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China Semiconductor Observatory

Baseline Report 2022

Jan-Peter Kleinhans, Director of Technology and Geopolitics, Stiftung Neue Verantwortung e.V
John Lee, Director, East West Futures

INTRODUCTION

STRENGTHS

China's mature node front-end manufacturing

China's back-end manufacturing capacity

China's chip design ecosystem

WEAKNESSES

China's cutting-edge front-end manufacturing

Chinese electronic design automation (EDA) tool suppliers

Chinese semiconductor manufacturing equipment (SME)

CONCLUSION

Jan-Peter Kleinhans | jkleinhans@stiftung-nv.de
John Lee | johnlee@eastwestfutures.com

INTRODUCTION

For decades, the Chinese state has seen semiconductors as a strategic technology and has made progressively more involved efforts to develop China's semiconductor ecosystem, with more success in some subsectors than in others. Over the past decade, Chinese companies in this industry have gained market share and increased their international competitiveness. Chinese industry achieved this through a mix of strategic acquisitions of foreign semiconductor firms, substantial government subsidies, investments by the state-backed Big Fund and the private sector, and technology transfer through joint ventures with foreign firms. The rising innovative and technical capacities of Chinese firms and the development of China's skilled workforce have also been important.

China's limited success in this industry has been based on participating in globalized trade and R&D networks within the semiconductor value chain and in end-user sectors such as consumer electronics and automotive. This globalized access is now being systematically targeted by the United States (US) through export controls and political pressure on other states. U.S. firms' dominance in some segments of the value chain means that in these areas, China is still heavily exposed to US-origin technology and thus to U.S. government actions. The Chinese state and industry are now focused on substituting for imports for US-origin technology, but in some critical technologies, this is likely to take decades, if it is possible to do at all.

The U.S. government has shown it is ready to target these vulnerabilities to pursue what is effectively a technological containment strategy against China. This is clear from recent statements by Biden administration officials and the U.S. export controls issued on 7 October 2022, designed to "freeze" China's technological capabilities in supercomputing, artificial intelligence (AI), manufacturing equipment and cutting-edge fabrication. However, the semiconductor value chain is extensive and complex. China's semiconductor ecosystem may be "frozen" in some areas but advance and excel in others, such as those (1) that are less dependent on US-origin technology or not at all or (2) that are not targeted by U.S. export controls.

This report provides a baseline snapshot of China's semiconductor ecosystem by highlighting areas in which China will most likely continue to depend on foreign (especially US-origin) technology and in which Chinese firms will likely continue to grow their market share and technological capabilities. For a broader and deeper look at China's chips ecosystem, its international linkages and development prospects, as well as policy implications, we recommend our 2021 study, "Mapping China's semiconductor ecosystem in a global context: Strategic dimensions and conclusions".

In the present report, we focus first on three strengths of China's semiconductor ecosystem, where we believe Chinese companies will be competitive internationally and where foreign companies may increasingly use products and services that are developed, owned or located in China. These fields are (1) front-end fabrication (manufacturing) in mature nodes, defined as 28 nanometers (nm) and above; (2) assembly, test and packaging (ATP), also called "back-end manufacturing"; and (3) chips "designed in China". We then assess three areas of weakness for China's semiconductor ecosystem, where it will be challenged to substitute foreign technology providers with domestic alternatives out to 2030, and thus will likely continue to depend to some extent on US, Japanese, Taiwanese and European firms. These areas are (1) cutting-edge wafer fabrication at 7nm or more advanced nodes; (2) electronic design automation (EDA) tools, which are needed to design modern chips; and (3) semiconductor manufacturing equipment (SME).

Much depends on the impacts of the 7 October U.S. controls, expected additional U.S. measures and the responses of non-U.S. firms and governments that are critical players in the global semiconductor value chain. Another report from us in late 2023 will take stock of these impacts, and what they mean for the US-China technological rivalry and for a global economy that, especially in digital technologies, has been built for decades on interdependence through transnational division of labor.

Jan-Peter Kleinhans | jkleinhans@stiftung-nv.de
John Lee | johnlee@eastwestfutures.com

STRENGTHS

China's mature node front-end manufacturing

While cutting-edge front-end manufacturing has received much attention recently, many end-user industries predominantly rely on older fabrication process nodes at 28nm and above. Just as processors in servers and smartphones depend on advances in cutting-edge manufacturing, analog chips, power semiconductors and microcontrollers depend on manufacturing at mature nodes with larger feature sizes. During the "chip crunch" of 2021 and 2022, manufacturing capacity was most constrained in these trailing-edge and mature node processes (40–180nm), resulting in a lack of chips for automotive, health, industrial and defense applications. Many European end-customer industries in particular, such as automotive, health and manufacturing, depend on chips fabricated using 65–90nm process technology. Additionally, many types of chips that are manufactured on mature nodes cannot be transferred to nodes with significantly smaller feature sizes; even in 2030, roughly half of the automotive chip market will depend on mature node fabrication processes.

