DIVERSE CHALLENGES • EMERGING TECHNOLOGIES • CREATIVE SOLUTIONS • DIVERSE CHALLENGES • EMERGING TECHNOLOGIES • CREATIVE SOLUTIONS

BLUE HERON:

Semiconductor Manufacturing International Corporation

August 2020

About SOS International

Since 1989, SOS International (SOSi) has provided specialized services supporting the national security interests of the United States and the security and stability needs of its allies. SOSi advances public safety and national security through innovative research, analysis and applied technology. SOSi conducts research and analysis in key areas of defense and intelligence work, provides high-level systems engineering services to selected national and homeland security organizations, and produces hardware and software products for government and commercial consumers.

This project was conducted within SOSi's Intelligence Solutions Group. Staffed by an experienced cadre of cleared analysts with advanced language skills, our mission is to provide cutting-edge, open source, and cultural intelligence support to the collection, analytical, and operational activities of the U.S. intelligence community, Department of Defense, and Federal law enforcement.

Comments may be sent to SOSi's Director of Intelligence Integration, Dr. James Mulvenon.

Dr. James Mulvenon
Director, Intelligence Integration
Intelligence Solutions Group
SOS International, LLC
2650 Park Tower Drive, Suite 300
Vienna, VA 22180
TEL: 571-421-8359
Email: James.Mulvenon@sosi.com

Table of Contents

A Note on Sources and Methods

The research for the following report was conducted using SOSi's proprietary research methods and sources. More information is available upon request.

SMIC and China's National Defense Industry

SMIC is mainland China's largest semiconductor foundry operator, producing semiconductor chips for a wide range of applications and offering complementary services in circuit design, mask-making, and testing. As China's top integrated circuit (IC) producer, a fact the Chinese press often notes, SMIC is a strategically important corporation, but it is even more so because of China's ongoing efforts to catch up to world-class standards in integrated circuit technology, much of which is inherently dual-use.

Box 1: PRC National Emphasis on Integrated Circuits

Chinese support for the IC industry reflects industrial policy guidance issued by the national government, such as 2011's "Some Policies Concerning Gradually Encouraging the Development of the Software and Integrated Circuit Industries" (《进一步鼓励软件产业和集成电路产业发展的若　政策》), which classified the integrated circuit industry as a strategic emerging industry and directed local governments to craft preferential policies in areas like taxes, investment, government funding for R&D, talent recruitment, and intellectual property rights.

The PRC has a broad venture capital strategy to facilitate the acquisition of advanced foreign technologies, with a specific State Council-driven plan to development and promotion the integrated circuit (IC) industry, outlining plans to increase government investment in order to improve China's top IC companies by 2030.

A February 2017 environmental impact report completed for a proposed expansion of SMIC subsidiary Semiconductor Manufacturing International (Beijing) Corporation (中芯国际集成电路制造(北京)有限公司)'s production line described the importance of government support for China's indigenous semiconductor industry in a section providing justification for the project. As the report stated, "Our country is a very large consumer of electronic chips, and in order to more quickly develop informatization, each level of government must make the integrated circuit industry a key focus for support and make it one of their most supported industries. They must develop and promulgate policies for preferential treatment, simplify approval processes, cut taxes and raise profits, and create an excellent development environment for all types of integrated circuits and related companies in China."

Military and Defense Industrial Ties

- SMIC appears to have an ongoing relationship with CETC Electronic Equipment Group Co., Ltd., a wholly-owned subsidiary of the defense electronics conglomerate China Electronics Technology Group Co., Ltd. (CETC). SMIC subsidiaries have helped CETC Electronic Equipment Group Co., Ltd. test new manufacturing technologies and have used technologies developed by CETC Electronic Equipment Group Co., Ltd. in their own manufacturing processes. A representative from a SMIC subsidiary also attended a 2018 CETC Electronic Equipment Group Co., Ltd. product launch as an honored guest.
- A series of PLA university and defense industrial complex researchers use SMIC processes and chips to conduct their research, indicating that this research is tailored to SMIC production specifications, making it impossible for them to manufacture their chips at another foundry.
    - A significant portion of this research involves radiation hardening for IC chip designs, a line of research primarily used for aerospace and military applications.
- A recent SMIC annual report states that it engages in "business collaboration" with Datang Telecom Group (SMIC's largest shareholder), which is notable given that Datang Telecom Group is a major state-owned enterprise with long-standing commercial and R&D ties to the Chinese military.

- Another SMIC shareholder, Tsinghua University, is a state-operated national university linked to industrial development policy initiatives.

Party-State Ties:

- The sources reviewed for this profile illustrate that the Chinese government is considerably invested in SMIC's success, and numerous high-ranking Chinese leaders have made inspection visits to SMIC subsidiaries. SMIC's leadership also includes executives with experience working in major state-owned enterprises and central government ministries, which suggests both a certain level of perceived political reliability as well as ingrained understanding and presumed sympathy with government goals and aims.
- SMIC's four largest shareholders as of 2018, Datang Telecom, China IC Fund, Tsinghua University, and Zhao Weiguo, all have strong connections to the Chinese party-state and its development policies for China's semiconductor industry.
- Other connections between SMIC and the Chinese party-state include tax and import duty incentives provided to SMIC's subsidiaries as qualified integrated circuit production enterprises, and branch offices of the Chinese Communist Party hosted by SMIC subsidiaries in mainland China.

Semiconductor Manufacturing International Corporation (中芯国际集成电路制造有限公司)

Semiconductor Manufacturing International Corporation (SMIC, 中芯国际; also known as Zhongxin International) is mainland China's largest semiconductor foundry operator and, according to company materials, also the country's most advanced chipmaker. SMIC is listed on the Hong Kong stock exchange under ticker symbol 0981 and debuted on the Shanghai Stock Exchange's science and technology STAR Market in July 2020.[1] The company is registered in the Cayman Islands, but it is headquartered in Shanghai and operates primarily through a network of subsidiaries in mainland China. SMIC has key corporate entities in Shanghai, Beijing, Tianjin, and Shenzhen, but the company also has non-Chinese subsidiaries, such as LFoundry in Italy, and it leads a joint venture integrated circuit R&D company with investment from Huawei, U.S. company Qualcomm, and Belgium's Imec (the SMIC Advanced Technology Research & Development (Shanghai) Corporation).[2]

The primary SMIC subsidiary is SMIC (Shanghai), which is wholly owned by the holding company SMIC Investment (Shanghai) Corporation (中芯集电投资（上海）有限公司), itself wholly-owned by the umbrella SMIC in Hong Kong. This top-level SMIC currently has two listed shareholders, Datong Holdings (Hong Kong) Investment Co., Ltd. (大唐控股(香港)投资有限公司) and Xinxin (Hong Kong) Investment Co., Ltd. (鑫芯(香港)投资有限公司), which cumulatively total 32.76 percent of the company's shares. News reports indicate that Xinxin (Hong Kong) Investment Co., Ltd. is a vehicle for China's National Integrated Circuit Fund (国际集成电路产业投资基金股份有限公司), which is the sole owner of Xinxin (Hong Kong) Investment Co., Ltd. Previous annual reports have disclosed Tsinghua University, Pagoda Tree Investment Co., Ltd., and the individual Zhao Weiguo as prior and potentially current additional shareholders (see Appendix I for investor information).

