Forecast Analysis: Semiconductor Devices Manufactured With FinFET Technologies, Worldwide

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Initiatives: Technology Market Essentials

The demand increase in PCs, servers and 5G smartphones from the digital economy accelerated by the pandemic drives the use of FinFET technologies. Semiconductor device revenue generated by FinFET will reach $138.6 billion in 2025, up from $87.6 billion in 2020.

Additional Perspectives

- Invest Implications: Forecast Analysis: Semiconductor Devices Manufactured With FinFET Technologies, Worldwide
  (26 August 2021)

Overview

Forecast Assumptions

- To meet the increased performance requirements from workloads, all devices in data centers will utilize fin field-effect transistor (FinFET) technologies by 2025, up from 95% in 2020.
- Demand for premium features and lower technology costs will drive 100% adoption of FinFET-based systems-on-chip (SoCs) in all smartphones by 2025, up from 80% in 2020.
- The number of foundries/integrated device manufacturers (IDMs) supplying FinFET technologies will increase to seven in 2025, up from six today, with an estimated $65 billion total budgeted in capital spending per year.

Market Impacts

- Chip revenue for microprocessors for computation manufactured with FinFET technologies will increase from $48.3 billion in 2020 to $55.4 billion in 2025.
- From 2020 through 2025, revenue for SoCs based on FinFET technologies for premium smartphones will grow from $28.1 billion to $42.8 billion.
- As the competition by major manufacturers in the bleeding-edge technologies becomes intensive, the market share leader will be the one capable of delivering volume production at high yield early.

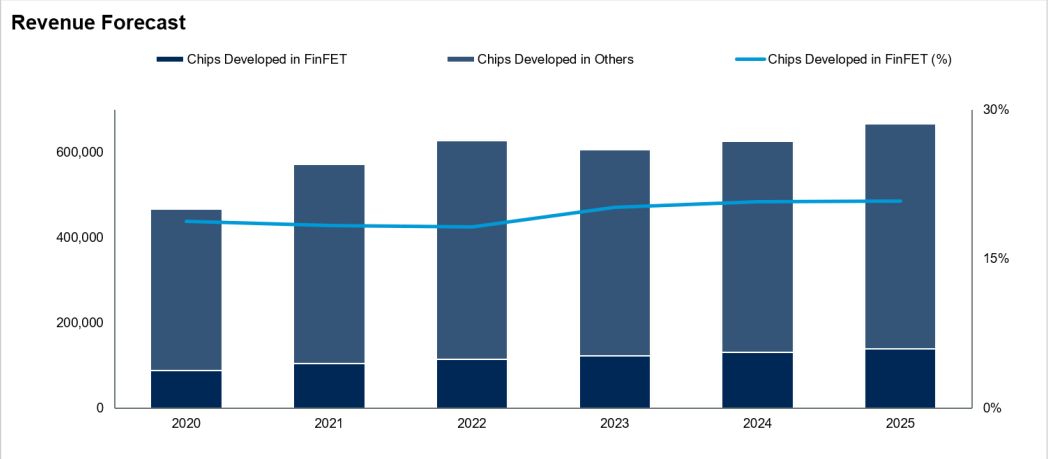
Notable Changes

The revenue generated by FinFET technology shown in this report has been revised upward from its previous 2020 version. The change is based on the latest data reported in Semiconductor Forecast Database, Worldwide, 2Q21 Update and Forecast: Semiconductor Foundry Revenue and Supply and Demand, Worldwide, 2Q21 Update. For more details about the forecast methodology used to create these documents, please see Market Definitions and Methodology: Semiconductor Devices and Applications and Market Definitions and Methodology: Semiconductor Foundry Services.

Forecast Data Summary

Based on the 2Q21 forecast update of the electronics and semiconductor industry by Gartner, the semiconductor device revenue generated by FinFETs from 2020 through 2025 is shown in Figure 1.

Figure 1: Forecast Revenue for Semiconductor Devices Processed Using FinFET Technology Versus Planar Technologies (Memory Revenue Removed), Worldwide, 2020-2025 (Millions of U.S. Dollars)



Gartner

Source: Gartner (August 2021)

Table 1 shows the addressable market for major semiconductor device types developed in FinFET technology.