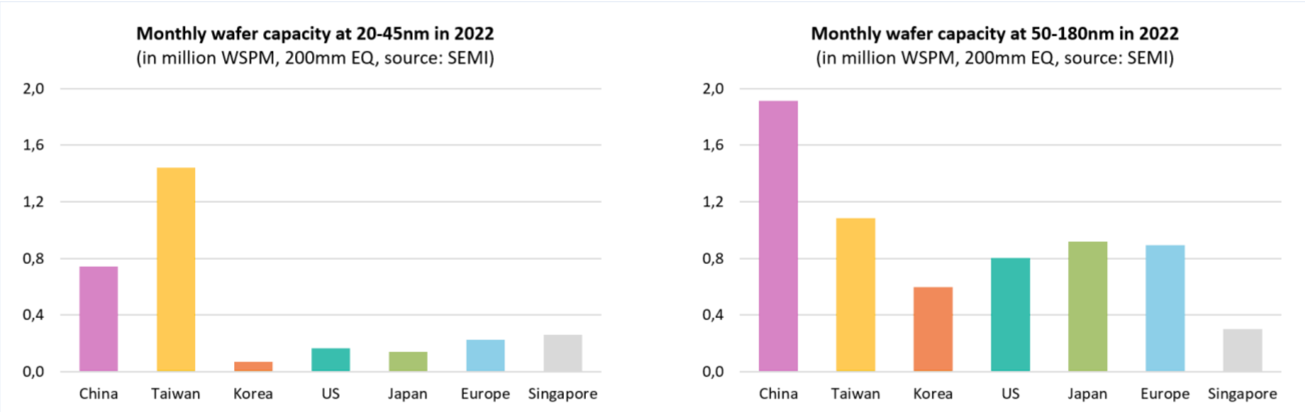

Figure 1: Mature node wafer capacity

Figure 1 shows the monthly front-end manufacturing capacity in million wafer starts per month (WSPM) at mature nodes (excluding memory fabs) by country or region. The figure shows that at 50–180nm process nodes, the European Union (EU) and other advanced economies depend heavily on fabs located in China. This dependence is even greater for wafer capacity at 20–45nm, which is increasingly needed for microcontrollers in automotive, health and industrial applications. For example, Chinese foundry leader SMIC's announced fabs currently under construction in Tianjin (100.000 wspm, 28–180nm), Shanghai (100.000 wspm, ≥28nm) and Beijing (100.000 wspm, ≥28nm) all focus on mature node processes. Additionally, China imported semiconductor manufacturing equipment worth $93 billion in 2017–2022, which is more than any region worldwide. Although much of this equipment went to memory chip fabs (DRAM and NAND), none of it was for cutting-edge logic fabs—further solidifying China's dominant role in mature node wafer fabrication.

Older manufacturing technologies are not nominally targeted by the U.S. export controls of 7 October 2022, although the breadth of the controls' drafting means that the controls could potentially include these technologies. For the time being, front-end fabrication in China can continue expanding at mature nodes. The U.S. official in charge of BIS recently stated that there was no intention to stop, for example, basic chips for cars being made in China. The transition to electric vehicles, the expansion of the internet of things (IoT) and other trends mean that the importance of this mature node fab capacity in China to the international economy and the resilience of the global semiconductor supply chain will likely keep increasing.

Jan-Peter Kleinhans | jkleinhans@stiftung-nv.de
John Lee | johnlee@eastwestfutures.com

China's back-end manufacturing capacity

Back-end manufacturing—consisting of assembly, test and packaging (ATP)—is the last process step in semiconductor manufacturing. Historically, back-end manufacturing has had relatively small added value, substantially lower capital expenditures, less R&D intensity, and smaller profit margins than front-end manufacturing. Many chip manufacturers rely on outsourced semiconductor assembly and test (OSAT) companies for contract back-end manufacturing, or they off-shore their back-end fabs to countries with low labor costs in Southeast Asia. Today, China and Taiwan are the most important economies for back-end manufacturing. *Figure 2* shows that China has the highest number of (134) back-end fabs, operated mainly by (Chinese and foreign) OSAT companies for contract back-end manufacturing.

