APEX STANDARDS

Chiplet Breakthroughs and the Geopolitical Landscape of Semiconductor Policy

Chiplets are driving a revolution in the semiconductor industry by integrating specialized components into a single chip, resulting in enhanced compute power sensitive to national security. They are now integral to key applications such as AI, 5G/6G and High Performance Computing (HPC). The Joint Electron Device Engineering Council (JEDEC) is responsible for such standardization, with US, EU, China, Taiwan and South Korea engaging in a high-stakes competition backed by national policies Table 1. Amid US-China competition specifically, Huawei's inclusion in the 2018 US Entity List followed by JEDEC membership reinstatement highlights China's strategic resilience in global semiconductor standardization.

SMIC, another Chinese firm and also a major JEDEC contributor, encountered similar hurdles after the ASML export control ban. Nevertheless, they innovatively employed Deep Ultra-Violet (DUV) lithography—which is commonly used for older 14nm processes—to achieve domestic 7nm production. Despite at higher costs and lower yields compared to Taiwan's TSMC and South Korea's Samsung, both using ASML's newest Extreme Ultra-Violet (EUV) lithography for 7nm productions, SMIC's progress stresses China's dedication to competing with the frontrunners. China saw a 32% increase in JEDEC member companies in 2022 alone, reaching 18% of total members and expected to grow due to investment and demand for new electronics. In contrast, despite owning the majority of foundational technology, the US has seen its chips output drop from 73% in the early 2000s to 24% last year mainly due to Intel's over-reliance on the PC market and missed opportunities in mobile, especially during the period when OEM revenue from smartphones and tablets surged from $42b to $355b since Apple's iPhone launch according to IHS. While AMD, another US firm, has recently recaptured Intel's lost share with its Ryzen and Epyc chiplet innovations, its most sophisticated 7nm/5nm CPUs are manufactured far off shore by TSMC in Taiwan. The industry is led by Taiwan and Samsung, with a continued focus on the foundry business Table 2. To counteract the decline, US enacted CHIPS Act with bipartisan supports in 2022, to improve its competitive position, prioritizing semiconductor R&D, domestic manufacturing and boost economic growth.

The global semiconductor sector is witnessing intense competition. The display of China's determination via Huawei and SMIC poses a challenge to the US's longstanding influence and the current dominance of Taiwan's TSMC and South Korea's Samsung, alongside testing effectiveness of EU's ASML EUV ban. These collectively will define the trajectory of technological advancements, emphasizing the significance of every strategic maneuver. ▮