Table 1: Forecast Revenue for Semiconductor Devices Manufactured Using FinFET Technology by Device Type, 2020-2025 (Millions of U.S. Dollars)

(Enlarged table in Appendix)

Device Type	2020	2021	2022	2023	2024	2025	CAGR 2020-2025
Microprocessor, Compute	48,267	50,656	51,207	52,887	53,392	55,338	2.8%
Integrated Baseband/Application Processor	8,542	12,335	14,177	16,550	18,894	20,338	18.9%
Discrete GPUs	5,668	7,051	8,109	9,042	9,842	11,350	14.9%
Discrete Application/Multimedia Processor	6,419	8,793	9,523	9,645	10,175	10,446	10.2%
Wireless Connectivity (NFC, Wi-Fi, BT, GPS, Combo)	3,755	4,736	5,405	5,896	6,349	6,942	13.1%
Discrete Cellular Baseband	3,401	4,099	3,926	3,644	3,290	3,146	-1.5%
Wired Connectivity (All Interface Functions and Controllers)	3,624	6,558	8,773	9,876	10,601	11,884	26.8%
Others	7,902	10,531	12,883	14,477	17,299	19,133	19.3%
Total	87,579	104,760	114,001	122,016	129,841	138,578	9.6%

FPGA = field-programmable gate array; GPS = Global Positioning System; GPU = graphics processing unit; NFC = Near Field Communication; Wi-Fi = Wireless Fidelity

Source: Gartner (August 2021)

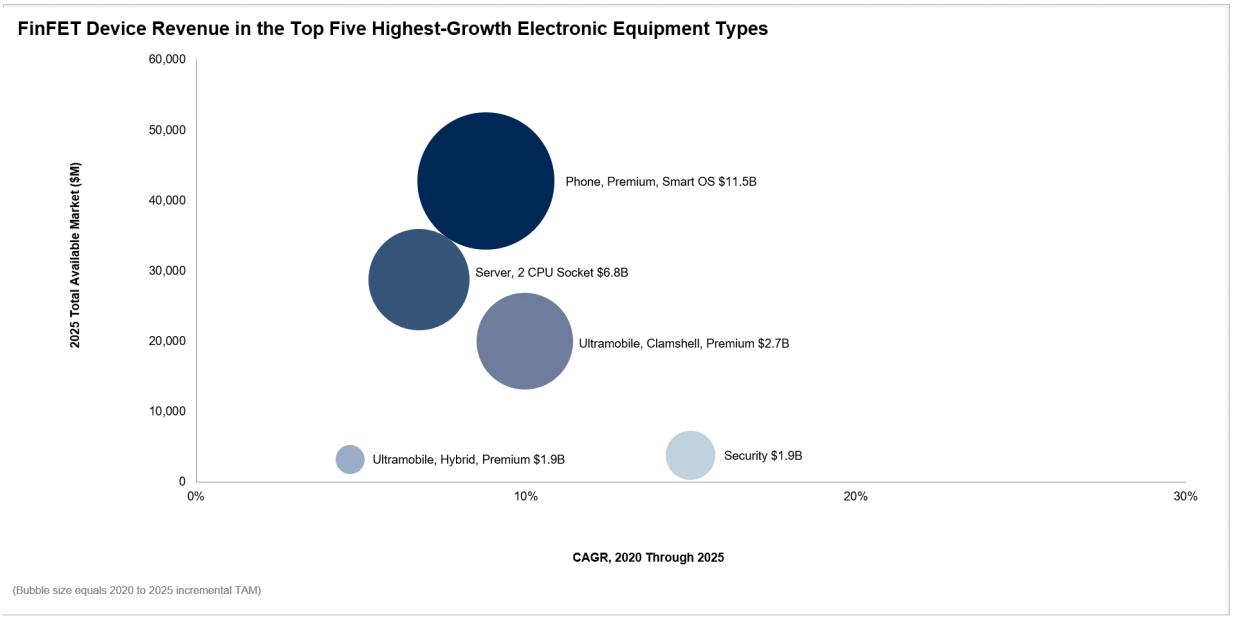
FinFET as a Key Semiconductor Manufacturing Technology

This Forecast Analysis provides an update to the FinFET forecast that was published in 2020. FinFET is considered by Gartner as a critical semiconductor manufacturing technology for vendors to gain future market access. Technology service providers at semiconductor vendors should plan to leverage the information provided when developing new products and wanting to win business in the major growth electronic equipment types. Figure 2 and Table 2 show revenue for FinFET devices targeted for utilization in the top five electronic equipment types, per Gartner's Semiconductor Forecast Database, Worldwide, 2Q21 Update. "Other" represents the remaining 15 opportunities in the top 20 equipment types.

For the purpose of clarification, FinFET technologies in this article do not include memory technologies nor legacy processes of wider than 22 nm geometries. By 2023, Gartner estimates that gate-all-around (GAA) logic technology could be developed by some manufacturers when geometry is scaled down to 3 nm. However, it is evident from TSMC's technology roadmap that FinFET will be applied in 3 nm, and also, GAA is considered as an extension of the FinFET technology in this article.