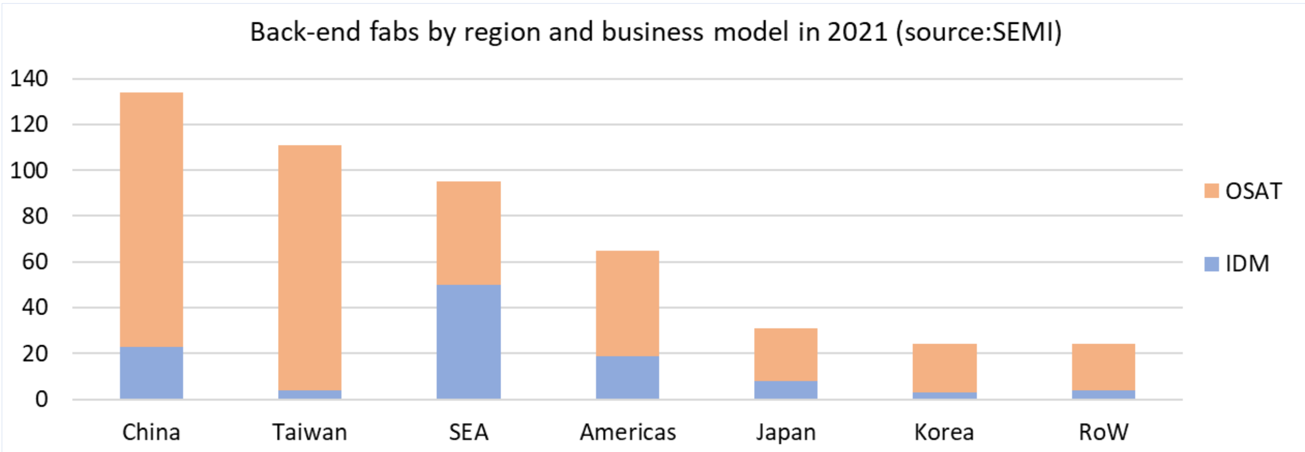

Figure 2: Number of back-end fabs by country/region

The largest Chinese OSAT companies are **JCET Group** (the third largest worldwide, $4.8 billion revenue in 2021), **Tongfu Microelectronics** (the fifth largest worldwide, $2.4 billion revenue in 2021) and **Tianshui Huatian Technology** (the sixth largest worldwide, $1.9 billion revenue in 2021). Chinese OSAT companies are ranked behind Taiwanese (ASE Group, $11.6 billion revenue in 2021) and U.S. American (Amkor Technology, $6.1 billion revenue in 2021) market leaders in terms of technological competitiveness and market share, but Chinese firms have gained substantial market share in recent years through acquisitions of foreign operations. The most recent example is JCET's 2021 acquisition of an ATP facility in Singapore from U.S. chipmaker Analog Devices. JCET also announced the construction of an advanced packaging facility in Jiangyin, China, in 2022. Although Chinese OSAT companies are not technology leaders, they are becoming increasingly competitive internationally. For example, JCET offers several advanced packaging processes, such as wafer-level packaging, and JCET's South Korean subsidiary received an "Excellent Supplier Award" from U.S. chip design leader Qualcomm in 2022.

Some Chinese market actors, such as SMIC, Huawei and the Chinese IP leader VeriSilicon, see potential in utilizing advanced packaging processes to achieve performance gains without relying on foreign cutting-edge front-end processes. Whether advanced packaging provides China with a workaround to avoid the tightening export controls in the US and other countries, the attention being given in China to technologies such as chiplets and the market share of Chinese ATP vendors mean that China will likely play a notable role in advanced packaging. Several Chinese firms, including VeriSilicon, JCET and Tongfu, are members of the new international consortium for standardizing chiplet technologies.

To date, back-end manufacturing has not been targeted by U.S. export controls, and the U.S. official in charge of BIS recently stated that the intention behind the 7 October 2022 semiconductor-related controls is to allow non-sensitive commercial sectors to continue doing business with Chinese companies. Therefore, it is likely that Chinese companies will strengthen their international competitiveness in ATP. However, it is also possible that security risks of so-called "hardware backdoors" facilitated by the concentration of ATP in China will cause this sector to be targeted by foreign government controls, as an issue of espionage and supply chain security. The U.S. government is funding advanced packaging R&D and, in the future, may seek to exploit advances in this field to "re-shore" or "friend-shore" ATP away from China for security purposes.

