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A Semiconductor Ecosystem

Japan's Perspective: Creating an Ecosystem Linking Diverse Semiconductor Needs

Moore's law is becoming a privilege that only a few major companies can enjoy

In 1965, Gordon Moore, one of the founders of Intel, proposed what came to be Moore's law in which the density of semiconductors would double every 18-24 months[1]. In order to improve semiconductor density, companies need to invest in a wide range of technologies. So, once the 1990s rolled around, a horizontal division of labor between design and manufacturing had developed, and a structure had been established in which foundries specializing in manufacturing led investment toward miniaturization in order to disperse these huge amounts of technology investments. As a result, Moore's law has continued to function for more than half a century, underpinning the innovative performance improvements of various devices that support digital society.

However, in recent years, people have begun to speak about how Moore's law is approaching its limit. Behind this, there lies the challenges that the supply side and demand side of the industry are facing. The technical hurdle for EUV lithography[2], which is essential for the miniaturization of 7 nm and beyond, is high and is regarded as a major problem on the supply side. ASML is the only company that has been able to commercialize corresponding lithography equipment[3]. Furthermore, as of 2019, only three companies—Intel, Samsung, and TSMC—have expressed their intention in 2019 to continuously invest into further miniaturization using EUV technology[4].

Cutting-edge manufacturing processes have become more difficult to use for the demand side, which mainly consists of fabless companies specializing in semiconductor design and

development. Because of the expensive upfront development costs and the high unit price per lot when ordering semiconductors from foundries, it is difficult to make a return on investment except for single-design chips that are expected to ship in large quantities. Consequently, it has become difficult for all but a few major semiconductor companies to enjoy the benefits of manufacturing cost reductions brought about by miniaturization.

New Trends in semiconductors that don't rely on miniaturization

In this era, the concept of domain specific architecture (DSA) is attracting attention as a breakthrough to improve the performance of semiconductors without relying on miniaturization. To put it simply, DSA is a design philosophy by which performance exceeding general-purpose processors provided by major players is achieved by creating dedicated (customized) designs for specific applications[5].

As it is becoming increasingly difficult for set manufacturers and service providers to improve the performance of general-purpose semiconductors by way of miniaturization, having semiconductors optimized for their specific applications has become a powerful strategy for strengthening competitiveness. There are numerous cases where companies like Apple, Google, and Tesla have moved from using general-purpose chips to designing their own custom chips.

The applications expanding business opportunities for custom semiconductors are those for machine learning (ML) and artificial intelligence (AI). The high-speed parallel computing of big data required for these applications is difficult to achieve with CPUs meant for general-purpose computation. There are many semiconductor start-ups planning and designing AI-specific chips in anticipation of a demand explosion. Investments into semiconductor start-ups in the U.S. during Q2 2018 have also surged 13.5 times over the same period of the previous year to about $1.7 billion[6].

AI-specific chips can be classified into two types: server-side and edge-side chips. Server-side chips are used for machine learning based on big data gathered from a variety of edge devices. Large cloud-based IT companies such as Google, Amazon, Alibaba, and Huawei are working on their own semiconductors, while U.S. start-ups such as Wave Computing[7] and Cerebras Systems[8] and U.K.'s Graphcore[9] have also proposed chips optimized for specific purposes. In Japan, AI chip development has diversified in AI companies. For example, Preferred Networks (PFN) develop AI chips optimized for their own deep learning framework[10].

The demand for semiconductors in edge devices is going to become further diversified and is expected to grow for AI chips in autonomous vehicles in the early 2020s. Beyond that, these chips are expected to be used in the IoT market which includes a variety of autonomously operated machinery, such as household robots for home use indoors, cooperative robots and automated guided vehicles in factories, and unmanned home delivery vehicles and construction machinery for the outdoors, etc.

The three gaps cutting across new trends

Although new trends have emerged in which IT companies and set manufacturers develop their own custom semiconductors to meet future diversified demands, three gaps exist between new semiconductor consumers and foundries and these are hampering the success of this trend.