The FinFET semiconductor revenue opportunities from 2020 to 2025 generated by the top five highest-growth electronic equipment types are shown in Figure 2.

Figure 2: FinFET Revenue in the Top Five Highest-Growth Electronic Equipment Types



Source: Gartner (August 2021)

Table 2: Forecast Semiconductor FinFET Device Revenue for the 20 Highest Incremental Growth Opportunities (Memory Revenue Excluded), Worldwide, 2020-2025 (Millions of U.S. Dollars)

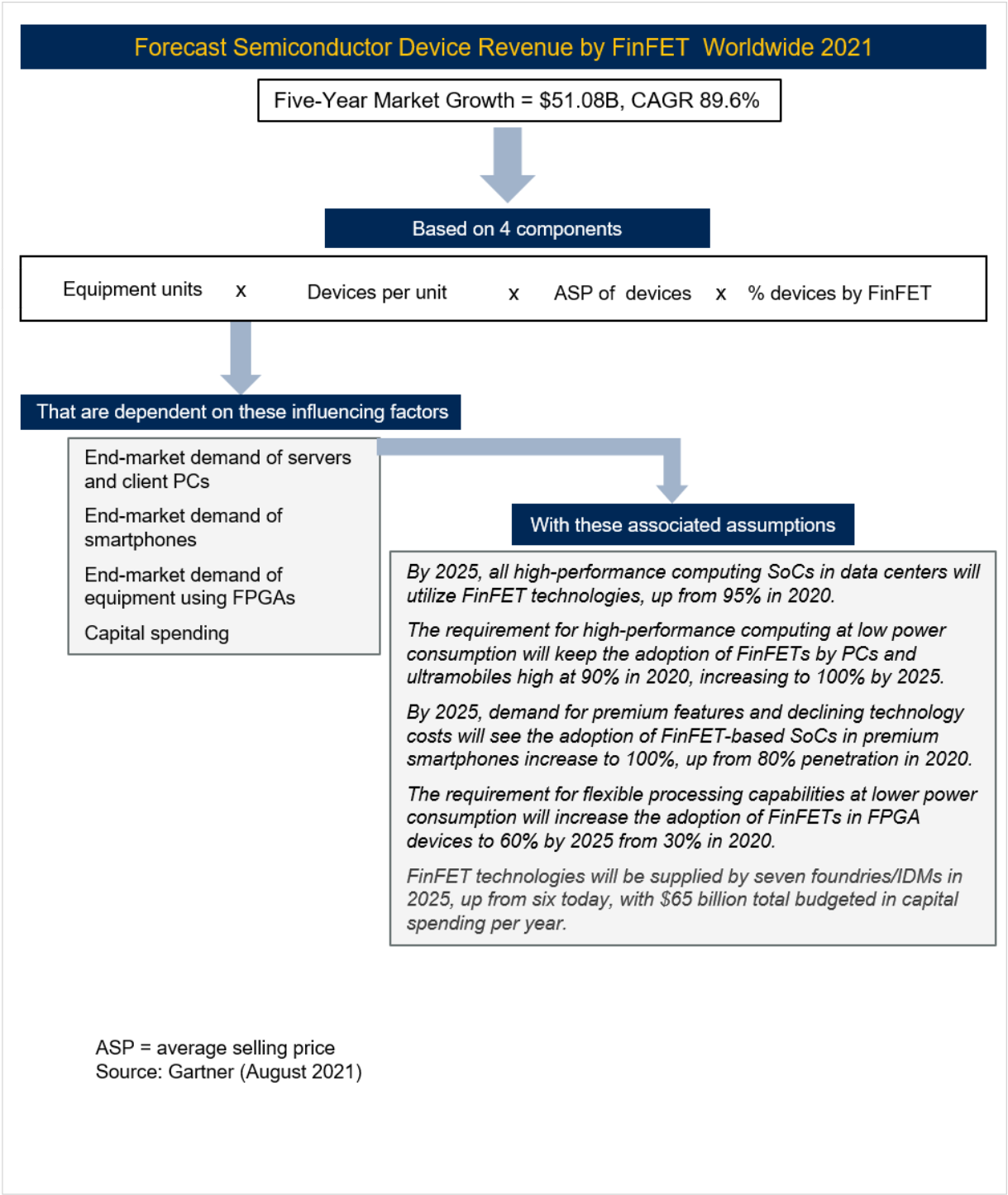
Equipment	2020	2021	2022	2023	2024	2025	CAGR 20-25
Phone, Premium, Smart OS	28,078	36,598	40,321	40,199	40,771	42,772	8.8%
Server, 2 CPU Socket	20,751	22,270	24,146	26,003	27,429	28,775	6.8%
Ultramobile, Clamshell, Premium	12,455	15,953	17,566	18,096	19,087	20,023	10.0%
Ultramobile, Hybrid, Premium	2,541	3,224	3,436	3,173	3,042	3,192	4.7%
Security	1,877	2,316	2,876	3,429	3,597	3,774	15.0%
Remaining 15 Top Equipment Types	1,868	2,075	2,218	2,317	2,445	2,565	6.5%
Total, Top 20 Equipment Types	67,571	82,437	90,563	93,216	96,371	101,101	8.4%

