Forecast Analysis: Semiconductor Foundry Services, Worldwide

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Initiatives: Technology Market Essentials

The chip shortage has led chip vendors to sign multiyear contracts with foundries. Foundry revenue will grow by 22.6% to reach $95.0 billion in 2021, followed by 11.9% growth in 2022. Elevated capital spending will result in oversupply in 2024 and 2025 as the fab utilization rate dips below 80%.

Overview

Forecast Assumptions

- COVID-19-induced supply-chain uncertainties and national security concerns have led the U.S., European Union (EU) and South Korea individually to provide subsidies and tax breaks to invest at least $150 billion over the next 10 years in domestic chip manufacturing.

- Wafer purchase agreements with chip customers will provide foundries a 10.1% increase in the blended average selling price (ASP) to $1,112 per 200 mm equivalent wafer in 2021. The blended ASP will increase 4.5% in 2022.

- Capital expenditure (capex) of foundries will be $50.8 billion and $57.4 billion in 2021 and 2022 at 48.7% and 13.0% growth, respectively, assuming the spending will not be bottlenecked by the supply of equipment, raw wafers and materials.

- Demand will fall short of capacity expansion during 2024 and 2025, causing the foundry utilization rate to drop below 80% from 94% now.
Market Impacts

- Foundries will leverage the incentives provided by various governments to expand their production manufacturing to different countries.
- A chain reaction of price inflation in the supply chain will shape up as upstream raw wafer and material vendors will only invest in production expansion after foundries agree to sign long-term purchase agreements.
- As foundries enjoy another good year in 2021 with 22.6% revenue growth, many will step up expansion plans by leveraging the prepayments from customers.
- The tightness of 200 mm foundry supply will continue while an excess supply of 300 mm wafers on mature nodes, 28 nm to 90 nm, will be a concern in 2024 and 2025 due to the capex overinvestment in 2021 and 2022.

Notable Changes

The current 3Q21 foundry forecasts reflect the growing demand for and increasing relevance of semiconductors across a variety of applications and industry verticals. Semiconductor industry revenue for 2021 is now projected to grow by 26.9% to reach $591.4 billion, an increase of $20.6 billion from the 2Q21 forecast. The nonmemory segment of the semiconductor industry will grow by 23.7% to reach $422.6 billion, an increase of $17.7 billion from the previous forecast. The increases are driven by higher chip selling prices, demand from enterprise PCs and data centers, and recovery in the automotive sector as trends like vehicle electrification and autonomy drive chip revenue growth. With strong overall demand, highly utilized capacity and a continuous component shortage, foundries have stepped up capital investment further in 2021 when capital expenditure (capex) will grow by 48.7% to reach $50.8 billion.

The supply-demand pictures will vary between different nodes in the foundry industry. Strong competition in mature-node technologies, 28 nm to 90 nm, is expected as many foundries are adding new 300 mm capacity. An oversupply of such wafers is projected in 2024 and 2025 as the result of aggressive investment in 2021 and 2022. In the bleeding-edge technologies of 7 nm and finer nodes, the foundry competition will continue to be limited to three players: TSMC, Samsung and Intel. The winner will be the one that can consistently provide high yield in high-volume production. In the 200 mm foundries, the tight supply problem will not be resolved soon because most of the capacity expansion will be in China. Many U.S. customers will be restricted from using such Chinese foundry services due to the trade war.
This document estimates the revised revenue and associated five-year compound annual growth rate (CAGR) for the semiconductor foundry market. The 3Q21 difference relative to our 2Q21 forecast is based on the following changes:

- Foundry revenue in 2021 is revised up to 22.6% year-over-year growth, up from the previous 16.6% forecast.
- The fab utilization rate in 2021 will hold up at 94.3% and will decline in 2022 to 90.3% which is higher than the previously projected 84.9%.
- Foundry capex in 2021 is revised up by $2.2 billion from our previous forecast to reflect the foundries’ more aggressive investment strategy.

Gartner updated the constant currency regime to a new base year of 2020. Data reported in constant currency now uses the 2020 U.S. dollar exchange rates as the base value (2020 as base year) to convert other currencies, instead of the 2013 exchange rates as the base value (2013 as base year) used in previous iterations.

For more details about the forecast methodology used to create the report, please see Forecast: Semiconductor Foundry Revenue, Supply and Demand, Worldwide, 3Q21 Update, and Market Definitions and Methodology: Semiconductor Foundry Services.

**Forecast Data Summary**

Figures 1 and 2 show the semiconductor foundry revenue by segment and the forecast for 2020 through 2025. Table 1 compares the updates from the 2Q21 forecast to the current, 3Q21 forecast.
Figure 1: Semiconductor Foundry Revenue, Worldwide

Semiconductor Foundry Revenue, Worldwide

- Worldwide Market Revenue, 2025 = $121.01 Billion
- Five-Year Market Growth = $43.5 Billion (CAGR 9.3%)

Source: Gartner (October 2021)
Figure 2: Semiconductor Foundries, Worldwide Revenue Growth by Device Type

Semiconductor Foundries, Worldwide Revenue Growth by Device Type

Growth, 2021

ASIC = application-specific integrated circuit; ASSP = application-specific standard product; MCU = microcontroller unit; PLD = programmable logic device.