Corporate Registration Information for Semiconductor Manufacturing International (Shanghai) Corporation

Unified Social Credit Code	91310115710939629R
Type of Company	Limited liability corporation (sole proprietorship of foreign legal person) (有限责任公司(外国法人独资))

[1] SMIC was previously listed on the New York Stock Exchange under symbol SMI but it voluntarily delisted from the exchange in June 2019. Reporting on the company's decision cited low trade volumes and "burdensome costs," though it was widely understood as a product of the U.S.-China trade war and increasing tensions between the two countries and fits with China's efforts to encourage "red chip" companies listed abroad to "return home." As of 14 June 2019, SMIC's American Depository Shares (ADSs) are eligible for trading in the United States in the OTCQX over-the-counter (OTC) market, using the symbol SMICY.

[2] A 2015 Qualcomm press release announcing the joint venture stated that the new company will "focus on the development of next-generation semiconductor technology" and that "the goal of the project is to boost China's semiconductor capabilities." The company's R&D focus includes complementary metal-oxide semiconductor (CMOS) logic and it planned to develop 14 nm CMOS technology for mass production in its first phase.

Date of Incorporation	December 21, 2000
Registered Capital	2,190,000,000 USD
Registered Address	No. 18 Changjiang Road, Pilot Free Trade Zone, Shanghai, China (中国(上海)自由贸易试验区张江路 18 号)
Website **Telephone**	https://www.smics.com/ +86 (21) 3861-0000
Legal Representative	Zhao Haijun (赵海军)

Military and Defense Industry Research and Customer Ties

SMIC's annual reports do not identify its primary customers, referring to them in official filings only as "Customer A," "Customer B," and so on. Media reports have stated that SMIC's biggest customers include Qualcomm and Huawei, though the company also has ties to major entities within China's military industrial complex, most notably through its cooperation with entities owned by China Electronics Technology Group Corporation, Limited (CETC), a state-owned defense conglomerate specializing in the research and production of military-use electronics, defense electronic information infrastructure, and military-use software. Numerous CETC subordinate institutions are U.S. Department of Commerce BIS Listed Entities.[3]

Beyond SMIC's well-documented and multi-faceted cooperation with CETC, numerous other Chinese defense industrial and military chip designers are linked to SMIC, manufacturing their research devices at SMIC or using SMIC processes. The researchers' choice to use SMIC's process design and test simulation software package, which is specific to a particular foundry, means that they are designing chips that would be constructed by that foundry and only that foundry. This implies that any future production of innovations these defense researchers accomplish would be produced by SMIC. These defense industrial research relationships are discussed in more detail below.

SMIC and CETC

In addition to fabricating chips with SMIC processes, CETC organizations design and develop equipment that installed in SMIC production lines and furthers China's development of advanced semiconductor technology. This is evident in the relationship between SMIC and CETC Electronic Equipment Group Co., Ltd. (中电科电子装备集团有限公司), a wholly-owned CETC subsidiary that manufactures military electronic equipment and components, including integrated circuit equipment and chips.

On 21 November 2017, CETC Electronic Equipment Group Co., Ltd. announced that it had developed its own commercial-use 200 mm chemical-mechanical polishing (CMP) machine. China's press hailed it as a major step forward in the country's efforts to achieve self-sufficiency in semiconductor production. According to news reports, the machine was set to begin use on production lines at SMIC Tianjin (中芯国际集成电路制造(天津)有限公司), a second-tier, wholly-owned SMIC subsidiary, after SMIC Tianjin completed a "marathon" (马拉松) testing

[3] This includes CETC's 10th, 11th, 13th, 14th, 20th, 29th, 38th, 54th, and 55th research institutes some two dozen of their subordinate companies as of August 2020.

process to ensure the equipment met customer requirements. According to the news reports, SMIC Tianjin and CETC Electronic Equipment Group Co., Ltd. worked closely together to efficiently manage the testing process.

In August 2018, Chinese media reported that 12-inch ion implanters (12 英寸离子注入机) developed by CETC Electronic Equipment Group Co., Ltd. had begun mass production at SMIC Beijing (中芯国际集成电路制造(北京)有限公司), a second-tier, wholly-owned SMIC subsidiary.

Also in August 2018, Chinese news reports stated that Zhang Xin, the General Manager at SMIC subsidiary Semiconductor Manufacturing North China (Beijing) Corporation (中芯北方集成电路制造(北京)有限公司), was one of several executives and government officials who served as honored guests at the ceremony marking the launch of CETC Electronic Equipment Group Co., Ltd.'s "Semicore" (烁科) product lines.[4] There was a strong defense industry presence at the product launch, with officials present from SASTIND, the former Central Military Commission (CMC) Equipment Development Department (军委装备发展部), the State-owned Assets Supervision and Administration Commission (SASAC), and the China National Nuclear Corporation (CNNC, China's nuclear defense industry conglomerate). The news items did not state or imply the reasons why a representative from Semiconductor Manufacturing North China (Beijing) Corporation was at the product launch.

Beyond the work of CETC Electronic Equipment Group Co., Ltd., two other CETC research institutes appear to fabricate their chips using SMIC processes according to published research from scientists affiliated with their institutes.

The former CETC 58th Research Institute (中科芯集成电路股份有限公司/原第五十八所), with the commercial name China Key System and Integrated Circuit Co., Ltd. (CKS), engages in the design, development, and manufacture of integrated circuits, wafer fabrication, packaging, and reliability tests, semiconductor chip processing, mobile communication, IoT products, and cloud computing. In 2016, researchers declaring an affiliation with the 58th RI published a paper in the proceedings from the annual International Conference on Integrated Circuits and Microsystems (ICICM) presenting a "high performance low jitter PLL." The paper's abstract notes that the PLL "is fabricated in SMIC 65 nm CMOS low leakage process."

