Chip Scale Review®

ChipScaleReview.com

The Future of Semiconductor Packaging

Volume 26, Number 6

November • December 2022

Double-sided probing system for 150µm pitch co-packaged optics

page 11

- Powering chips from the backside
- Device validation: the ultimate test frontier
- HPC applications drive reliability of HD FO packaging
- Large-panel FO perspective on cost, yield, and capability
- Cooperation is key to success of the CHIPS and Science Act

Cooperation is key to success of the CHIPS and Science Act

By Asif R. Chowdhury [UTAC Group]

There has been a lot of talk and discussion regarding the recent CHIPS and Science Act. Passed by the U.S. Congress in an unusual show of bipartisan support, the bill allocates US$52.7 billion in the form of subsidies to promote a domestic semiconductor eco-system and achieve a higher level of national independence through increased domestic manufacturing of semiconductors. About US$39 billion of the funds is earmarked for semiconductor fabrication facilities, with US$2 billion specifically allocated for mature semiconductor products that are considered vital for national defense and security—this also includes chips used in the automotive sector. The balance of the funds is targeted to foster increased research and development efforts and cultivate a talent pool essential for the sector. The bill does come with some guardrails, i.e., imposing restrictions in establishing manufacturing sites in certain geographic regions.

Three sides to the debate

The discussions and debates about the CHIPS Act have evolved mostly around three primary views and arguments. The patriotic argument is that such focus is essential for the United States to have long-term sovereign independence of critical semiconductor components, economic growth and national security. After all, microchips are ubiquitous today, used in literally everything from toaster ovens to watches, to our every-day vacuum cleaners, to weapons systems.

Another side argues that such protectionist moves play against the free-market dynamics. The natural flow of the evolution of semiconductor manufacturing over the past decades has followed the market path of optimum labor and technology dominance – manufacturing primarily in lower cost geographic regions (i.e., Asian nations), while advanced design is concentrated mainly in the U.S. Free-market advocates are keen to point out that this kind of national subsidy will disrupt the free market, thereby resulting in an increase in manufacturing costs and a waste of resources, ultimately hurting consumers.

Then there is a third viewpoint that argues that this whole effort is nothing more than a geopolitically-motivated, futile effort to deter an increasing manufacturing share of Asia, particularly that of China. This side also adds that, despite the subsidy, the effort will likely not achieve its goal with decades of lack of attention and funding of the industry that led to the U.S. decline in its manufacturing capability and capacity in the first place.

Each of the three perspectives has some merits, especially when reviewed in isolation. But in today's connected global ecosystem, it would be unwise to view any key semiconductor policy decision in isolation.

A global perspective

Today, the semiconductor industry contributes to less than 0.5% of the global gross domestic product (GDP), but plays a critical role in most of the balance of the 99.5% of the GDP. The significant supply chain disruption caused by COVID-19 served as a wakeup call, not only for the U.S., but also for Europe and Japan. The impact and importance of semiconductors in our daily lives and national interests quickly became apparent, and the realization was further solidified by recent geopolitical instability. These concerns prompted these regions to seriously contemplate a path towards increasing self-reliance. Undoubtedly, the trade war between the U.S. and China has become a valid concern for many countries, even though many may not necessarily openly show more support to one side than the other. Nevertheless, wheels are now being set in motion across geographic regions that will likely have a significant impact on the semiconductor manufacturing landscape by the end of the decade.

From the standpoint of recent supply chain disruptions, the trade war and the geopolitical risks, the first argument about achieving some level of sovereign semiconductor independence perhaps holds water. America still leads the world in semiconductor technology: in 2021, the U.S. held 54% of global semiconductor market share and 7 of the top 15 semiconductor companies were American. Over the past decade, the U.S. has spent almost twice as much in research and development as the rest of the world combined. These statistical figures while spectacular, provide a false sense of security. Indeed, the U.S. leads in semiconductor design and market share, but it has fallen far behind in the manufacturing sector. While semiconductor devices and technology were invented in America, only about 10% of the world's supply comes from the U.S. today—down from 37% in 1990. In comparison, China's share has grown from 0% to 24% during the same period. Today, 75% of the global chip supply are manufactured in Asia, with 40% of that coming from Taiwan alone. Taiwan accounts for 66% of the global foundry market share with TSMC commanding an impressive 56% of the share by the end of this year. **Figure 1** shows this historical trend clearly and predicts the outcome by the end of the decade—and it is not a pretty picture for the U.S., Europe and Japan. The design capability in itself is not of much use if these products can't be manufactured with access to a steady stream of supply to meet demand. MITRE Engenuity, a non-profit organization that manages federally-funded research and development centers, defines the