There firstly exists a gap in market interaction. As the business domains that new semiconductor consumers operate in are so different from the domains that foundries are in, a lack of understanding exists for each other's industry. It is difficult for new semiconductor consumers to select foundries that provide the best manufacturing process for their custom semiconductors with the best business conditions. Foundries similarly have limited access to these new types of consumers, which is making it difficult to match the two. While much of AI start-up demand are concentrated around well-known, large foundries, such foundries' business priorities are to sell their cutting-edge processes to large consumers, so it is difficult for them to come to an agreement on business conditions regarding diverse medium-to-small scale demands. As a result, more businesses are anticipated to struggle in the future with having their company's semiconductor design and manufacturing needs unmet.

Secondly, there is a gap in development skills. The skills required to develop a semiconductor considerably differ from the skills required to develop final sets or services. In order to outsource production to foundries, fabless companies need to provide design data. However, the creation of such data requires special design tools and skilled engineers with deep understanding of semiconductor design. This often becomes a barrier for new players, as it is not easy to hire or train talent with these design skills.

The third is the gap in timing between supply and demand. Semiconductor demands for a wide range of applications are expected to see exponential growth in the future. On the other hand, should semiconductor start-ups and suppliers directly negotiate business condition, foundries and consumers could face difficulties in reaching an agreement within the necessary timeframe due to business conditions such as capacity, lead times, and prices not matching.

Efforts being made toward an ecosystem that fill in the gaps

In order to eliminate these gaps, there is movement to form an ecosystem by adopting functions to connect the two sides. Next-generation companies aiming to dominate the semiconductor ecosystem brought about by the new trends are making moves to establish their position in the market.

To start, let's take an example of how a company responded to the gap in market interaction. U.S. company AnySilicon has developed a service for matching semiconductor consumers

with IP vendors and design houses on the web, thereby lowering the barrier for start-ups planning to design their own chips[11]. Using this service, users can compare IP cores and foundries online that match their desired semiconductor specifications and even get price quotes. Many semiconductor manufacturers have conventionally relied on one-on-one sales from large customers, but as it is difficult to connect with new start-ups using this sales style, it is important to build an efficient means of market interaction using digital technology.

Next, regarding the gap in development skills, numerous companies in China, including VeriSilicon[12] and Moore Elite[13], have started to provide full turnkey services to design semiconductors for customers based on end-user specification requirements, match them with foundries, remotely monitor production, and even handle logistics. Technologies and tools have also been developed that allow engineers who have not previously designed semiconductors to easily design chips[14,15,16], and these technologies and tools have the potential to accelerate the formation of the next-generation semiconductor ecosystem.

And finally, the gap in timing between supply and demand. Since the Great East Japan Earthquake in 2011, this is an area whose importance is being newly recognized from a Business Continuity Management (BCM) perspective in Japan, and business models of partnering with external foundries based on the situation of one's business have already begun to sprout among major semiconductor companies[17]. Going forward, in order to provide a flexible and economically rational supply system to new semiconductor consumers, it will be effective to form an ecosystem involving not just a handful of major foundries, but multiple foundries of varying sizes.

The strategic view required for semiconductor manufacturers: creating markets

The slowdown of miniaturization has forced Japanese semiconductor companies to reconsider their business strategy. However, trends that don't rely on cutting-edge processes as discussed so far suggest the possibility that diverse manufacturers will be able to co-exist using their core technology, thus completely transforming the conventional oligopolistic market.

In order for Japanese semiconductor companies to leverage the new opportunities generated from the change in the industrial structure and once again demonstrate their presence in global markets, they need to take the challenging strategic view of connecting the gaps between markets and shaping the actual market itself. It is necessary to develop strategies for identifying and establishing the position of one's business within the semiconductor ecosystem in light of mid- to long-term changes in the semiconductor market. By choosing a position different from the conventional semiconductor mega player without clinging to one's former business domains, Japanese semiconductor companies will be able to revive the market in a way that fully leverages their uniqueness as a Japanese company.

Notes

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IS 669126 / ISO 27001