[4] This marked the launch of CETC's first "civilian brand." At the official release of the product line, CETC's party secretary and chairman Xiong Qunli called the Semicore equipment "the cornerstone" of China's national chip ambitions. The event also marked the official unveiling of the nascent "Semicore Electronic Equipment Co., Ltd." (烁科电子装备有限公司). Chinese corporate records do not reveal any established company under that exact name, but several CETC-owned companies were established in 2018 and 2019 with "Semicore" in their name that likely work to further the Semicore brand. The ion implanter-focused company Beijing Semicore Zhongkexin Electronic Equipment Co., Ltd. (北京烁科中科信电子装备有限公司) was established in June 2019 with CETC Electronic Equipment Group Co., Ltd. and CETC 48th RI as its largest shareholders; Beijing Semicore Microelectronics Equipment Co., Ltd. (北京烁科精微电子装备有限公司) was established in September 2019 with CETC 45th RI and CETC Electronic Equipment Group Co., Ltd. as its largest shareholders. In 2018, CETC established Shanxi Semicore Crystal Co., Ltd., a semiconductor R&D and production company bound up in a CETC ownership web that is co-located and directed under CETC 2nd RI (also known as Northwest Electronic Equipment Technology Research Institute), a research institute that promotes military-civilian fusion for its silicon carbide (SiC) development.

CETC 36th Research Institute (中国电子科技集团公司第三十六研究所), known as the CTRONICS Technology Group or Jiangnan Electronic Communications Research Institute (JNECR) (江苏电子通信研究所) develops network information systems, technical reconnaissance, marine electronics, smart cities, ecological environment monitoring, and counter-jamming technology. Authors affiliated with the 36th RI published a paper presenting a design of a programmable frequency divider based on a pulse swallow counter, which the researchers note "is fabricated in SMIC 0.18μm CMOS process."

PLA and Defense Industrial Complex Use of SMIC Processes

Beyond CETC research institute authors, other researchers in China's military and defense industrial research ecosystem make use of SMIC processes in developing their circuits.

Most notable among these are the multiple PLA technical researchers at PLA universities who appear to have made extensive use of SMIC processes and technologies in their research, including SMIC 0.18 μm and 0.65 μm processes. Some examples of this research are summarized in the table below.

Table 1: PLA University Research Using SMIC Chips and Processes

Researcher Affiliation	Process Referenced	Notes	Date
PLA SSF Information Engineering University	SMIC 180 nm	"Logical synthesis is performed under the SMIC 180 nm…" (在 SMIC 180 nm 下进行逻辑综合).	2017
PLA SSF Information Engineering University	SMIC 65 nm	"…a new high-speed reconfigurable rotation-permutation unit (HRRU) is designed. The unit has completed logic synthesis in the SMIC 65 nm process" (设计了一种新型可重构移位-置换单元.该单元在 SMIC 65nm 工艺完成了逻辑综合).	2017
PLA Engineering University (解放军理工大学) (now PLA Army Engineering University)	SMIC 65 nm CMOS	"SMIC 65 nm CMOS process technology is used to realize the comparator circuit…" (该比较器电路采用 SMIC 65 nm CMOS 工艺技术实现).	2017
PLA Information Engineering University (now PLA SSF Information Engineering University)	SMIC 0.18 μm	"Based on SMIC 0.18 μm standard CMOS technology, the area of our SoC is 250 million gates and can work at the frequency of 100 MHz" (基于 SMIC 0.18 μm 工艺综合后的结果显示，工作频率能够达到 100 MHz，面积约为 250 万门).	2012
PLA Information Engineering University (now PLA SSF	SMIC 0.18 μm	"The design has been realized using Altera's FPGA. Synthesis, placement and routing of reconfigurable design have accomplished on 0.18μm SMIC process."	2007

Information Engineering University)			

Beyond the PLA universities, researchers using SMIC chips in their work include those working under institutions that support China's surveillance apparatus and defense industrial base, including the "Seven Sons of National Defense" universities (国防七子) subordinate to the Ministry of Industry and Information Technology (MIIT), which are responsible for a substantial portion of China's defense-related academic research. For example, researchers from the Department of Electronic Engineering within the School of Information Science and Technology at Beijing Institute of Technology (BIT) published a 2006 article titled "ASIC Design for Real-Time Reconfigurable FFT Processor" that states that "The ASIC design is synthesized, placed and routed using Synopsys with SMIC CMOS 0.18μm library." The research received funding from the National Ministries Pre-Research Project (国家部委预研项目).

Other researchers at universities with obscured defense links are also working to research semiconductors using SMIC technologies. For instance, Shanghai Jiaotong University is home to the National Key Laboratory of Science and Technology on Micro/Nano Fabrication jointly run with Peking University was established by COSTIND. Authors from the School of Microelectronics at Shanghai Jiaotong University published a 2012 article on "High-throughput sorted MMSE QR decomposition for MIMO detection" using SMIC technology, noting "the proposed SQRD preprocessor implemented in SMIC 0.13μm CMOS technology achieves the throughput up to 25×106 SQRD per second which outperforms other works with equal functionality."

Researchers from the School of Information and Communication at Guilin University of Electronic Technology also received support from the National Natural Science Foundation of China for their research "Design Of A New Switched-Current Biquadratic Filter," which states that they used SMIC technologies for their simulation, concluding "using SMIC 0.18μm CMOS process parameters and Spectre, the simulation results agree well with the theoretical anticipation."

Radiation Hardened Research Using SMIC

Researchers studying radiation hardened IC design use the SMIC process design kit (PDK). Radiation hardened chips are used in two primary applications: space systems (either military or civilian) and military electronics that must be designed to withstand electromagnetic pulses like those that emanate from a nuclear blast. Many of these researchers are affiliated with China's defense universities or its military-industrial complex. Their use of SMIC's proprietary software design/test simulation package, specific to its foundry parameters, means that these researchers would be unable to take their designs to another foundry or build the chips themselves, tying them to SMIC production of their future work.

For example, an article on radiation hardened IC design published by researchers affiliated with the PLA's National University of Defense Technology (NUDT) and Hunan University in 2019 conducted heavy ion experiments to study the effect of a deep n+ well (DNW) on single-event transients (an event in which a single cosmic particle deposits "enough charge in the sensitive volume of a semiconductor device to cause a potential change in the transient state"), a question the researchers explicitly note pertains to the use of circuits in aerospace electronic instruments,

highlighting the importance of research on single-event effects of ICs to the growing application of electronic technology to the aerospace field. The study looked at the effects of the DNW on a single-event transient in both "the domestic 65nm bulk NMOSFET and triple-well NMOSFET" and notes that both were "built and calibrated according to the SMIC 65 PDK." The research looks closely and concludes that their "research has proved that triple-well NMOSFET technology has the natural disadvantage in the design of radiation hardened integrated circuits and may not be used in the design of integrated circuits in radiation environments." The study was funded by three NUDT institutions (the Institute of Microelectronics, Institute for Quantum Information, and the State Key Laboratory of High Performance Computing) and the National Natural Science Foundation of China.

