

The Future of the Semiconductor Industry from the Perspective of Advanced Packaging

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The rapid rise of generative AI has swiftly disrupted traditional perceptions of technology within a remarkably short period. To secure leadership and influence in this technological race, companies worldwide are actively investing in related technologies and end-user applications. In the tech industry, semiconductors and AI are interdependent, complementing each other. AI has not only redefined integrated circuit design (IC design) but also provides solutions in areas such as IC chip defect detection, process optimization, and fault prediction, significantly enhancing the efficiency and profitability of the semiconductor industry. Additionally, the development of AI has led to the creation of chips specifically designed to meet its unique requirements. Historically, due to production layouts established by brand owners and assembly plants, Asia has inadvertently become a major hub for the semiconductor packaging industry, with key locations in Taiwan, Malaysia, South Korea, the Philippines, Vietnam, and mainland China.

Reflecting on 2018, then U.S. President Donald Trump signed the Memorandum Targeting China's Economic Aggression, accusing China of stealing American intellectual property and trade secrets. Invoking Section 301 of the Trade Act of 1974, Trump directed trade representatives to impose tariffs and establish other trade barriers on imports from China, with the aim of compelling China to alter its unfair trade practices. In the same year, the U.S. Defense Advanced Research Projects Agency (DARPA) announced a \$1.5 billion investment over five years to support the long-term development of the semiconductor industry. DARPA's Electronics Resurgence Initiative (ERI) included more flexible and innovative chip architectures to meet the demands of emerging technologies such as AI and high-speed computing, collaborating with industry, academia, and research institutions on materials and chip design research.

From an industry perspective, a search was conducted using the Global Patent Search System (GPSS) of the Taiwan Ministry of Economic Affairs' Intellectual Property Office, focusing on the keyword "advanced packaging" for applications filed between 2020 and 2024. After deduplicating patents and their families, a total of 1,253 patents were identified. The top five countries for patent filings are Mainland China (628

patents), the United States (385 patents), Taiwan (113 patents), Germany (31 patents), and Japan (21 patents). Among the top ten companies in terms of patent ownership, five are based in Mainland China and four in the United States. The detailed rankings are as follows: NCAP China with 239 patents, Shanghai Xianfang (a subsidiary of NCAP) with 78 patents, TSMC with 75 patents, Intel with 64 patents, Applied Materials with 43 patents, JCET with 42 patents, Huawei with 26 patents, Hefei Advanced Packaging Ceramics with 20 patents, Apple with 19 patents, and IBM with 15 patents.

On the other hand, in the after Moore's Law era, the primary avenues for enhancing semiconductor performance are microtechnology, advanced packaging, and the development of new materials. Recently, the United States has urged allies such as Japan, the Netherlands, Germany, and South Korea to broaden the scope of technology restrictions and has announced a ban on exporting advanced microtechnology equipment for processes below seven nanometers to mainland China. This action has compelled China to pursue breakthroughs in packaging technology and the development of new materials, which accounts for the surge in related patents over the past four years.

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