China's chip design ecosystem

The U.S. export controls issued on 7 October 2022 are nominally intended to curb China's technological advances in AI chips and high-performance processors. Chinese chip design companies that focus on these areas, such as Biren Technologies, will face challenges in continuing to innovate, let alone trying to compete internationally. However, we argue that China's chip design industry will continue to develop, driven by growing activity by (1) Chinese hyperscalers, (2) Chinese system companies and (3) Chinese chip design startups. All are investing in chip design capabilities. *Table 1* is a non-exhaustive list of recent Chinese-designed chips.

Table 1: Recently announced Chinese chip designs

Company	Chip	Type	Comment
Alibaba/T-Head	Yitian 710	Server CPU, ARM	TSMC 5nm
	XuanTie E9xx, C9xx	RISC-V Cores	Open source
	TH1520	Laptop SoC, RISC-V	Uses XuanTie C910 core
Baidu	Kunlun II	Cloud AI accelerator	7nm
Biren Technology	BR100	GPGPU (AI training)	TSMC 7nm
Black Sesame	BST A1000	Autonomous Driving	
BYD Semiconductors	BF1181	1200V driver chip	Automotive
	BS9000xx	Microcontroller	Automotive
	unknown	SiC power module	Automotive
Cambricon	SD522x	L2-L4 self-driving chip series	Press release Sep 2022
	Siyuan 290, 370, 590	Server AI training	Press release Sep 2022
Horizon Robotics	Journey 3	Autonomous Driving	TSMC 16nm
	Journey 5	Autonomous Driving	TSMC 16nm
Iluvatar CoreX	Tiangai 100	GPGPU (AI training)	TSMC 7nm
	Intelligent Armor 100	GPGPU (AI inference)	TSMC 7nm
InnoSilicon	Fenghua	Desktop/Server GPU series	12nm
Moore Therads	Chunxiao	Desktop/Server GPU series	12nm
OPPO	*unknown*	Mobile SoC	No official release date
	MariSilicon X	Imaging NPU	TSMC 6nm
Tencent	Zixiao	Server AI inference	Press release Nov 2021
	Xuanling	Smart NIC/DPU	Press release Nov 2021
	Canghai	Video transcoding	Press release Nov 2021
UNISOC	Tiger T6xx/T7xx	4G mobile SoC series, ARM	TSMC 12nm
	Tanggula T7xx	5G mobile SoC series, ARM	TSMC 6nm, 12nm

Hyperscalers	System companies	Fabless/startups

As illustrated in *Table 1*, China has an increasingly competitive and fast-growing chip design ecosystem that serves a range of end-user functions. Among the chips listed in the table, to date, only Biren's B100 has been impacted by the U.S. export controls of 7 October. The Chinese firms on this list are engaged in chip design in response to market incentives, not simply because this activity aligns with the Chinese state's industrial policy goals. For example, Chinese hyperscalers are incentivized to develop their own processors, just like their U.S.

Jan-Peter Kleinhans | jkleinhans@stiftung-nv.de
John Lee | johnlee@eastwestfutures.com

competitors. Alibaba wants to equip 20% of their servers with Yitian 710 chips (cloud processors developed in-house and based on the ARM instruction set) by 2024. Alibaba is also investing heavily in the RISC-V ecosystem, which is often seen as an open-source alternative to proprietary ARM and therefore, as less exposed to U.S. government restrictions.

Another prominent area of chip design activity in China is the electric and autonomous vehicle sector. Chinese electric vehicle (EV) brands control around 80% of China's EV market. This provides huge market potential for Chinese chip design companies, given their proximity, cultural-linguistic affinity and lower exposure to foreign export controls compared with foreign design vendors. These factors also incentivize foreign firms to enter into partnerships with Chinese firms. Examples include Volkswagen's planned joint venture with Horizon Robotics, with an investment of $2.4 billion to work on advanced and autonomous driving solutions, and Japanese power management semiconductor vendor Rohm's partnership with Nanjing SemiDrive to develop a "digital cockpit" autonomous driving SoC.

The Chinese state's promotion of chip design plays to these market trends, but also supports wider technology development goals, given the importance of semiconductors in so many fields. Growing Chinese chip design capabilities will interact with other advances. In late 2022, one of China's leading quantum science laboratories established a new unit for IC design, radio frequency and microwave device development, with advances in key components the priority. As for the military uses that were emphasized in the justification for the 7 October U.S. export controls, developing Chinese design prowess may eventually benefit the Chinese PLA's capabilities in areas such as AI applications, although presently most military technology does not require cutting-edge processors.