Other examples of defense industry researchers using SMIC processes and chips for radiation hardened IC design research are presented in the table below.

Table 2: Radiation Hardened IC Chip Research Using SMIC Processes

Researcher Affiliations	Research Topic	SMIC Link	Date	Funding
College of Electronic and Information Engineering, Nanjing University of Aeronautics and Astronautics Science and Technology on Electronic Information Control Laboratory	The Design of Compact SM4 Encryption and Decryption Circuits That Are Resistant to Bypass Attack	"Finally, using Synopsys DC (Design Compiler, Mountain View, CA94043DC, USA) to synthesize the designed circuit, the results show that the area of the designed circuit in the SMIC 0.18 process is 82,734 μm^2, which is 48% smaller than results reported in other papers."	July 2020	Fundamental Research Funds for Central Universities, Aeronautical Science Foundation of China, Project of Science and Technology on Electronic Information Control Laboratory
School of Microelectronics, Beihang University Beihang-Goertek Joint Microelectronics Institute, Qingdao Research Institute, Beihang University Hefei Innovation Research Institute, Beihang University School of Electronics and Information Engineering, Beihang University	Active Tunable THz Metamaterial Array Implemented in CMOS Technology	"The idea was achieved in a 180nm six-layer metal process from Semiconductor Manufacturing International Corporation (SMIC)."	June 2020	National Key R&D Program of China, National Natural Science Foundation of China, Beijing Natural Science Foundation
School of Electronic Engineering, Heilongjiang University	Design and Verification of Radiation Hardened Scanning D Flip-Flop	"Aiming at the problem of no scanning D flip-flops in the radiation resistant standard cell library of SMIC 0.18um, the radiation hardened scan D flip-flops are designed and verified from the circuit and layout levels. The simulation results show that the radiation hardened scanning D flip-flop has a reliable radiation resistant ability under the premise of ensuring the correct function. Then, by embedding our designed 30 scanning D flip-flops to the SMIC 0.18um standard cell library, the further evaluation shows that the	May 2020	UKN

		designed scanning D flip-flops can realize the testability design requirements of the radiation resistant SoC chip."		
National Innovation Institute of Defense Technology, Academy of Military Science School of Aerospace Science and Technology, National University of Defense Technology	Scheduling of Data Access for the Radix-2k FFT Processor Using Single-Port Memory	"Based on the testing on the field-programmable gate array (FPGA) and ASIC implementation using the SMIC 40-nm CMOS technology, it is demonstrated that the proposed FFT processor can offer high throughput and simultaneously achieve remarkable area and power efficiency."	May 2020	UKN
School of Electronics and Information Engineering, Anhui University	Novel Write-Enhanced and Highly Reliable RHPD-12T SRAM Cells for Space Applications	"Simulation results in Semiconductor Manufacturing International Corporation (SMIC) 65-nm CMOS commercial standard process show that the proposed RHPD-12T cell can tolerate all single-node upsets."	Jan. 2020	UKN
State Key Laboratory of ASIC & System, Fudan University	Design of Asynchronous High Throughput SHA-256 Hardware Accelerator in 40nm CMOS	"The proposed design was implemented in SMIC 40nm technology and performed simulation and verification with Synopsys VCS."	Nov. 2019	UKN
School of Information and Electrical Engineering，Harbin Institute of Technology	Design of a low power floating point FFT processor	"The design of processor is synthesized by using Semiconductor Manufacturing International Corporation (SMIC) 0.18 μm process library."	2018	China Postdoctoral Science Funding Project (中国博士后科学基金资助项目)
School of Electronic Science and Engineering, University of Electronic Science and Technology of China	A novel single-event-hardened charge pump using cascode voltage switch logic gates	"Simulation results based on SMIC 130 nm bulk CMOS technology showed a significant reduction of the voltage perturbation in the input of the voltage-controlled oscillator."	Dec. 2018	UKN

School of Information and Electronics, Beijing Institute of Technology Beijing Key Laboratory of Embedded Real-Time Information Processing Technology, Beijing Institute of Technology	A Multi-mode SAR Imaging Chip based on a Dynamically Reconfigurable SoC Architecture Consisting of Dual-operation Engines and Multilayer Switching Network	"A prototype SAR imaging chip was implemented in a 65 nm SMIC technology."	Sept. 2018	National Natural Science Foundation of China; Chang Jiang Scholars Program; Hundred Leading Talent Project of Beijing Science and Technology
School of Electronic and Information Engineering, Beihang University	A High Speed VLSI Implementation of 256-bit Scalar Point Multiplier for ECC over GF (p)	"In the VLSI design, a high-speed \pmb256×256 -bit scalar point multiplier is achieved based on SMIC's 65nm process."	Aug. 2018	UKN
China Aerospace Components Engineering Center, China Academy of Space Technology	A Front-End Amplifier for Neural Signal Acquisition	"Fabricated in SMIC 180nm CMOS process, the amplifier yielded a mid-band gain of 57dB and a -3dB bandwidth from 9.2Hz to 80k Hz and input referred noise of 3.06uV while power consumption of 144uW."	July 2018	UKN
State Key Laboratory of Cryptology Microelectronics Center, Harbin Institute of Technology at Weihai	The Effectiveness of a New Current Flattening Circuit as Countermeasure against Power Analysis	"In this paper, the circuit is designed under SMIC the 65nm logic low leakage CMOS process, the core circuit layout area is 0.071mm^2."	2017	UKN
Institute Aviation Industry Corporation of China, Aeronautics Computing Technique Research	Architecture Design for a Four-Way Pipelined Parallel Texture Engine	"The design of the texture engine is synthesized under SMIC 40 nm CMOS process technology."	Dec. 2017	UKN
Department of Radiation Hardening Design, Beijing Microelectronics	Design of a novel 12T radiation hardened memory cell tolerant to	"Proposed RH-12T cell using SMIC 65nm CMOS twin well process is presented."	Nov. 2017	UKN