Source: Gartner (August 2021)

Forecast Model Summary

Figure 3 shows our market model for the worldwide FinFET device revenue forecast. The market model and methodology are detailed below.

Figure 3: Market Model for FinFET Device Revenue Forecast



Influencing Factors and Assumptions

Gartner's 2Q21 semiconductor device forecasts have reflected the growing demand and increasing relevance of semiconductors across a variety of applications and industry verticals due to the COVID-19 pandemic. Semiconductor industry revenue for 2021 is now projected to grow by 22.4% to reach $570.8 billion, an increase of $25.7 billion from the 2Q21 forecast. Both are significantly higher than projected at the beginning of COVID-19 lockdown. This was driven by higher demand for notebook computers, higher smartphone ASPs with transition to 5G, and an inventory buildup in response to the U.S.-China trade issues. With strong overall demand and ongoing chip shortages, fabs worldwide have drastically raised their spending budget to increase the production capacity.

> **Influencing Factor: End-Market Demand From Data Centers and PCs**
>
> The end market dictates the semiconductor business in wafer unit demand, wafer prices and technology requirements. As the digital economy is accelerated by the pandemic, work from home continues and factory automation becomes more adopted, more PCs and data centers will be required.

Forecast Assumption: By 2025, all high-performance computing SoCs in data centers will utilize FinFET technologies, up from 95% in 2020.

Forecast Assumption: The requirement for high-performance computing at low-power consumption will keep the adoption of FinFET by PCs and ultramobiles high at 90% in 2020, increasing to 100% by 2025.

Updated — To meet the ever-increasing processing demand from new software workloads for the new 5G era, vendors must transition their semiconductor devices to the latest-generation FinFET-based technologies. These transitions are driven not only by the need for the increased performance that results from faster-switching transistors, but also increased transistor density that enables microarchitectural enhancements, yielding significant performance increases. Microprocessing unit (MPU) and GPU vendors must closely track the semiconductor process transitions and optimize their designs for the latest-generation processes.

The majority of Intel's processor product lines have migrated to 10 nm FinFET, with 7 nm under development. Meanwhile, AMD, with its Zen microarchitecture devices (Ryzen and EPYC), has already migrated its MPU product lines to 5 nm FinFET manufactured by TSMC. While MPUs scale their performance by means of transistor switching speed and architectural enhancements, GPUs scale by increasing the number of processing elements that can be implemented within a given die area. For this reason, the major GPU vendors (NVIDIA, AMD and now Intel) are also rapidly transitioning their devices to latest-generation 5 nm FinFET-based processes. In its latest IDM 2.0 business strategy, Intel has mentioned expanding its wafer outsourcing to foundries; both the GPU and CPU will be manufactured by TSMC's 5 nm and 3 nm nodes starting in 2021 and 2022, respectively. As such, FinFET adoption in data processing will reach saturation by 2025, when all MPUs and GPUs will be manufactured by FinFET structure.

> **Influencing Factor: End-Market Demand From Smartphones**
>
> Early users of the most bleeding-edge process technologies have been the chip designers enhancing the performance of smartphones. Many of the features delivered by premium smartphones are made possible only by adopting FinFET-based SoCs. As the popularity of 5G smartphones continues to grow, the use of FinFET technologies increases in future years.

Forecast Assumption: By 2025, demand for premium features and declining technology costs will see the adoption of FinFET-based SoCs in premium smartphones increase to 100%, up from 80% penetration in 2020.