Jan-Peter Kleinhans | jkleinhans@stiftung-nv.de
John Lee | johnlee@eastwestfutures.com

WEAKNESSES

China's cutting-edge front-end manufacturing

Despite China's dominant position in mature node wafer capacity, front-end manufacturing capabilities at the cutting-edge (≤14nm) are severely lacking. Furthermore, the U.S. government's outspoken goal for the export controls of 7 October is to "freeze" China's front-end manufacturing above 14nm logic (FinFET) chips. Because U.S. equipment manufacturers, such as Applied Materials, Lam Research and KLA, play an indispensable role in cutting-edge front-end manufacturing, it will be extremely difficult for China's front-end fab ecosystem to advance their capabilities, at the FinFET level and beyond, if the U.S. export controls are rigorously enforced.

Even before the most recent U.S. export controls, Chinese fabrication leaders had made only limited progress in growing their cutting-edge front-end capabilities. SMIC has a 14nm process node and achieved 7nm manufacturing, at least to some extent (see CSO Briefing, September 2022), but the company's core business lies in process nodes at >28nm. *Figure 3* shows that five years after SMIC's introduction of a 28nm process node (3Q 2015–2Q 2020), wafer fabrication at 28nm and below accounts for less than 10% of revenue. Even during 2021, when 28nm capacity was in great demand globally, SMIC's process nodes at 28nm and below still accounted for less than 20% of the firm's revenues.

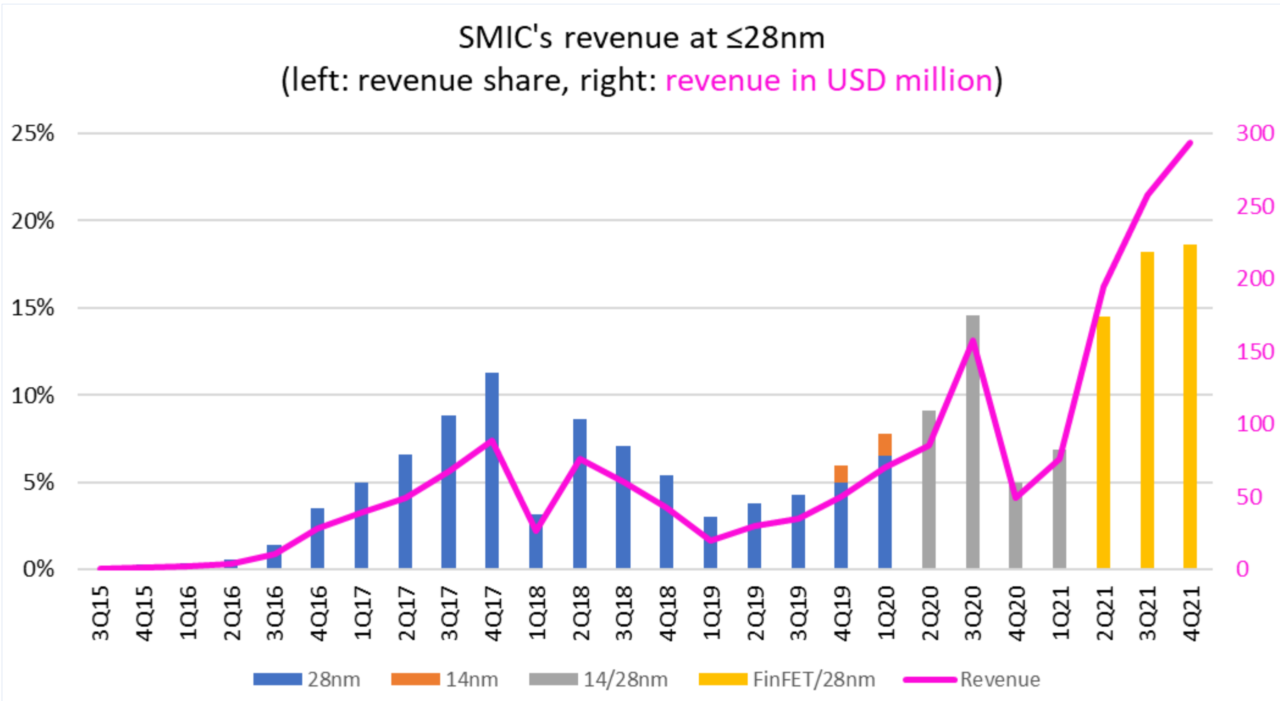

Figure 3: SMIC's revenue share at 28nm and below (Source: SMIC quarterly earnings)

