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How Taiwan Underwrites the US Defense Industrial Complex

Advanced semiconductors play an important role in the defense industry, and Taiwan supplies the lion's share of those chips.

By **Eric Lee**
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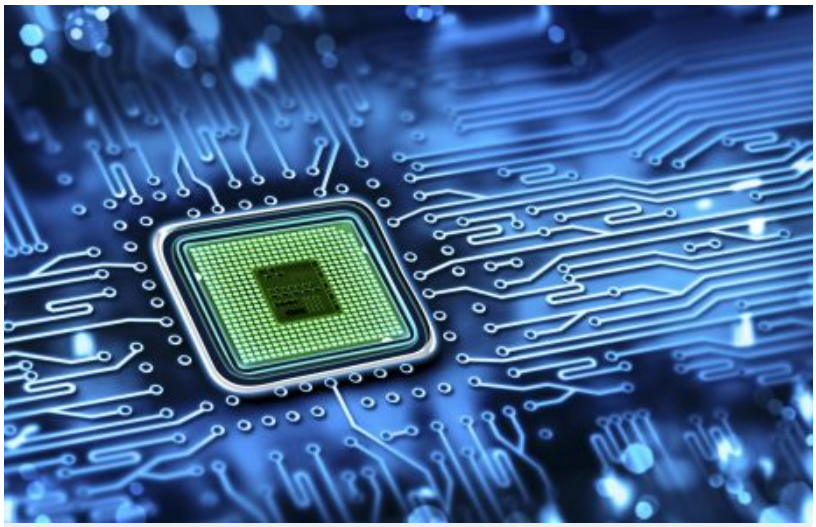

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TSMC-1136
U.S. Patent 8,253,180

Advanced semiconductors play an important role in the defense industry. This is increasingly so as the U.S. military posture relies on relatively few high-quality systems that are underwritten by advanced microelectronics. While supply chain visibility is low, especially in the defense sector, it's clear that semiconductors increasingly provide significant value to complex weapons systems – and that Taiwan provides the steel in the spine for the U.S. defense industrial complex.

Semiconductors for commercial and military applications are not necessarily mutually exclusive. Electronic components in sophisticated military systems use many of the same logic and memory chips that appear in consumer electronics. For example, field-programmable gate arrays (FPGAs) are frequently used in military systems due to their low-cost and high modularity. However, there are military-specific requirements that call for semiconductors with certain features. While commercial chip production is heavily driven by cost and timely, large-scale production, the defense sector's demand for chips emphasizes performance. Namely, military-specific chips must be more durable and reliable, have a higher heat tolerance, and in some cases, be radiation tolerant.

As such, many military-specific chips contain compound semiconductors, which have superior electronic properties such as high electron mobility and direct band gap compared to silicon-only based semiconductors. Specifically, gallium arsenide (GaAs) and gallium nitride (GaN)-based chips appear most frequently in military-specific applications. Radio-frequency integrated circuits (RFICs) and monolithic microwave integrated circuits (MMICs) use GaAs and GaN technologies for a wide range of defense and aerospace uses. These include electromagnetic spectrum operations, signals intelligence, military communications, space capabilities, radars, jammers, and more.

Taiwan plays a central role in global compound semiconductor manufacturing. To illustrate, Taiwan's

WIN Semiconductors holds 9.1 percent of the total GaAs device market share, third in the world behind American firms Skyworks (30.6 percent) and Qorvo (28.6 percent). But in terms of pure-play GaAs foundry revenue, WIN Semiconductors holds by far the largest share at 79.2 percent. The next three firms are Tainan-based AWSC (8.6 percent), California-based GCS (4.2 percent), and Hsinchu-based Wavetek (3.4 percent). Together, the top three Taiwanese firms hold over 90 percent of the GaAs foundry market.

However, the United States has done well to keep critical defense-related compound semiconductor manufacturing onshore and, in many cases, in-house. Many U.S. defense primes, such as Raytheon and Northrop Grumman, and other contractors maintain their own foundries, most of which are certified as trusted suppliers to the U.S. government as part of the Department of Defense's Trusted Foundry Program. An American stronghold over power and analog semiconductor devices is the primary reason why manufacturing in this case has been kept onshore. Drivers in the analog semiconductor market differ from those in digital semiconductors, which are characterized by longer life-cycles and lower capital equipment requirements. These defense-related semiconductors are largely untethered by advancements in the broader commercial market for state-of-the-art capabilities. However, as weapons systems require increasingly advanced chips, U.S. primes may have to lean on Taiwan for compound semiconductor manufacturing in the future.