Note: The size of each bubble represents 2020 foundry revenue by device segment in current U.S. dollars.

Source: Gartner [October 2021]
Table 1: Comparison of the 2Q21 and 3Q21 Forecast Data
(Enlarged table in Appendix)

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Source: Gartner (October 2021)

**Forecast Model Summary**

Figure 3 summarizes the influencing factors and forecast assumptions used in the forecast.
Figure 3: Market Model for Semiconductor Foundry Forecast, 3Q21

Market Model for Semiconductor Foundry Forecast, 3Q21

Forecast Semiconductor Foundries 3Q21 Worldwide

Five-Year Market Growth = $43.5B, CAGR 9.3%

Based on four components

Wafer Demand + Technology Demand / Wafer Shipments x Wafer Prices

That are dependent on these Influencing Factors

Macroeconomic Conditions
Foundry Pricing and Profitability
Foundry Capital Spending
Foundry Supply-and-Demand Balance

With these associated assumptions

- COVID-19-induced supply chain uncertainties and national security concerns have led the U.S., EU and South Korea individually to provide subsidies and tax breaks to invest at least $150 billion over the next 10 years in domestic chip manufacturing.
- Wafer purchase agreements with chip customers will provide foundries a 10.1% increase in the blended ASP to $1,112 per 200 mm equivalent wafer in 2021. The blended ASP will increase 4.5% in 2022.
- Capex of foundries will be $50.8 billion and $57.4 billion in 2021 and 2022 at 48.7% and 13.0% growth, respectively, assuming the spending will not be bottlenecked by the supply of equipment, raw wafers and materials.
- Demand will fall short of capacity expansion during 2024 and 2025, causing the foundry utilization rate to drop below 80%.

Source: Gartner (October 2021)
Influencing Factors and Assumptions

The chip shortage in effect since late 2019, caused by the rise of 5G smartphones, the U.S.-China trade war, the COVID-19 pandemic and the inventory buildup, has caused the increase of chip and foundry wafer prices. As the chip crisis is expected to last through the middle of 2022, long-term purchase agreements have been signed by suppliers and customers across the entire semiconductor supply chain. Foundries are aggressively expanding their capacity hoping to ease up the supply shortage issue earlier, while incentives offered by various nations to encourage investment in local semiconductor manufacturing capability add to the reasons for record high capital spending by fabs. The forecast of foundry revenue, capex, capacity, shipments and wafer ASPs have all been adjusted upward in this 3Q21 forecast.

Influencing Factor: Macroeconomic Conditions

Overall macroeconomic conditions include factors that relate to a larger aspect of the economy, such as geopolitical issues, import duties, inflation, investment, gross domestic product and unemployment. These factors govern the dynamics of semiconductor supply and demand and, hence, foundry capacity expansion.

Forecast Assumption: COVID-19-induced supply-chain uncertainties, technology sovereignty, and national security concerns have led the U.S., European Union (EU) and South Korea to consider acts for providing subsidies and tax breaks to encourage domestic chip manufacturing.

Chip shortages and supply chain uncertainties due to the U.S.-China trade war have exposed the strong reliance on Asia for foundry manufacturing. Gartner's report, Taiwan Is a Potential Chokepoint for the Global Electronics Supply Chain, discusses potential risks with this dependence. As a result, the Biden administration in the U.S. initiated a supply chain resilience review of electronics for critical industries in the U.S., and there has been a growing sentiment to support domestic chip manufacturing in the U.S. and EU. The U.S. Senate has approved a bill authorizing $190 billion of public money for new technology, including $52 billion on chips.
The same holds true for the EU, which under the COVID-19 economic recovery package, has already pledged $150 billion to a Digital Compass initiative that will improve its digital infrastructure and digital skills. Their goal is to produce at least 20% of the world's semiconductors by 2030 in the EU, up from 10% last year. South Korea has said it will spend $451 billion over the next decade by combining public and private investment to become a semiconductor manufacturing giant. China has continued to invest heavily to catch up at the same time as sanctions impact its access to chip technology, as well as advanced fab equipment.

**Influencing Factor: Foundry Capital Spending**

With the desire to win market share and leverage the incentives from governments, foundries’ heavy investment in fab equipment will continue in future years.

**Forecast Assumption: Capex of foundries will be $50.8 billion and $57.4 billion in 2021 and 2022 at 48.7% and 13.0% growth, respectively, assuming the spending will not be bottlenecked by the supply of equipment, raw wafers and materials.**

Due to the continued chip shortage, strong demand from high-performance computing, increased 5G smartphones, the increased business from integrated device manufacturers (IDMs) and incentives from government policies, foundries are stepping up the capital spending in fab expansion to win market share. Total foundry spending is expected to make a new record in both 2021 and 2022.