Country/Region	National Policy	Key Persons	Strategic Consideration	Funding Amount	Year
China	National Integrated Circuit Industry Dev.	Premier Li Keqiang	To promote growth of China's domestic semiconductor industry	N/A	2014
China	Made in China 2025	President Xi Jinping	China's goal to become a high-tech manufacturing powerhouse	N/A	2015
European Union	Digital Single Market strategy	EU Commissioner for Digital Economy and Society Mariya Gabriel, President Jean-Claude Juncker	To promote the development of the digital economy in the European Union, of which semiconductors are a key component	N/A	2015
Taiwan	Digital Nation and Innovative Economy	President Tsai Ing-wen, Minister of Economic Affairs Wang Mei-hua	To promote the growth of Taiwan's semiconductor industry through increased investment, talent development, and international collaboration	N/A	2016
Israel	National Advancement of the High-Tech Ind.	Prime Minister Benjamin Netanyahu, Minister of Finance Moshe Kahlon	To support the growth of Israel's high-tech industry, including semiconductors	N/A	2017
Italy	Piano Nazionale Industria 4.0	Prime Minister Paolo Gentiloni, Minister of Economic Development Carlo Calenda	To support the development of Italy's high-tech manufacturing sector, including semiconductors	$13 billion USD (€13 billion)	2017
Singapore	Electronics Industry Transformation Map	Prime Minister Lee Hsien Loong, Minister for Trade and Industry Chan Chun Sing	To transform Singapore's electronics industry, including semiconductors, through increased investment, innovation, and skills development	N/A	2017
UK	Industrial Strategy Challenge Fund	Prime Minister Theresa May, Business Secretary Greg Clark	To invest in key technologies, including semiconductors, to boost productivity and competitiveness in the UK	$1 billion USD (£1 billion)	2017
UK	Digital Strategy	Prime Minister Theresa May, Secretary of State for Digital, Culture, Media and Sport Karen Bradley	To promote the growth of the UK's digital economy, including semiconductors	N/A	2017
France	Plan Industriel pour l'Avenir	President Emmanuel Macron, Minister of the Economy Bruno Le Maire	To support the development of France's high-tech manufacturing sector, including semiconductors	$10 billion USD (€10 billion)	2018
Germany	Key Technologies for the Future program	Chancellor Angela Merkel	To promote innovation in key technologies, including semiconductors	$3 billion USD (€3 billion)	2018
Germany	National Action Plan on AI	Chancellor Angela Merkel	To support the development of AI and related technologies, including semiconductors	$3 billion USD (€3 billion)	2018
United States	Export Control Reform Act	President Donald Trump and U.S. Congress	To regulate the export of foundational technologies, including semiconductors	N/A	2018
India	National Policy on Electronics	Prime Minister Narendra Modi, Electronics and IT Minister Ravi Shankar Prasad	To promote the growth of India's electronics industry, including semiconductors, through increased investment, incentives, and regulatory measures	N/A	2019
India	Production-Linked Incentive Scheme	Prime Minister Narendra Modi, Finance Minister Nirmala Sitharaman	To provide financial incentives to domestic and foreign companies for manufacturing semiconductors and other electronics products in India	$6.65 billion USD	2020
Japan	Basic Plan for Semiconductor Ind.	Prime Minister Yoshihide Suga, Economy Minister Yasutoshi Nishimura	To strengthen Japan's semiconductor industry through increased investment and collaboration	$6.8 billion (¥774 billion)	2020
South Korea	New Deal for Digital	President Moon Jae-in, Finance Minister Hong Nam-ki	To accelerate digital transformation in South Korea through increased investment in key technologies, including semiconductors	$62 billion USD (₩76 trillion)	2020
South Korea	Semiconductor Ind. Promotion Plan	President Moon Jae-in, Economy Minister Hong Nam-ki	To strengthen the competitiveness of South Korea's semiconductor industry through increased investment and support for R&D	$450 million USD	2021
European Union	European Chips Act	EU Commissioner Thierry Breton, President Ursula von der Leyen	To promote the development of the European semiconductor industry	$43 billion USD (€43 billion)	2022
United States	CHIPS for America Act	President Joe Biden and U.S. Congress	Concerns about the U.S. semiconductor competitiveness and national security	$52 billion USD	2022

Table 2 outlines national policies targeting the semiconductor industry over the past decade, revealing geopolitical dynamics where semiconductors are crucial to the digital economy, and global powers engage in a strategic race to dominate the industry. China initiates the National Integrated Circuit Industry Development (2014) and Made in China 2025 policy (2015) early on. Taiwan boosts its semiconductor prowess with the Digital Nation and Innovative Economic Development Plan (2016). Amid tensions, the US enacts the Export Control Reform Act (2018) and the $52 billion CHIPS for America Act (2022) to protect competitiveness and national security. Japan and South Korea strengthen their roles, with Japan's Basic Plan (2020) allocating $6.8 billion and South Korea investing $62.45 billion through the New Deal for Digital (2020) and Semiconductor Industry Promotion Plan (2021). The EU pursues digital unity with the Digital Single Market (2015) and the $43 billion Chips Act (2022). Leading nations strategically invest and innovate in the competitive semiconductor landscape.