Technology Institute (CASC 772nd RI)	single event upsets (SEU)			
Beijing Microelectronics Technology Institute (CASC 772nd RI)	An All-analogue Duty Cycle Corrector with High Accuracy, Wide Correction Range and Configurable Crossing	"The DCC has been implemented in 65nm SMIC CMOS technology with a power supply of 1.8V."	Nov. 2017	UKN
School of Microelectronics, Shanghai Jiao Tong University Shanghai Institute of Aerospace Electronic Communication Equipment	An on-chip circuit for timing measurement of SRAM IP	"This circuit is fabricated in SMIC 130nm CMOS technology."	Oct. 2017	UKN
Department of Computer Science, National University of Defense Technology Electrical and Computer Engineering, University of Maryland, College Park	A Scalable and Resilient Microarchitecture Based on Multiport Binding for High-Radix Router Design	"We have fabricated an ASIC MBTR chip with 28nm technology."[5]	June 2017	UKN
Beihang University	Design of High Dynamic and Low Power Consumption Automatic Gain Control System for Navigation Receiver	"The design is fabricated based on SMIC 0.18μm CMOS process."	Mar. 2017	Major special project of the former COSTIND, "Development and industrialization of a satellite navigation receiver IC chipset" (原国防科工委重大专项"某卫星导航接收机IC芯片组研制及其产业化")

[5] In 2017, SMIC was the only foundry in China capable of manufacturing 28nm chips.

Beijing Institute of Control Engineering China Aerospace Science and Technology Corporation	Design and Comparison of High-Reliable Radiation-Hardened Flip-Flops Under SMIC 40nm Process	"In such circumstances, several radiation-hardened flip-flops are designed and simulated under SMIC 40nm process."	2016	UKN
School of Electronic Science and Engineering, National University of Defense Technology	High reliability multi-channel output voltage switch for multitime programmable memory in standard CMOS process	"According to the post simulation results based on SMIC 0.13-μm standard CMOS process, the maximum delay time of the row and the column voltage switches are 11.15 ns and 9.48 ns, respectively, and the average power consumption within 2.5 ms are 309.5 nW and 485.3 nW, respectively."	Aug. 2016	UKN
Institute of Microelectronics, Chinese Academy of Sciences	A 130 nm radiation hardened flip—flop with an annular gate and a C-element	"This cell has been designed under an SMIC 0.13 μm process and 3-D simulated by using Synopsys TCAD."	July 2013	UKN

Other SMIC Defense Industry and PLA Customers

Industry experts have reported additional confirmed and likely SMIC customers with ties to the PLA and PRC defense industry, which are profiled below. Chinese chip companies are generally reliant on China's two leading foundries, SMIC and Shanghai Huali Microelectronics Corporation (HLMC). In many cases, Chinese fabless companies, especially those with PLA ties, choose not to indicate where their chips were produced to avoid jeopardizing their relationships with the foundries. Below are a number of sensitive Chinese chip companies and defense industrial research institutions that have been confirmed to use SMIC technologies in their research designs or are likely fabricating their devices at SMIC.

Beijing Microelectronics Technology Institute (BMTI) (中国航天北京微电子技术研究所)

Beijing Microelectronics Technology Institute (北京微电子技术研究所; BMTI), also known as the CASC 772nd Research Institute, is the military aerospace microelectronics research arm of the PLA and a major designer of defense- and aerospace computing products. Founded in 1994, the Institute is subordinate to the CASC 9th Academy and focuses on systems-on-chips (SoC/SoPC), microprocessors, microcontrollers, field-programmable gate arrays (FPGAs), and bus circuits, among other product types.

As a "National Key Military Electronic Component Research and Development Unit," BMTI does radiation-hardened production and produces a significant number of products that have military end uses. In recent years, the company has reportedly provided military industrial aerospace, aviation, weapons, ships, electronics, and nuclear groups with: applications including special circuits (ASIC), system on chip (SoC/SoPC), highly reliable integration of microprocessor (CPU), microcontroller (MCU), FPGAs, analog-to-digital/digital-analog converters (ADC/DAC), bus circuits, and radio frequency and microwave circuits. Its "integrated microelectronics solutions" are based on Chinese core chips, which "strongly promotes the independent and controllable development of military and aerospace microelectronic products." Some of these products, such as aerospace-grade FPGAs, are likely manufactured at SMIC.

BMTI researchers published a paper titled "A Design of M-LVDS Transmitter IP" in December 2015 as part of the 4th International Conference on Mechatronics, Materials, Chemistry and Computer Engineering. The paper notes that for the research, "an integrated M-LVDS transmitter IP was designed and fabricated in SMIC 130nm CMOS standard technology." The layout of the transmitter is pictured in the figure below:

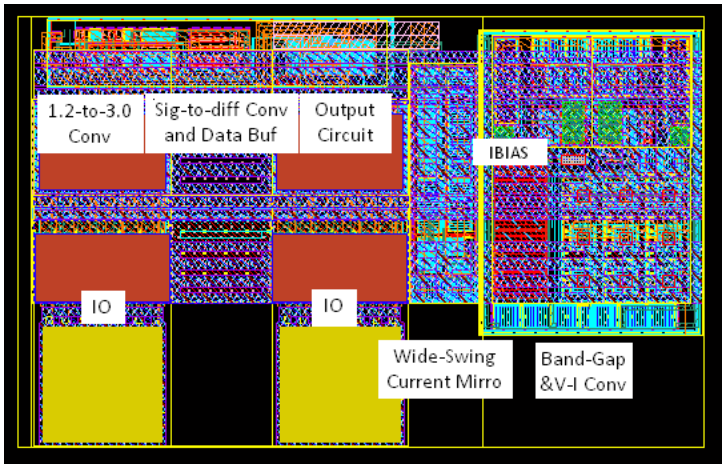

Figure 1: Layout of the M-LVDS transmitter IP

The use of SMIC processes in BMTI research indicates that any research to move toward full production would also rely on SMIC foundries.

National University of Defense Technology (NUDT, 国防科技大学)

NUDT is a top military academy and national key university under the dual supervision of the Ministry of National Defense and the Ministry of Education. NUDT is a BIS Listed Entity (80 FR 8524; 84 FR 29373, 2/18/2015) due to its use of U.S.-origin multicores, boards, and (co)processors to produce the TianHe-1A and TianHe-2 supercomputers located at the National Supercomputing Centers in Changsha, Guangzhou, and Tianjin.

Several NUDT-designed HPC chips such as the "China Accelerator" for the Tianhe IIA systems were fabricated using the "FT-Matrix2000 architecture as a scientific computing accelerator on a 40nm process." SMIC is one of only two fabrication plants in China with the capability to produce these chips.