As the equipment is most expensive in the bleeding-edge processes and future technology migration will rely much on advanced packaging technologies, the highest capital spending will be from three players — TSMC, Samsung and Intel — on wafer production of 7 nm and finer nodes plus investment to 2.5D and 3D system-in-package (SiP) technology. In the mature nodes, 28 nm to 90 nm, the higher capital spending will be from TSMC, GF, UMC, SMIC, Powerchip Semiconductor Manufacturing Corp. (PSMC), Huahong Grace, Huali Microelectronics, GTA Semiconductor and China Resources Microelectronics (CR Micro).
Not included in the fab capacity of our current foundry data are several other unconfirmed new fab projects, such as the two 300 mm fabs at Kaohsiung in Taiwan by TSMC, which is also evaluating new fab feasibility in Japan and the EU; Samsung's new U.S. fab project in Williamson County, Texas; and SMIC's Shenzhen and Beijing 300 mm fabs. Had all these fabs become reality, the capex investment will need to be raised even higher. In the opposite scenario, if the supply of raw wafers, semiconductor materials and fab equipment becomes a bottleneck for any reason, such as the recent power crisis in China that disrupted chemical production, foundries would adjust and lower their capex spending.

**Influencing Factor: Profit Margin and ASP**

In easing up the cash flow due to higher capex budgets, foundries have requested upfront deposits from customers in signing up their multiyear wafer agreements. In addition, wafer price increases have been announced by most foundries for future purchases in lifting up their profit margin.

**Forecast Assumption: Wafer purchase agreements with chip customers will provide foundries a 10.1% increase in the blended average selling price (ASP) to $1,112 per 200 mm equivalent wafer in 2021. The blended ASP will increase 4.5% in 2022.**

In the last several months, foundries have been openly discussing the higher wafer price strategies to boost their revenues and profit margins. More than three foundries are aiming for more than 40% revenue growth in 2021, while most foundries are targeting more than 20% growth. Such astonishing growth will only be achievable through a combination of raised wafer prices and selection of customers in high-margin products.

For the rest of 2021 and 2022, foundries’ business is pretty much guaranteed as fabless customers have signed multiyear wafer purchase agreements accompanied by interest-free loans or deposits. One example is the case of UMC, which has signed prepayment with eight customers (Mediatek, Novatek, Richtek, Himax, Yili, Phison, Samsung and Qualcomm) to have secured a total $100 billion New Taiwan Dollars. Each of these customers will be able to receive allocated wafers when the UMC Fab12A P6 is in production by 2023. Many other fabless companies felt to have missed this UMC deal have made similar prepayment to other foundries (PSMC, GF and VIS) in supporting their fab expansion projects.
Due to the lifted wafer prices at foundries and the long-term agreements signed with customers, the blended wafer ASP will be 10.1% higher in 2021 than 2020, and an additional 4.5% increase is projected for 2022. These percentages are to compare with the historical norm of less than 3% over the last decade, when the wafer prices were expected to get reduced year over year. The only way to increase blended wafer prices was to ship more-advanced wafers with higher prices.

Influencing Factor: Foundry Supply-and-Demand Balance

The imbalance of supply and demand will turn the chip shortage situation of 2021 into oversupply in early 2024.

Forecast Assumption: Demand will fall short of capacity expansion in 2024 and 2025, causing the foundry utilization rate to drop below 80% from 94% now.

As the capacity of bleeding-edge technologies is increased by TSMC, Samsung and Intel, the capacity for mature nodes (28 nm to 90 nm) will be expanded by most foundries not in the game of advancing nodes to 7 nm. Our assumption is that the demand increase will fall short of the capacity expansion, price competition on such mature nodes could become severe, and the fab overall utilization rate will drop below 80% in early 2024.

The tightness of 200 mm fabs will remain while the oversupply happens in the 300 mm fabs. Foundries invest heavily in advanced equipment, resulting in a 300 mm capacity increase from 19.1 300 mm million wafers a year in 2020 to 31.6 million wafers in 2024 at 66% growth. During the same time frame, 200 mm capacity has increased from 35.1 million 200 mm wafers a year to 44.5 million at 27% growth.

Most of the 200 mm capacity will be in China, where more used 200 mm equipment was obtained in the last few years and new equipment will be built by local Chinese equipment companies. Due to concern of further interruption of the U.S.-China trade, not all global customers will like to use these added 200 mm Chinese fabs in easing up the tight supply of 200 mm wafers in future years.

Document Revision History

Forecast Analysis: Semiconductor Foundry Services, Worldwide - 27 July 2021
Forecast Analysis: Semiconductor Foundry Services, Worldwide - 3 May 2021
Forecast Analysis: Semiconductor Foundry Services, Worldwide - 26 October 2020
Forecast Analysis: Semiconductor Foundry Services, Worldwide - 20 July 2020
Forecast Analysis: Semiconductor Foundry Services, Worldwide - 23 April 2020

Recommended by the Author

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Semiconductor Forecast Database, Worldwide, 3Q21 Update
Forecast: Semiconductor Foundry Revenue, Supply and Demand, Worldwide, 3Q21 Update
Conventional Wisdom of Semiconductor Leaders Will Be Challenged by the COVID-19 Epidemic
Market Trends: China's STAR Market Boosts Domestic Semiconductor Industry
Market Definitions and Methodology: Semiconductor Foundry Services

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