Yet this reliance would only represent an even larger share of defense-related semiconductor dependencies on Taiwan. While compound semiconductor production has largely been kept onshore, advanced commercial-off-the-shelf (COTS) chips will play an increasingly vital role in weapons systems. For example, a radar system that uses FPGAs for transmit/receive module processing would source from Taiwan, as TSMC is the world's leading manufacturer of these chips. Other devices such as

computer processing units (CPUs), graphics processing units (GPUs), and memory chips at advanced nodes are also mostly manufactured outside of the United States – most notably in Taiwan.

Reliance on Taiwan semiconductor production is due to the emergence of the fabless business model. As fierce competition among U.S. semiconductor firms rose in the 1980s, so did capital equipment costs for fabricating advanced chips. Fabs became more expensive as semiconductor devices got smaller, due to greater requirements for atomically-precise fabrication technology, more expensive manufacturing equipment, and increasingly complex designs. American semiconductor firms found it more efficient to separate design activity from chip manufacturing and even more so to focus on the former. Due to high margins from the fabless model and large capital expenditures associated with maintaining foundries on U.S. soil, many American firms began to outsource manufacturing overseas, most of which went to Taiwan.

Despite current private and public sector efforts in the U.S. to advance domestic semiconductor manufacturing capabilities, American dependencies on Taiwan are unlikely to reduce. That is because immense costs of maintaining and advancing state-of-the-art fabs continue today. TSMC's forthcoming $12 billion Arizona fab costs roughly the same as the U.S. Navy's Ford-class aircraft carrier. At the moment, the U.S. government and semiconductor industry are unwilling to compete on the same footing with Taiwanese investment. While the CHIPS Act, which passed the U.S. Senate and is awaiting markup in the House of Representatives, will allocate $52 billion for domestic semiconductor R&D and manufacturing, TSMC alone intends to spend $100 billion over the next three years in the same areas.

Although the fabless model has surged U.S. tech companies like Nvidia and Apple to the top of the commercial market, it has had significant impacts on the defense sector's supply chain security of semiconductors.

Today, the largest U.S. manufacturer of GaAs semiconductors, Skyworks, while maintaining its own fabs, is to a degree reliant on Taiwan's WIN Semiconductors for its foundry services. The largest producers of FPGAs are American firms Xilinx, Lattice, Intel, and Microchip Technologies, and they all depend on Taiwan in one form or another. While Xilinx invented the FPGA, most of its semiconductor wafers are manufactured by TSMC and UMC, with TSMC being the primary provider for advanced devices.

Taiwanese semiconductors provide critical functionality for advanced U.S. systems such as advanced fighters and ballistic missile defense systems. If requirements for compound chips surpass what Trusted Foundries can provide, Taiwan may soon be the largest provider of both compound and COTS semiconductors to the U.S. defense industrial establishment. Supply chain disruptions during a peacetime environment might not have short-term consequences; however, increased disruptions to production ahead of, and during, war would present a vulnerable chokepoint for American forces. Semiconductor supply chain disruptions in Taiwan would impact production, maintenance, repair, and overhaul at least two to five tiers upstream.

The reality is that the military demand in the semiconductor market is a drop in the bucket. Adhering to market demands, the commercial sector has outpaced national security focused requirements in innovation and cutting-edge technology. Gone are the days of ARPANET; the U.S. defense sector has little say in the direction of semiconductor trends and bases much of its systems on commercially available platforms. Continuing this path, adversaries that have similar access to such technologies could reverse engineer, out-innovate, and reduce American force impacts.

As the U.S. military grows increasingly dependent on American commercial technology firms, who in turn depend on Taiwanese chip manufacturing, a path forward could be to more closely coordinate and integrate

U.S. and Taiwan defense and technology sectors. This could come in the form of a U.S.-Taiwan Senior Level Steering Group for Supply Chain Security and Defense Industrial Cooperation. As defense technologies trend toward more integrated, autonomous, and unmanned platforms, more advanced semiconductors will be increasingly central to weapons systems. The United States and Taiwan would do well to explore co-development and co-production of next generation defense platforms. If the two leading semiconductor powers nurture the development of future commercial applications, this could benefit the evolution of bleeding-edge military technologies.

AUTHORS

GUEST AUTHOR

Eric Lee

Eric Lee is associate director of programs at the Project 2049 Institute.

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