Research from NUDT scientists indicates that they regularly use SMIC processes to manufacture their test chips.

- A 2011 conference paper on the "Design and Chip Implementation of a Heterogeneous Multi-core DSP" from researchers affiliated with the Institute of Microelectronics and Microprocessors, College of Computer Science,[6] National University of Defense Technology notes that the "YHFT-QDSP is implemented under SMIC ® 130nm LVT CMOS technology and can run 350MHz@1.2V with 114.49 mm 2 die area."
- For a 2009 conference, researchers from NUDT's College of Computer Science presented research on "A Heterogeneous Multicore SoC Optimized for Embedded Visual Media Process." They note that for this research, "we designed a prototype SoC chip design based on the architecture and structure described above. The host processor EStar based on which we build the SoC chip, was a high performance 32-bit embedded RISC processor which we designed and taped-out in 2004, using SMIC 0.18um CMOS technology. As the technology was improved, the SoC chip was implemented under SMIC 0.13um CMOS technology. The technology improving will give us

[6] The college (计算机学院) is variously translated as the "College of Computer," "College of Computer Science," "School of Computer," and "College of Computer Science and Technology."

higher frequency and lower power consumption. The SoC chip was implemented by SMIC 0.13um CMOS Logic Standard Cell Library provided by Artison."

- In 2016, authors from NUDT published an article titled "80GBaud Time Division Multiplexing Optical Transceiver," which references the use of 65nm SMIC CMOS technology, noting "The driving voltage waveform is generated by the driver circuit schemed out in Figure 2 under 65nm SMIC CMOS technology…which is the electrical part of the optical sampling pulse generator."
- In 2019, NUDT authors from the university's College of Computer Science published an article detailing their research into the sensitivity of clock distribution networks (CDNs) in ICs to single-event transients using electrical simulation and heavy ion experiment. The article specifies that its test chip was fabricated at SMIC, and that the test chip includes eight test chains.
- In March 2020, authors from the NUDT College of Computer Science also published a conference paper titled "SSR: A Stall Scheme Reducing Bubbles in Load-Use Hazard of RISC-V Pipeline. They note that "the scheme was implemented in the open source RISC-V SoC generator Rocket-chip and synthesized in SMIC 130-nm technology."

Changsha Jingjia Microelectronics Co., Ltd (Jingjia Micro, 景嘉微)

Jingjia Micro is China's top fabless GPU design company, based in Changsha, Hunan Province. Jingjia Micro is a military-civilian fusion company whose products are used in military aircraft and display and control systems in military equipment. The company's core team is comprised of experienced NUDT researchers and it has received PRC state support in National IC Funding. It is listed on the Shenzhen Stock Exchange (300474).

Jingjia Micro's first generation of chips was geared for the military aircraft market, and the company's website indicates that its GPUs have been embedded into Chinese military systems such as drones. Company announcements and securities reports indicate that the company is targeting its second-generation high-performance GPU JM7200 chip specifically for the party, government, and military market, putting it in a leading position, with an expected civilian version to follow later.

Jingjia Micro also cooperates with other entities in the PRC defense industrial complex, as indicated by its strategic cooperation agreement with the Chinese defense conglomerate AVIC's Chinese Aeronautical Radio Electronics Research Institute (CARERI / 中国航空无线电电子研究所).

Jingjia Micro previous generation of GPU (the JM5400) was reportedly produced at SMIC using its 65 nm process, and its upcoming 28 nm GPUs are also likely to be produced at SMIC, given their targeted use in Chinese military and government systems.

Shenwei (Wuxi) (Sunway, 神威（无锡）信息产业有限公司))

The Shenwei (Sunway) series of chips that are in use in PLA supercomputers were developed by the Jiangnan Computing Technology Institute (江南计算技术研究所, a cover for the PLA 56th Institute). Reports state that the "world's number one" "supercomputing Sunway TaihuLight chip (超算神威太湖之光芯片) is manufactured by SMIC. The SW1600 process node is 65 nm while the SW 26010 (in the Shenwei supercomputer) is 28 nm, most likely produced at SMIC or HLMC.

Multiple entities using the Shenwei name involved in high-tech computing have close connections to PRC state-backed and PLA computing institutes. An entity using the name Shenwei Micro reportedly operates out of the "Shanghai High Performance IC Design Center," an entity tied to the Ministry of Public Security and apparently also synonymous with the PLA Strategic Support Force 56th RI. The website for Shenwei Micro (www.shenweimicro.com) lists the name and logo of the Shanghai High-Performance IC Design Center at the top of its webpage design. A section on the "Shenwei Industry Alliance" (申威产业联盟) member list notes that the alliance was established in 2012 and is based at the Shanghai High-Performance IC Design Center.

A company established in September 2019 called Shenwei (Wuxi) Information Industry Co., Ltd. (神威（无锡）信息产业有限公司) is registered to conduct high-performance computing services, high-performance computing incubation, cloud computing technology development, business management services, internet and Internet of Things technical services, technology development, technology transfer, and technology consulting, among other activities. The Wuxi Yijiesheng Investment Partnership (LP) (无锡艺捷昇投资合伙企业（有限合伙）) owns a 70 percent stake of the company, while the remaining 30 percent is owned by the National Supercomputing Center in Wuxi (国家超级计算无锡中心), designated as the ultimate beneficiary. The company's address is Room 604, 6th floor, Yanchuang (Research and Innovation) Building No. 1 Yinbai Road, Binhu District, Wuxi (无锡市滨湖区吟白路 1 号研创大厦 6 楼 604), and its registered email address goes to a mail.nsccwx.cn domain for the National Supercomputing Center in Wuxi. An archived version of the National Supercomputing Center in Wuxi notes that its address is 1 Yinbai Road, Binhu District, Wuxi.

Shanghai High-Performance IC Design Center（上海高性能集成电路设计中心）

Baidu Maps shows that the National High-Performance IC Shanghai Design Center is co-located with Ministry of Public Security (MPS 3rd RI).[7] While some sources identify the National High-Performance IC Shanghai Design Center as the designer of the Shenwei processors used in China's Sunway TaihuLight supercomputer, other sources identify the GSD 56th RI as the designer (总参 56 所). Furthermore, an article published on Sina's website in 2015 refers to this facility as a front (马甲) for the GSD 56th RI (now part of the Strategic Support Force or SSF).[8] According the Center's website, it actively undertakes national major scientific research projects and is primarily engaged in domestic high-performance processor development and promoting the industrialization of technological achievements. The products currently listed on its website include the "Shenwei 1610" (申威 1610) high-performance multi-core processor, the "Shenwei 410" (申威 410) domestic high-performance multi-core processor, and the domestic IO microchip SWICH. Given the above information and its proximity to PLA Unit 61398, it is highly likely that the National High-Performance IC Shanghai Design Center is indeed a front for the GSD 56th RI.