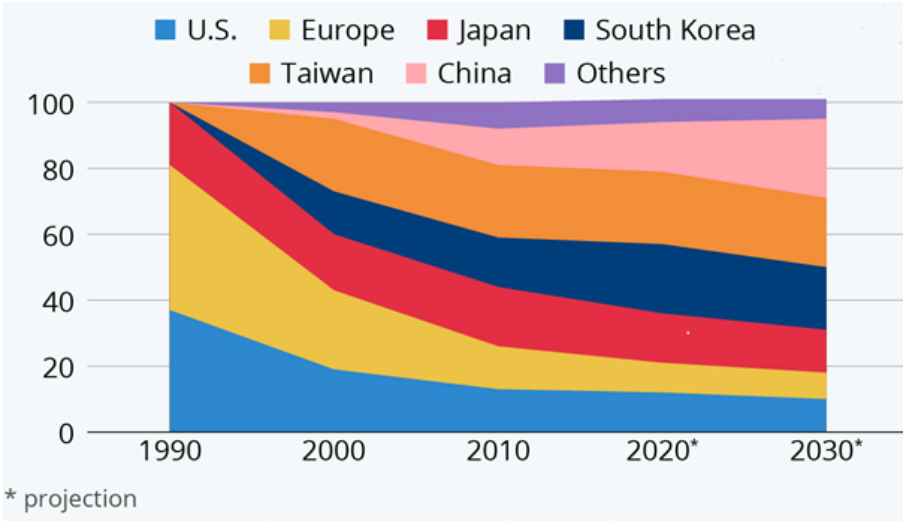

Figure 1: Global semiconductor manufacturing by location in percent. SOURCES: Boston Consulting Group, Semiconductor Industry Association, SEMI

problem statement as: "U.S. leadership in semiconductor is threatened by the lack of U.S.-based capacity for prototyping, scaling and transfer-to-manufacturing of breakthrough semiconductor technologies that are the foundation of future information and communications solutions necessary for national security and economic resiliency." The CHIPS Act is geared towards a "course correction" to grow the capability from lab-to-fab domestically.

The second argument about such industry subsidies being a protectionist move is not unfounded either. Indeed, despite all the progress in globalization made during the last decades, the recent trend seems to be more toward protectionism with an increasingly polarized view of the world—a world that has become increasingly complex by the realities of today's heightened geopolitical tensions. But the goal here is not necessarily to take over semiconductor manufacturing domination from the likes of Taiwan or the Asian nanoscale duopoly of Samsung and TSMC, but rather to achieve a healthy level of independence of the semiconductor supply chain to reduce the risk of dwindling or no supplies, at least for some of the critical products. Even if the U.S., EU and Japan tried to take over semiconductor manufacturing dominance, it will take years, perhaps even a decade or so, based on their capabilities today.

The U.S. is not alone in this quest to achieve a healthy level of independence. Both Europe and Japan have launched their own equivalent "CHIPS Act" to try to achieve their own strategic autonomy and resilience. The EU launched an ambitious project in 2013 to double its onshore share of semiconductor production. However, almost ten years on, its share has remained around 10%. This time around, seemingly more serious, the EU has launched its own "CHIPS Act" in February of this year that is geared to generate €43 billion in public and private funding. Similar to the U.S. bill, the EU Act has three distinct pillars. The first pillar is to increase research, development and pilot production lines on European soil. This partnership not only includes the 25 EU countries, but also Israel, Turkey and Norway. The second pillar is to set up more "Open EU Foundries" using advanced technology nodes. The third pillar is to ensure continuity of supply to the continent and the ability to intervene in case of a supply-related crisis.

Similar to the EU's efforts, Japan's Ministry of Economy, Trade and Industry (METI) has taken significant steps to boost domestic production of advanced chips. In the late eighties, Japan manufactured over 50% of the world's semiconductors. Today, it supplies less than 10%. **Figure 2** shows the historical trend and the 2022 forecast of semiconductor capital expenditure (CapEx) by headquarters location. The lack of focus on semiconductors on the part of the U.S., EU, and particularly Japan, is very telling in these trend lines. While the percent of the U.S. semiconductor-related CapEx has dropped from 31% to 27%, and Europe's has dropped from 8% to 3% from 1990 through today, Japan's share of semi CapEx has dropped significantly, from 51% to less than 4%, during the same period. Just like the U.S. and the EU, the Japanese government is also adopting policies to ensure "strategic autonomy and indispensability." In November of 2021, it approved a ¥774 billion package to boost domestic semiconductor production that included a ¥400 billion subsidy to TSMC for a new foundry in the southern island of Kyushu.