Updated — Momentum is evident from the adoption of 7 nm and 5 nm FinFET to 4 nm from foundries by smartphone makers. As such, Gartner expects all application processors for premium smartphones will be manufactured using FinFET technology in 2025. But due to the low cost consideration, some application processors used in basic- and utility-tier smartphones have remained on 14 nm FinFET or 28 nm planar and coarser geometries. As new features are continuously added to smartphones, a quick adoption of the FinFET process to manufacture these new application processors, even for nonpremium smartphones, will be unavoidable. By 2025, all premium smartphones will have adopted FinFET technologies in the application processors.

> **Influencing Factor: End-Market Demand From FPGAs in Equipment**

> Due to cost considerations, the adoption of FinFET technologies for FPGA applications has been a more gradual process than for premium smartphones, PCs and data centers. But over time, more FinFET-based FPGAs will be required by end users in high-performance applications.

Forecast Assumption: The requirement for flexible processing capabilities at lower power consumption will increase the adoption of FinFETs in FPGA devices to 60% by 2025 from 30% in 2020.

Updated — These new workloads are evolving, and often, the algorithms and equipment functionality need to be updated after initial deployment. This drives a need for flexible hardware solutions that can be reconfigured after deployment. For many developers, field-programmable gate arrays (FPGAs) provide the ability to design high-performance complex logic functionality into their equipment without the need to commit to an expensive application-specific integrated circuit (ASIC) development. Large-scale FPGAs are available with millions of logic elements and also the option of integrated processor cores. These FPGA designs leverage latest-generation FinFET technologies to achieve the required logic density and enable developers to design the highly complex systems necessary to manage 5G base stations or to implement neural networks for sophisticated AI applications.

> **Influencing Factor: Capital Spending by Foundries and IDMs**
>
> Even though the required investment in technology development and capacity installation is expensive on FinFET technologies, large foundries and integrated device manufacturers (IDMs) are expected to invest heavily in FinFET in order to win market share.

Forecast Assumption: The number of foundries/IDMs supplying FinFET technologies will increase to seven in 2025, up from six today, with an estimated $65 billion total budgeted in capital spending per year.

Updated — FinFET production technologies were first introduced in 2011 by Intel in its 22 nm FinFET (Tri-Gate) technology as a solution to the short channel effects challenging the scaling of planar transistors. Intel subsequently transitioned to 14 nm in 2014 and 10 nm in 2019. Similar FinFET production was offered by TSMC and Samsung in early 2015 with 16 nm/14 nm technologies, and now TSMC's 4 nm process has become production-ready. Although FinFET technology was also used by GLOBALFOUNDRIES and UMC in 14 nm, these two vendors have decided not to pursue the 7 nm node due to the technology challenges and heavy investment. The leading Chinese foundry company SMIC started its 14 nm FinFET in 4Q19 and will continue to migrate down to the N+1 and N+2 nodes, its naming for 8 nm-like and 7 nm-like nodes. With this, FinFET technology migration beyond 14 nm is currently only being pursued by four vendors: Intel, TSMC, Samsung and SMIC. One other Chinese foundry, Huali, has claimed to get its 14 nm FinFET technology developed by 2021. By 2025, the list of FinFET manufacturers could have seven companies: Intel, TSMC, Samsung, GLOBALFOUNDRIES, UMC, SMIC and Huali.

TSMC has disclosed that over the three-year time frame, it will invest $100 billion in capital expenditure (capex), mostly on the advanced technology and production expansion. Samsung is expected to allocate 40% to 50% of its annual $30 billion capex investment also on advanced logic technology. Intel in its several 2021 events has disclosed that its capex budget will be about $20 billion a year. Among these top players, the capex spending will be about $85 billion a year including the spending on advanced process technology, advanced packaging technology and others. The estimated capex just on the FinFET wafer technology can be $65 billion a year. The race of technology development continues, and the market share leader is the one that is the first in bringing the most bleeding-edge process technology to volume production at high yield.

Document Revision History

Forecast Analysis: Semiconductor Devices Manufactured With FinFET Technologies, Worldwide - 9 September 2020

Forecast Analysis: Semiconductor Devices Manufactured With FinFET Technologies, Worldwide - 6 September 2019

Recommended by the Author

Some documents may not be available as part of your current Gartner subscription.

Market Definitions and Methodology: Semiconductor Foundry Services

Forecast Analysis: Semiconductor Devices Manufactured With FinFET Technologies, Worldwide

Semiconductor Forecast Database, Worldwide, 2Q21 Update

Forecast: Semiconductor Foundry Revenue, Supply and Demand, Worldwide, 2Q21 Update

Forecast Analysis: Semiconductor Foundry Services, Worldwide

Forecast Analysis: Electronics and Semiconductors, Worldwide

Market Insight: Advanced Packaging Technology Will Create a New Business Model for Semiconductor Manufacturing

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