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Country	Company	Key Persons	Title	Commercial Product	End-Users Industry	Breakthrough	Primary JEDEC Standard	Related JEDEC Standard	Year
United States	AMD	Jerry Sanders	Founder	Athlon Processor	High Performance Computing	Silicon-on-insulator introduction	JESD79-4: Wide Bandgap Power Semi.	JESD204C: Serializer-Deserializer (SerDes)	1999
United States	Nvidia	黃仁勳 (Jen-Hsun Huang)	Co-Founder	GPU	High Performance Computing	First parallel GPU computing	JESD232: Graphics Double Data Rate (GDDR)	JESD9C: GDDR1 Design Specification	2000
United States	Apple	Steve Jobs, Steve Wozniak	Co-Founders	iPhone SoC	Mobile Computing	First mobile SoC	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2007
United States	Intel	Justin Rattner	CTO	Teraflops Research Chip	High Performance Computing	MIC architecture introduction	JESD71: System-on-Chip (SoC)	JESD235: High Bandwidth Memory (HBM)	2007
United States	Tilera Corp	Anant Agarwal	Founder	Tile Processor	High Performance Computing	First many-core single chip	JESD71: System-on-Chip (SoC)	JESD235: High Bandwidth Memory (HBM)	2007
Taiwan	TSMC	劉德音 (Mark Liu)	Director	3D IC Technology	Various	First multi-layer chip stacking	JESD229-3: Wide I/O 2	JESD230: 3D Stacked Memory	2011
United States	Intel	Ronak Singhal	Engineer	Embed Multi-die Intercon (EMIB)	High Performance Computing	First multi-chip single package	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2012
China	Huawei	任正非 (Zhengfei Ren), 余承东 (Richard Yu)	Founder, Rotating Chair	Kirin Processor	Mobile Computing	First multi-component single chip	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2014
Japan	Toshiba	福馬雅雄 (Masao Fukuma)	CTO	Multi-Chip Module	Various	First multi-chip single package	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2015
Taiwan	MediaTek	蔡明介 (MK Tsai)	Chairman	Tri-Cluster Technology	Mobile Computing	First multi-core single chip	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2015
United States	AMD	蘇姿豐 (Lisa Su)	CEO	Chiplet Architecture	High Performance Computing	First multi-chip single package	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2018
United States	Intel	Jim Keller, Raja Koduri	Engineers	Foveros	High Performance Computing	First 3D logic-memory stacking	JESD230: 3D Stacked Memory	JESD204C: Serializer-Deserializer (SerDes)	2018
China	Huawei	张平翔 (Pingxiang Zhang)	Engineer	Kirin 980 SoC	Mobile computing	First 7nm dual-NPU mobile	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2018
China	Huawei	许晨晔 (Eric Xu)	Rotating Chair	Kunpeng 920	Datacenter	First ARM server chiplets	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2018
Japan	Fujitsu	新城直樹 (Naoki Shinjo)	Engineers	A64FX	High Performance Computing	First ARM high-performance chiplets	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2019
China	Cambricon	陈天石 (Chen Tianshi)	Founder	AI Processor	Artificial Intelligence	First multi-component single chip	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2019
China	Huawei	许晨晔 (Eric Xu)	Rotating Chair	Ascend Processor	Artificial Intelligence	First multi-component single chip	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2019
China	Huawei	徐文伟 (Xu Wenwei)	CTO	Da Vinci Architecture	Artificial Intelligence	First multi-component single chip	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2019
South Korea	Samsung	인엽 강 (Inyup Kang)	President	Exynos 990	Mobile Devices	First multi-chiplet mobile processor	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2019
United States	Intel	Jim Keller	Engineer	Foveros 3D Packaging	Various	First vertical chip stacking	JESD230: 3D Stacked Memory	JESD235: High Bandwidth Memory (HBM)	2019
China	Huawei	许晨晔 (Eric Xu)	Rotating Chair	Kirin 990	Mobile Devices	First 5G chiplet mobile processor	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2019
Japan	Renesas	柴田秀敏 (Hidetoshi Shibata)	Executives	R-Car V3H	Automotive	First chiplet automotive processor	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2019
China	Alibaba	闵万里 (Wanli Min)	AI Scientists	XuanTie 910	Datacenter	First RISC-V datacenter chiplets	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2019
United States	Intel	Pat Gelsinger	CEO	Compute Express Link	Various	First high-speed chip interface	JESD204C: Serializer-Deserializer (SerDes)	JESD235: High Bandwidth Memory (HBM)	2020
South Korea	Samsung	인엽 강 (Inyup Kang)	Executive	Exynos 2100	Mobile Devices	First 5G chiplet mobile processor	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2020
South Korea	Samsung	인엽 강 (Inyup Kang)	President	HBM-PIM	High Performance Computing	First high-bandwidth memory chiplets	JESD71: System-on-Chip (SoC)	JESD235: High Bandwidth Memory (HBM)	2020
South Korea	SK Hynix	이경렬 (Kevin Lee)	Engineers	HBM2E-SkHynix	High Performance Computing	First high-bandwidth memory chiplets	JESD235: High Bandwidth Memory (HBM)	JESD71: System-on-Chip (SoC)	2020
China	Horizon Rbts.	于凯 (Kai Yu)	Founders	Journey 5	Automotive	First chiplet automotive processor	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2020
United States	Intel	Jim Keller	Engineers	Lakefield 3D Stacking	Mobile Devices	First Foveros mobile processor	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2020
United States	Apple	Johny Srouji	SVP Hardware	M1 Processor	Mobile Computing	First multi-component single chip	JESD71: System-on-Chip (SoC)	JESD227: MIPI Alliance UniPro Protocol	2020
Japan	Renesas	鴨原志郎 (Shiro Kamohara)	Engineers	R-Car V3U	Automotive	First Ethernet automotive chiplets	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2020
United States	AMD	Mark Papermaster	EVP	Ryzen 4000 series	Computing, Mobile Devices	First chiplet mobile CPUs	JESD71: System-on-Chip (SoC)	JESD204C: Serializer-Deserializer (SerDes)	2020
United States	Qualcomm	Steve Mollenkopf	CEO	Snapdragon 8cx Gen 3	Mobile Devices	First 5G chiplet mobile processor	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2020
Taiwan	TSMC	劉德音 (Mark Liu)	Co-CEO	Wafer-on-Wafer	Various	First vertical wafer stacking	JESD229-3: Wide I/O 2	JESD230: 3D Stacked Memory	2020
United States	AMD	Mark Papermaster	CTO	3D V-Cache	High Performance Computing	First memory-CPU stacking	JESD235: High Bandwidth Memory (HBM)	JESD230: 3D Stacked Memory	2021
Japan	Fujitsu	新城直樹 (Naoki Shinjo)	Camera Expert	A64FX 2.0	High Performance Computing	A64FX performance upgrade	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2021
United States	Intel	Pat Gelsinger	CEO	Alder Lake	Computing	First hybrid desktop chiplets	JESD229-3: Wide I/O 2	JESD71: System-on-Chip (SoC)	2021
United States	AMD	Mark Papermaster	CTO	EPYC 7003 series	Datacenter	First datacenter chiplet processors	JESD235: High Bandwidth Memory (HBM)	JESD235: High Bandwidth Memory (HBM)	2021
United States	Nvidia	黃仁勳 (Jen-Hsun Huang)	CEO	Grace CPU	High Performance Computing	First multi-component single chip	JESD71: System-on-Chip (SoC)	JESD227: MIPI Alliance UniPro Protocol	2021
China	Huawei	陈宇群 (Yuqun Chen)	President	Liquid Lens Camera Tech	Mobile photography	Faster, efficient autofocus and zoom	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2021
Taiwan	TSMC	魏哲家 (C. C. Wei)	Co-CEO	N6RF	Computing	First chiplet RF front-end	JESD71: System-on-Chip (SoC)	JESD230: 3D Stacked Memory	2021
United States	Intel	Anne Kelleher	Senior Fellow	Node Tiles	High Performance Computing	First disaggregated chiplet architecture	JESD204C: Serializer-Deserializer (SerDes)	JESD235: High Bandwidth Memory (HBM)	2021
United States	Intel	Raja Koduri	SVP	Ponte Vecchio	High Performance Computing	First datacenter GPU chiplets	JESD235: High Bandwidth Memory (HBM)	JESD204C: Serializer-Deserializer (SerDes)	2021
China	Huawei	徐文伟 (Xu Wenwei)	Director	Shengteng AI Processor	Artificial Intelligence	First multi-component single chip	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2021
Taiwan	TSMC	魏哲家 (C. C. Wei)	Co-CEO	SoIC	Computing	First diverse chiplet integration	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2021
China	SMIC	陈梦松 (Mengsong Chen)	Director	7nm FinFET Process	High-performance computing	Performance and efficiency	JESD71: System-on-Chip (SoC)	JESD229-3: Wide I/O 2	2022