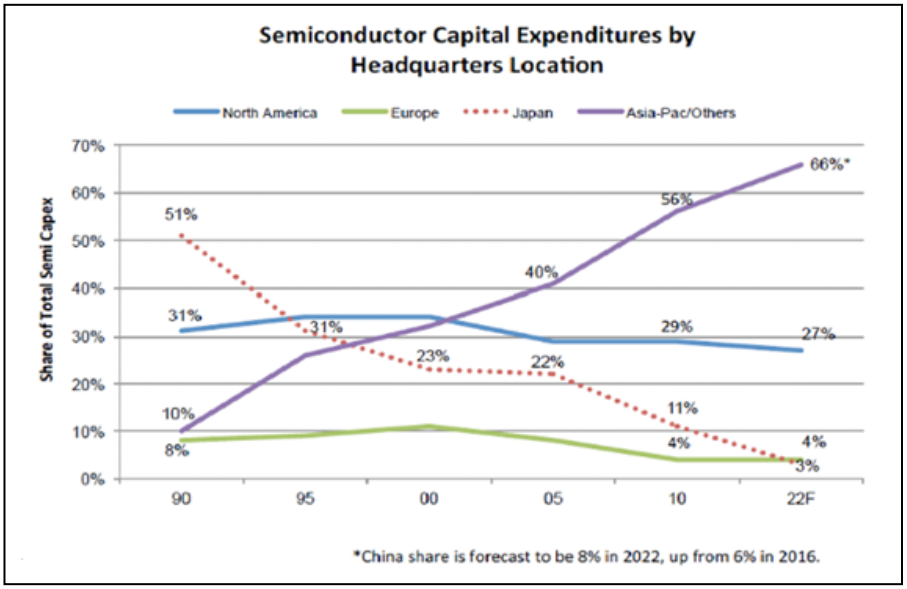

Figure 2: Semiconductor capital expenditure by headquarter locations. SOURCE: IC Insights

Additionally, these seemingly protectionist moves on the part of the U.S., EU, and Japan seem to include a certain level of international cooperation. In May of 2022, President Biden and PM Kishida agreed to explore joint U.S.-Japan development of next-generation semiconductors. In October, there was a "Chip 4" meeting, led by the U.S., which included Taiwan, Japan and South Korea to discuss possible cooperation regarding semiconductor supply chain resilience. These moves toward gaining strategic autonomy in semiconductor manufacturing seem be less of isolated protectionism and effectively more of a "collective and coordinated" protectionism. If done through proper international cooperation, it can create a competitive global landscape that will, in turn, allow healthy progression of technology development and cost competitiveness.

There is nothing fundamentally wrong or immoral about an honest effort to boost the internal manufacturing capability for any nation. Government incentives such as the CHIPS Act are a common way to achieve this boost when significant capital is involved to entice companies to set up domestic manufacturing plants. While the U.S., EU and Japan have newly enacted such subsidies, China has been doing this for almost a decade starting with its 2014 National Integrated-Circuit Plan and Fund, which was endowed with US$150 billion from central and provincial governments. Their latest 14th Five-Year Plan includes significant government focus and funding for the advancement of domestic semiconductor development and production—the Shanghai municipal government alone is supposed to fund RMB 300 billion towards the initiative. China is not alone in providing such subsidies. Last year, South Korea announced tax credits up to 50% of investment in semiconductor research and development creating a US$450 billion investment from local companies.

The third argument that these moves are geopolitically motivated to a large extent is undeniable. Despite all the political rhetoric and trade sanctions, the world finds itself in the awkward position of not being able to ignore the huge China market—the largest market for semiconductors by sales commanding about a 35% share. At the same time, China is not going to sit by idly and will continue to explore ways to catch up. What China has been able to achieve on many fronts in a relatively short period of time is a testament to its national resolve, discipline and ability. It will continue to compete, at least on manufacturing at the lower end of the semiconductor manufacturing technology spectrum. Such products are, and will continue to be, widely used in many applications.

A new era of competitiveness

The new focus on manufacturing through sovereign investment in the U.S., Europe and Japan in the front end, with a similar focus of southeast Asian countries in the back end, along with China's burning ambition to catch up in the technology, could usher in a new level of market competitiveness the world hasn't witnessed in decades. And such healthy competition is always a good thing for innovation and cost-effective solutions that help propel the broader global market economy, and that ultimately, benefits the consumer.

The U.S. effort to impede China's ability to access advanced semiconductor technology is a matter of concern for many nations. Most of the players in the Asia region are playing it "safe" by trying not to displease either superpower to ensure access to both the advanced technologies and the China market. Additionally, many countries in the Asia Pacific region such as Thailand, Malaysia, Philippines, Singapore and Vietnam are likely to reap benefit as companies, worried about future sanctions, may want to start or increase production in these countries, especially in the back-end sectors of assembly and test, so as to diversify away from China. Along this line, India seems to have renewed its ambition to become a major player in the semiconductor manufacturing space, and in a true sense of support, the government is putting money behind its mouth this time around. The country is counting on benefiting from the West's increasing concern on relying too much on China and trying to become a key semiconductor manufacturing hub even though it will take at least a decade, if not longer, to do so. It is telling that, for the first time, some of Apple's iPhone 14s are assembled in India.