SMIC is China's best prospect for cutting-edge fabrication, as the country's only foundry that has advanced beyond planar transistors (process nodes below 22nm depend on new, non-planar transistor architectures, called "FinFET"). China's second-largest foundry, Hua Hong, has around 3.2% of the global foundry business and generates most of its revenue at 55nm, with funds from its recent Shanghai STAR market IPO largely earmarked for a new 12-inch wafer specialty process fab, although some money will go to R&D "for specialty processes". However, SMIC also seems to not be prioritizing technological advancement, as the company does not focus on trailing-edge (22/28nm) capacity, let alone advancing or scaling up FinFET nodes.

Jan-Peter Kleinhans | jkleinhans@stiftung-nv.de
John Lee | johnlee@eastwestfutures.com

Constrained access to input technologies due to U.S. controls and U.S. pressure on third-country vendors like ASML is one likely reason for this business choice. SMIC's apparent lack of emphasis on developing more advanced process nodes, or at least its aversion to drawing attention to such activity given U.S. government pressure, is reflected in (1) not reporting 14nm revenue shares, except for 4Q 2019–1Q 2020; (2) renaming its "14/28nm" node "FinFET/28nm" around the time the company reportedly started manufacturing 7nm chips (2Q 2021); (3) stopping reporting revenue shares by technology node altogether in 2022; and (4) not announcing its 7nm process node.

A comparison may be made with SMIC's approximate peer, UMC (Taiwan's second-largest foundry). UMC's revenue share from ≤28nm process nodes has been at or above 10% since 2015 and at least 20% since 2021. Thus, it appears that SMIC is focused on growing its business in mature nodes (>28nm) and potentially trailing-edge capacity (22–28nm). This also makes sense in terms of servicing the growing demand for chips produced at these nodes that stems from the rapid expansion in China of IoT systems, the EV industry and other sectors.

A key question is whether SMIC's business choices will remain the same if the Chinese state decides to assert control and redirect its priorities. SMIC's performance has suffered from corporate governance interventions and perverse investment incentives from government authorities and SOEs. This has led to managerial instability, dead-end investments (in memory chip production) and over-extension in fab construction, which have not been compensated for by the easy access to capital enjoyed by Chinese SOEs. If SMIC is nationalized, or its management becomes state controlled, and if the company is freed from commercial constraints by state funding directed to it as a strategic enterprise, it is plausible that SMIC's investment priorities could switch to the development of cutting-edge capabilities.

In summary, China will likely continue to depend on foreign cutting-edge front-end manufacturing during this decade for two main reasons. First, if current U.S. export controls are maintained and adopted by U.S. allies, China will not be able to access US, Dutch and potentially Japanese equipment indispensable to cutting-edge process nodes. Second, China's leading foundry, SMIC, seems focused on mature node processes rather than on trailing-edge or cutting-edge wafer fabrication. However, SMIC's priorities may change if Chinese authorities decide that pursuing domestic cutting-edge fabrication is a national strategic priority which cannot be governed by commercial imperatives.

Chinese electronic design automation (EDA) tool suppliers

EDA software tools are indispensable to chip design. EDA tool suppliers cooperate closely with fabrication and packaging suppliers—foundries, integrated device manufacturers (IDMs) and OSAT companies—to precisely represent and semiulate physical production processes in software. Thus, EDA tools are the crucial link between a chip design and a specific fabrication process node. The need to closely collaborate with fabs to develop EDA software reinforces the market dominance of incumbents, which is one reason why the EDA market is highly concentrated: Three US-based EDA suppliers (Synopsys, Cadence and Mentor, now Siemens EDA) control more than 80% of the global EDA market. Within the last two years, these three firms' share of China's EDA market has been estimated at 90% or higher.

Jan-Peter Kleinhans | jkleinhans@stiftung-nv.de
John Lee | johnlee@eastwestfutures.com

Because of the increasingly complex design flows, chip design teams typically "mix and match" different EDA tools. Design flows can consist of more than 40 individual steps, and different EDA tools excel at different steps. Today, only the three U.S. EDA incumbents provide complete design flows across all chip categories, from analog semiconductors and sensors to cutting-edge processors and memory chips. It is highly unlikely that this oligopoly will be substantially diluted before the end of this decade. In essence, without access to these U.S. EDA tool suppliers, a company cannot design competitive chips.