Among others, the Center lists CETC 32nd RI (中国电子科技集团第三十二研究所) and CASIC 2nd Academy 706th Research Institute (中国航天科工集团第二研究院七零六所) as cooperation partners.

[7] Address listed as 399 Bisheng Road, Pudong New Area, Shanghai (上海浦东新区毕升路 399 号).

[8] Chinese text: 威由总参谋部第五十六研究所（无锡江南计算技术研究所）设计，上海高性能集成电路设计中心是 56 所的马 。

Ministry of Public Security Third Research Institute (公安部第三研究所 or MPS 3rd RI)

The MPS 3rd RI is charged with network security and smart police research and innovation and technical support, including police information intelligence awareness, police data security sharing, illegal crime monitoring and early warning, network attack and defense, network reconnaissance, technology reconnaissance, electronic forensics, big data analysis, and other areas.

MPS 3rd RI appears to be co-located with PLA Unit 61398 (61398 部队), also known as the General Staff Department (GSD) Third Department, Second Bureau (总参三部二局). In addition, MPS 3rd RI's Zhangjiang base is directly next to the National Information Security Engineering Technology Center (国家信息安全工程技术研究中心), an entity known to be affiliated with the GSD Third Department (see figure below).

Figure 2: Screenshot of Baidu Maps search results. The blue pin (3) marks the MPS 3rd RI building. Shanghai High-Performance IC Design Center is to the right, and National Information Security Engineering Technology Center is above ParkBox.

PLA Unit 61398 (aka GSD Third Department, Second Bureau)

According to a 2013 report by the cybersecurity firm Mandiant, PLA Unit 61398 is believed to be an Advanced Persistent Threat (APT) group known as APT1, and a source of Chinese cyberattacks on the United States, Canada, and likely anywhere English is the main language. The report's findings indicate that Unit 61398 is tasked with offensive computer network operations (CNO) and staffed by hundreds, if not thousands of employees, many of whom have highly technical computer skills and strong English proficiency. Unit 61398 has large-scale physical infrastructure and facilities associated with large military units or higher-level units in Pudong New Area, precisely where APT1 activity appears to originate. In 2014, the United States indicted five Chinese military officers from Unit 61398 on charges of cyber espionage.

Loongson (龙芯)

Loongson is a public-private partnership microprocessor company that plays a key role in China's quest to use domestically-produced technology in its government and military applications that uses SMIC production facilities. The chief architect of the company's line of Loongson processors is Professor Hu Weiwu, a researcher dual-hatted to the Chinese Academy of Sciences' Institute of Computing Technology and its State Key Laboratory of Computer Architecture. The company is backed by the Chinese Academy of Sciences and sells to military end users. Its Loongson 3A2000CPU based on the latest architecture GS464E is fabricated using SMIC's 40 nm technology.

A 2012 patent application from researchers at NUDT is for the invention of an address mapping method for a Loongson 3A platform large memory device, indicating the work that PLA researchers conduct using the company's products. A second NUDT patent application from the same year is for an embedded controller based on Loongson processor and FGPA technology (基于龙芯处理器和 fpga 技术的嵌入式控制器).

In 2016, researchers from the PLA Beijing Region Military Representative Office at the 706th RI in the CASIC 2nd Academy (中国航天科工集团二院七〇六所解放军某部驻北京地区军代室) published an article titled "Design and Implementation of a Security Protect Gateway Based on Loongson Platform."

One blog reported that the PLA had installed the Sugon-manufactured Loongson 3B server "to build an information security line of defense."

The Group's president is also involved in a leadership role with the state- and party-tied Zhejiang Youth Entrepreneurs Association, an organization "under the cordial care of the Provincial Party Committee and Provincial Government and the leadership of the China Young Entrepreneurs association and the Zhejiang Provincial Committee of the Communist Youth League."

Shanghai Zhaoxin (上海兆芯)

Shanghai Zhaoxin likely uses SMIC processes for its products, which are sold to military end users directly and indirectly. Reports on the 2017 ZX-D SoC processor (CentaurHauls Family 6, Model 31) indicated that it is produced by SMIC and HLMC using a 28 nm process. Looking ahead, Chinese-language industry reporting has underscored about the importance of a14/12 nm line in allowing SMIC to produce the Zhaoxin x86 processors domestically. Other reports in early 2020 pondered whether Shanghai Zhaoxin would choose SMIC or TSMC for its upcoming KX-7000 production line, noting that TSMC may be more likely still, but pointing toward a larger trend of indigenization in all phases of Chinese chip production.

Shanghai Zhaoxin has business ties to the PLA and participated in a 2018 PLA expo, offering a domestic, secure solution for the PLA. PLA procurement tenders require that systems support Zhaoxin chips, like the Strategic Support Force's call for bids for a data management system on behalf of PLA Unit 61081 that requires that the system support domestic chips like Feiteng, Longsun, Shenwei, or Zhaoxin.

Shanghai Zhaoxin also conducts joint product testing with companies like Rising (Ruixing), incorporating its processors into secure systems intended for government and military end users. The company's products also land in military-grade domestic servers with local crypto cards.

Other companies linked to PRC-backed research efforts to develop indigenous high-tech products use Shanghai Zhaoxin products. Companies like Beijing Supercloud and Tianjin Cheng Bai, which are linked to the Chinese Academy of Sciences for project work on research with the support of the nationally-funded 863 Program, tout their contribution to the development of China's national security and indigenous innovation through the development of China's first server using Shanghai Zhaoxin's 8-core x86 infrastructure-based processor.

The official website belonging to Shanghai Zhaoxin Semiconductor Co., Ltd. displays a large graphic containing 40 companies under the banner "cooperative partners." Some of these companies, notably Tsinghua Tongfang (清华同方), are immediately recognizable as suppliers to the People's Liberation Army and China's military-industrial complex.

Figure 3: Shanghai Zhaoxin Partners

Shanghai Zhaoxin was established in 2013 by the Shanghai SASAC Shanghai Alliance Investment Co., Ltd. (SAIL), a company with which it also shares key leadership figures. SAIL ostensibly functions as the investment arm of the city of Shanghai and is a wholly-owned subsidiary of the Shanghai State-Owned Assets Supervision and Administration Commission, which is directly subordinate to the municipal government of Shanghai. SAIL was founded in 1994 and appeared to have easy access to large sums of cash through its chairman, Jiang Mianheng, the son of former Chinese President and CCP leader Jiang Zemin, and his political connections to Chinese Communist Party elites, and is said to have functioned like his "personal piggy bank" until the firm was integrated into SASAC in 2014.