Finally, there is the added argument that these efforts to increase domestic manufacturing will be exercises in futility. Today, American core competency lies on the design side, whereas the state-of-the-art semiconductor manufacturing has moved to Asia, specifically Taiwan and South Korea, for advanced wafer nodes, and Southeast Asian nations for back-end assembly and test. It will take the U.S. over two years to catch up with the likes of TSMC and Samsung on the advanced wafer nodes. After letting the semiconductor manufacturing competency slowly erode away starting from the late 90s, the U.S. and Japan now lack the required talent pool to manufacture advanced semiconductors within their shores—this will take years to cultivate. Additionally, the funding required for U.S., EU and Japan to gain back the market share they once had would require substantially more capital than what the CHIPS Act has allocated. For example, the U.S. will have to spend about US$300 billion to get back the 37% market share it once had. Similarly, the EU will require a capital expenditure of US$164 billion to achieve its 20% share of semiconductor production. If these gaps in funding are to be filled from the private sector, the government will need to continually ensure such support. This may prove to be a difficult path if the political interest in achieving these goals starts to wane—one of the risks of democratic societies.

These "CHIPS Act" initiatives by governments already seem to be paying some dividends in terms of ushering in investment from the private sector. Intel, TSMC, GlobalFoundries and Samsung have all announced new wafer fab facilities in the U.S. through the next few years in Ohio, Arizona, Texas, and up-state New York. This includes a 5nm technology fab by TSMC. STMicro and GlobalFoundries just recently signed a memorandum of understanding to build a new fab in Crolles, France at a cost of €5.7 billion. Intel recently unveiled its massive €80 billion investment plan in Europe starting with two fabs in Magdeburg, Germany at a cost of €33 billion. Earlier this year, encouraged by METI's commitment to domestic semiconductor growth, TSMC planned its first ever wafer fab plant in Kumamoto in Kyushu Island, a joint venture with SONY and Denso.

It is not a zero-sum game

It is hard to argue that a certain level of global cooperation will be needed to make these acts and efforts successful and more importantly, sustainable. Market dynamics have led semiconductor manufacturing away from the U.S., Europe and Japan (while they still lead in design) to countries with lower labor costs over the last few decades. An argument can be easily made that this market led economy has produced an "efficient" global supply chain, ultimately benefitting everyone. In an ideal world, cooperation among all nations, each bringing to the table its own key ability and supply chain dynamics is best for the broader society. Even in our non-ideal reality, some level of cooperation is a must to bear fruit from these various efforts akin to the CHIPS Act. Ultimately, all these efforts to gain strategic autonomy cannot ignore the interdependent global order. Pure unilateral approaches will result in over investment, impede true innovation and misallocation of labor and precious resources. The policy makers will do well to consider the global supply chain order and allow a certain level of cooperation to ensure a positive sustainable outcome.

Despite what political leaders across the globe are trying to achieve, at the end of the day, it's not a zero-sum game. There are pockets of competencies that have been developed over decades—both on the technology front and the cost front. To try to reverse that may perhaps prove somewhat futile and lead to an inefficient use of resources. Nevertheless, the political divides we see today are a stark reality. And like everything else, the semiconductor landscape will also have to adjust to it despite the possibility of creating these pockets of inefficiencies for which, ultimately, consumers will end up paying. How these particular government interventions will play out to reshape the semiconductor manufacturing landscape, only time will tell. However, one thing is certain: given the current trajectory, the landscape will be starkly different by the end of the decade from what it is today.

Biography

Asif R. Chowdhury is SVP at UTAC Group, Singapore. He has over 30 years of experience in the semiconductor industry. Before joining UTAC, he held senior positions at Amkor Technology, Chandler, AZ, and Analog Devices, Wilmington, MA. He holds a BS in Mechanical Engineering from U. of Texas at Arlington, an MS in Mechanical Engineering from Southern Methodist U., and an MS in Finance and an MBA from Northeastern U. Asif's first book on the Japanese work culture entitled, "A Gaijin Sarariman," has just been published by Penguin Random House. Email asif_chowdhury@utacgroup.com


UTAC
NOW A BILLION DOLLAR ORGANIZATION
An Investment in Our Future
When you work with us, you can be assured that we are committed to making a positive impact in industry and the environment
CO2 emissions reduced by
37.7 %
(100,000 tons)
over 9 years
Energy Consumption reduced by
19.1 %
(100,000,000kWh)
over 9 years
Water Recycling increased by
96.8 %
over 9 years
Water Consumption reduced by
8.9 %
(500,000 cu.m.)
over 9 years
Singapore | China | Japan | South Korea | Israel | United Kingdom | Switzerland | United States of America
Scan to view our website, utacgroup.com