tech Firms Helping Huawei With China Chip Plants"**, *Bloomberg News*, 3 October 2023.

[25] Sihao Huang and Bill Drexel, **"China Goes on the Offensive in the Chip War What the United States Should Do to Keep Its Lead"**, *Foreign Affairs*, 11 October 2023.

[26] Konark Bhandari, **"Is India 'Ready' for Semiconductor Manufacturing?"**, *US DoD*, 23 May 2023.

programme aims to provide financial support to companies investing in semiconductors, display manufacturing and design ecosystem. ISM has been set up as an Independent Business Division within Digital India Corporation (DIC).[27]

Yet, for all the good intentions associated with ISM, it should avoid the pitfalls of the past which were a drag on India becoming a manufacturing hub. Robust inter-ministerial coordination and provisioning of necessary facilities including infrastructure and funds is essential for seamless policy implementation. India is home to 20 per cent of the global workforce that designs chips. But foreign firms own the intellectual property underlying the chip designs. In case of chip manufacturing, India's policy will require applicants to own production-grade, licensed technologies. Proper training of talent or the workforce is also essential. India also needs to address infrastructure concerns, especially the availability of land.[28]

[27] **"India Semiconductor Mission"**, Press Information Bureau, Ministry of Electronics & IT, Government of India, 23 March 2022.

[28] Konark Bhandari, **"Is India 'Ready' for Semiconductor Manufacturing?"**, no. 26.

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