SMIC PRC Government and CCP Ties

SMIC has only a small share (under 10 percent) of the global foundry market, but it is China's largest and most technologically advanced wafer foundry. As such, it is a national champion in an industry of key strategic importance, and the Chinese government has repeatedly signaled the political importance of developing the domestic IC industry in order to reduce Chinese dependence on foreign chip imports. The government has issued several iterations of industrial policy guidance mandating government support for the industry, such as 2011's "Some Policies Concerning Steadily Encouraging the Development of the Software and Integrated Circuit Industries" (《进一步鼓励软件产业和集成电路产业发展的若干政策》) and 2014's "National Outline on Promoting the Development of the IC Industry" (《国家集成电路产业发展推进纲要》). The policies have classified the IC industry as a strategic emerging industry and directed local governments to craft preferential policies in areas like taxes, investment, government funding for R&D, talent recruitment, and intellectual property rights.

Preferential tax and customs duties policies

As qualified integrated circuit production enterprises (ICPE), SMIC and its subsidiaries receive material incentives from the Chinese government under its industrial promotion policies. These are summarized in the table below:

Table 3: Benefits accruing to SMIC under Chinese integrated circuit industry promotion policies

Incentive	SMIS; SMIB; SMIT; SMIC Shenzhen; SMNC and SJ Jiangyin
Preferential Enterprise Income Tax Policies	Five-year full exemption and five-year 50% reduction upon approval from the local tax bureau
Incentive	**SMIS; SMIB; SMIT; SMNC and SJ Jiangyin**
Preferential Customs Duties and Import-related VAT Policies	Exemption from customs duties and imported-related VAT with respect to its qualified spare parts, and raw materials pursuant to the Tax-Exemption Categories (SMIC Shenzhen is located in Shenzhen Export Processing Zone).

Official Visits to SMIC

Over the years, SMIC has regularly hosted top leaders for inspection tours at its subsidiaries. These occasions signal the Chinese Communist Party's support for the company, specifically, and serve as reminders that the government is invested in the company's success. For instance, in June 2019 the head of Shanghai's Committee on Informatization and the Economy (上海市经济和信息化委员会), Wu Jincheng (吴金城), led a group of municipal officials on an inspection visit to SMIC. The group met with SMIC's chairman Zhou Zixue (周子学) and talked about the company's current situation and its upcoming planning. Wu praised the company for being "an outstanding representative for the Chinese IC industry" and called on SMIC to create an outstanding industrial ecosystem for the IC industry that increases R&D investment, attracts outstanding expertise, and steadily promotes the coordinated development of the overall IC industry. Wu also promised that the local Shanghai government would strengthen its overall planning for the IC industry, develop favorable policies for supporting the industry, promote good local infrastructure development, and continue to provide good service and government support for major projects and corporate development.

In December 2018 Ying Yong (应勇), currently serving as Shanghai Mayor and a national Central Committee member, visited SMIC to check on the construction progress of its new production line in Shanghai – a more than 10 billion USD investment that is designed to become China's most advanced chip production base. Unnamed SMIC officials briefed Ying on the project's status and he in turn asked them where they needed support (需要哪些支持). In his reported remarks, Ying stated that integrated circuits were "China's national treasure" (国之重器) and a strategic industry. According to Ying, Shanghai would "take the initiative in serving national strategies" (上海要主动服务国家战略), and would make every effort to create China's most complete, most technologically advanced, and most competitive IC industry system.

In August 2018, Ministry of Industry and Information Technology (MIIT) Vice Minister Wang Jiangping (王江平) led an inspection tour of SMIC's Beijing production line and received reports about SMIC's recent development. In his reported remarks, Wang praised the company for its long track record of excellence in chip production and expressed his hopes that the company would continue to work hard and make great contributions to the Chinese IC industry.

On 18 May 2017, Ma Kai (马凯) – Politburo member, vice premier, and chairman of the State Leading Small Group for Integrated Circuit Industry Development (*国家集成电路*产业发展 *领导小组*) – took an inspection tour of SMIC subsidiary Semiconductor Manufacturing International (Beijing) Corporation (中芯国际集成电路制造 (北京) 有限公司), accompanied by Miao Ke, the head of MIIT, Ding Xuedong, the chairman and CEO of China's sovereign wealth fund China Investment Corporation, and the Deputy Mayor of Beijing Yin Hejun. According to news reports, SMIC Chairman Zhou Zixue accompanied the officials, and gave them a "work report" (工作汇报) in which he discussed his views on the state of China's integrated circuit industry, SMIC's recent accomplishments, the company's future plans and the challenges it faced. As the company's representative, Zhou also offered policy proposals concerning how to develop China's integrated circuits industry (提出对于当前如何发展中国集成电路产业的政策建议). After listening to Zhou's work report, Ma Kai offered his approval and support for SMIC's current development, saying that the company's achievements in the last three years were obvious, and its prospects for future growth were very heartening. After the tour, representatives from companies within the integrated circuit industry supply chain held an informal discussion at SMIC with Ma Kai, focused on the topic of how to improve China's integrated circuits industry.

Chinese Communist Party Branches at SMIC subsidiaries

Like many large organizations in China, including not only state-owned enterprises but also private and foreign-owned companies, SMIC's Chinese operating subsidiaries have established Party branch offices ultimately reporting to the CCP's Organization Department. Party branches may play a role in business decision-making to ensure conformance with state policies and often manage any employee labor unions. Party branches also provide an additional channel connecting government administrators and enterprise managers. For example, a July 2018 news article posted to a website maintained by the Beijing Economic-Technological Development Area described a meeting organized by the Party branch at the Development Area Bureau of Statistics (开发区统计局党支部), the Party branch at the Development Area Investigation Team (调查队党支部), and

the Party committee (中芯国际北京北方党委) at SMIC subsidiary Semiconductor Manufacturing North China (Beijing) Corporation (SMNC), intended to promote the development of SMNC as an "internationally first-rate semiconductor manufacturing enterprise" (国际一流集成电路制造企业). Pan Zhousi (潘宙斯), SMNC deputy Party secretary, and Jiang Lei (姜镭), SMNC Party secretary, led representatives from the Development Area Bureau of Statistics and Investigation Team in touring production lines and learning about chip design and foundry operations.