Table 1 The global chiplets landscape has seen groundbreaking innovations that transformed industries and strengthened geopolitical ambitions. In 1999, Nvidia's 1st Gen GDDR marked the start of GPU computing, laying the foundation for today's mainstream AI. Its highly parallel computing enables efficient neural net computation and power recent AI breakthroughs such as GPT. More cently, China has been assertive in its ambitions, evident by Huawei's Kirin Processor, which became the first multi-component single chip in 2014, and the nation's SMIC launching domestic 7nm FinFET processes in 2022, despite being placed on the US Entity List. Taiwan has emerged as a dominant force in sub-7nm technologies with TSMC's 5nm, 3nm, and beyond. TSMC has been a key player, developing 3D IC Technology in 2011 and recently introducing SoIC for diverse chiplet integration in 2021. Intel's market share has been affected by increased competition from AMD, Apple, and Samsung. Japan also contributed, with Toshiba's Multi-Chip in 2015, Fujitsu's A64FX in 2019, and Renesas' R-Car V3H in the automotive industry. Huawei's Kirin 990, the world's first 5G chiplet that emerged before competitors like Samsung's Exynos and Qualcomm's Snapdragon series, was stifled following the company's 2018 US Entity List inclusion. However, Huawei persisted to innovate with Ascend Processor for AI in 2019 and Shengteng AI Processor in 2021. China's SMIC has followed a similar path, pursuing 7nm processes by overcoming performance and efficiency issues despite being placed on the 2022 US Entity List. These underscore advances in chiplet semiconductors as nations and companies compete for technological supremacy, reshaping sectors like HPC, AI, and next-gen communications.