China's chip design ecosystem depends heavily on U.S. EDA suppliers. However, China's domestic EDA industry has received substantial attention from public and private investors and has been extremely active, especially over the last three years. According to some estimates, there are currently around 50 Chinese EDA companies. They include startups, such as IC Bench (co-funded by Intel Capital and Lenovo Ventures), Hejian/UniVista (more than 20 Chinese investors) and X-Epic, and three publicly traded companies that went public in 2021: Empyrean Technology, Primarius Technologies and Semitronix.

Most of these companies focus on specific steps in the design process and do not offer complete design flows with the aim of substituting established U.S. EDA suppliers. One exception is Empyrean Technology, that provides complete design flow for trailing-edge logic designs and analog chips. According to Empyrean's technology roadmap the company wants to offer EDA tools covering the entire cutting-edge logic design flow by the end of this decade. By 2030, Chinese chip design companies will, most likely, be able to substitute U.S. EDA tools with Chinese supplied ones, at least for certain process steps, although perhaps not for the whole design flow. This goal will be easier to achieve for analog and trailing-edge logic chips than for cutting-edge logic chips.

That said, the recent U.S. export controls from 7 October 2022 make it unlikely that Chinese EDA suppliers can advance their capabilities at the cutting edge. Doing so would require collaborating with foreign foundries (TSMC and Samsung), which are unlikely to partner with EDA developers while existing U.S. controls remain in place. Accordingly, Chinese chip design companies are likely to continue relying on US EDA suppliers to design cutting-edge chips at least until 2030.

The Chinese state has long supported domestic EDA tool development with little success. However, under the pressure of the new U.S. export controls, state-provided incentives are likely to produce better results. In January 2022, for example, Shanghai's government committed to subsidizing "50% of the actual purchase amount for eligible independent, secure and controllable EDA tools purchased by IC enterprises and innovation platforms". Another policy in this package supported industry-assisted university courses aimed at developing 'autonomous, secure and controllable" EDA tools.

The Chinese Semiconductor Industry Association estimates that by 2025, China's EDA market will increase to 18.1% of the global total. This trend is reflected in the revenue growth of China's largest EDA vendor. Empyrean's Q3 2022 earnings report attributed a 33.2% increase year on year to the expansion of China's EDA market and the firm's growing market share. Empyrean's R&D share of operating revenue over Q1-2 2022 was 69.9%, reflecting the need for high R&D spending to be competitive in this field. globally, EDA vendors have the highest R&D to revenue ratios in the semiconductor sector.

Jan-Peter Kleinhans | jkleinhans@stiftung-nv.de
John Lee | johnlee@eastwestfutures.com

Chinese semiconductor manufacturing equipment (SME)

The targeting of SME in the 7 October U.S. export controls reflects the low level of Chinese domestic capacity in this segment of the value chain, and the high market share of U.S. firms. The U.S. official in charge of BIS recently asserted that the new controls cover 11 types of tools for which U.S. firms are the only suppliers worldwide. The other major SME vendors are Japanese and European firms, which, in some cases, still use US-origin IP or components. This means China's prospects to circumvent U.S. controls on SME depend either on non-US suppliers to invest heavily in replacing U.S. inputs in their own supply chains despite U.S. pressure or Chinese firms import substituting from significantly lagging positions. Chinese firms are scaling back plans for fabrication expansion due to the companies' inability to obtain the required SME. This, in turn, undercuts market demand for Chinese SME vendors, which are also reportedly now facing staff losses due to the shadow cast over their prospects by the U.S. controls. Furthermore, even leading Chinese SME vendors like AMEC, still rely on imported components.

Chinese authorities have long recognized this vulnerability and sought to remedy it. In 2008, Beijing instituted the "Integrated Circuit (IC) Megaproject for manufacturing equipment and complete processes' ('02 Special Project'), which directed R&D work on a range of specific SME technologies. Additional targets for SME import substitution were specified in the 2014 National IC Industry Development Outline and in the technical roadmap accompanying the 2015 'Made in China 2025' industrial upgrading plan. Despite this, the Big Fund's investments have not prioritized SME, which is potentially one reason for the state's recent disciplinary actions against Big Fund executives. China's national and provincial governments have introduced various tax breaks and other measures to facilitate SME and component imports, but imports must now run the gauntlet of the new US controls, which for SME are framed in terms that make their potential application very wide.

Although Chinese SME vendors now supply various products for advanced (28nm or below) processes, at these levels Chinese semiconductor fabrication still relies extensively on foreign-made SME. According to one foreign estimate, only 15% of Chinese industry's SME demand is currently met by domestic vendors, although their revenues tripled from 2018 to 2021. One mid-2022 Chinese market research report estimated China's self-sufficiency rate in 2020 across 10 SME categories at from 1% to 10% for four categories, 20% to 30% for four, and higher than 80% for only one (debonding equipment). The 10th category, photolithography, is especially challenging given the technical complexity of several components (e.g., the light source and the lens system) needed for advanced fabrication.

Under the 02 Special Project, Chinese institutions were allocated a division of labor to developing the critical components for advanced photolithography. Recent Chinese media reports suggest that these R&D efforts have progressed to a point where China's leading photolithography machine maker, SMEE, now has or will soon gain access to indigenized components to produce at least a prototype (ArF dry DUV) for 28nm production. The deadline for developing the progression of this technology (ArF immersion DUV) was reportedly set for the end of 2020. SMEE currently supplies machines for 90nm production, which can likely now be made with Chinese components.

To date, no confirmation of any 28nm machine is publicly available, although SMEE's entry in 2022 on the U.S. 'unverified entity' list may mean that the firm is simply keeping new developments quiet. Reports on component system development for the next step in photolithography (EUV) suggest that it remains at a stage that makes it unlikely China will produce an EUV prototype by 2030.

Jan-Peter Kleinhans | jkleinhans@stiftung-nv.de
John Lee | johnlee@eastwestfutures.com

CONCLUSION

China's semiconductor sector was already under pressure from economic contraction, disruption of supply chains and price volatility linked to weakening global consumption and the rolling lockdowns of China's zero Covid policy. At this fragile time, sweeping U.S. export controls targeting the weaknesses of China's semiconductor industry outlined above seem to have caught Chinese authorities without a well-developed counter-strategy, despite their decade-long hands-on approach to developing this industry. At an emergency meeting called by the Ministry of Industry and Information Technology in mid-October with firms targeted by the new U.S. controls, Chinese officials reportedly were unable or unwilling to clarify the government's response, other than providing assurances that the domestic market is large enough to support affected firms. One of China's leading IC industry experts recently reiterated that state-led R&D efforts remain inadequate to drive technological advancement.

Nonetheless, the strengths of China's semiconductor industry outlined above are likely to be sustainable. Despite global economic headwinds, the trend toward expansion of the IoT and greater use of computing power is unlikely to reverse. Led by state policy, China is playing a major role in these society-wide developments, which are creating international opportunities for Chinese firms and supporting secular growth in domestic demand for semiconductors of various types. For example, China's cloud computing market grew by around 45.5% year on year over Q1 and Q2 2022.

The main constraint on the Chinese semiconductor industry now is the efficacy of the new U.S. export controls. Gaps have already been found that could be exploited through cooperation between Chinese firms by utilizing their existing capabilities. Commentators have noted that the controls apply to China as a jurisdiction rather than to the entities' nationality, leaving a potential loophole for Chinese firms operating abroad to accumulate excess inventory, which could then find its way back to China. The enforceability and efficacy of the controls, by U.S. officials' own admission, depend heavily on allied governments adopting equivalent measures, which is Washington's expressed expectation regarding this issue.

European policymakers must grapple with a U.S. security policy directed at China that, by targeting semiconductors, now aims to slow Chinese technological progress in extremely broad ways. The section of the 7 October controls dealing with memory chips, for example, targets what is essentially a commodity product, with potentially negative flow-on effects for a range of end-user industries worldwide. U.S. official statements suggest that enforcement of these controls and expected follow-on measures will not be concerned with economic consequences, whether for the U.S. or third parties.

Recognizing that alignment with U.S. export controls targeting China may result in significant costs for European firms and their global competitiveness, European policymakers need to make informed choices. In such fields as automotive, chemicals and smart manufacturing, European industry leaders have found it commercially sensible to double down on China. However, the security and political implications of such links will also become progressively greater, especially as Chinese policymakers are likely to eventually respond to the U.S. controls with asymmetrical retaliation, including against U.S. allies and their companies. The controls mark an emerging U.S. policy of technological containment that will force Europe to confront the implications of defining China as a "strategic competitor" and a "systemic rival".

For European semiconductor firms, China is a significant market, and the trend in U.S. policy creates significant uncertainty about their future freedom of action. Mapping out the consequences of different policy choices targeting China and semiconductors is critical for informed decision-making that is in Europe's best interests. From a strategic perspective, such issues should ideally be resolved at the European level, as the long-term consequences will impact the EU as a whole.