Chips Are Not the Same

How do we differentiate between the semiconductor companies we buy as investments?

Brenda Bloch-Young, OLLI Summer 2022

F202/F202Z Investing Potpourri, July 7, 2022

Semiconductor / chip industry

Source: Statista

How much is the semiconductor industry worth?

$452.25 billion

The market is projected to grow from $483 billion in 2022 to **$893 billion** in 2029 at a CAGR of 9.2% during the 2022-2029 period.

YTD Performance

(Hint - not good)

- SMH - VanEck Semiconductor ETF tracks a market-cap-weighted index of 25 of the largest US-listed semiconductors companies.

PERFORMANCE [as of 06/30/22]	*1 MONTH*	*3 MONTHS*	*YTD*	*1 YEAR*	*3 YEARS*	*5 YEARS*	*10 YEARS*
SMH	-16.70%	-24.49%	-34.02%	-21.89%	23.79%	21.46%	21.94%

Some very basic information on semiconductor companies

What do they actually do?

- Foundry - a facility that melts metals in special furnaces and pours the molten metal into molds to make products. TSMC is the largest in the world, Samsung is second, Global Foundries (spun off from AMD several years ago) is 4th or 5th depending on the resource used.
- Fab - a factory where devices such as integrated circuits are manufactured. TSMC is both a foundry and a fab as an example as it fabricates the M1 chip for Apple.
- IDM / Integrated Device Manufacturer - Intel is a good example here as it is a foundry, a fab, and designed it's own chip, the x86, that had been used in most computers until the last few years.
- Design (and supporting software) - Nvidia and AMD do not manufacture their chips

Differentiation by process in chips

- **Fabless semiconductor companies** and **electronics manufacturers** (and independent design companies) create the design and specifications required for their chips.
- **Foundries** are contracted to manufacture the designed chips.
- **OSAT (outsourced semiconductor assembly & test)** companies assemble, package, and test the chips for consumption. ASE Global is the market leader in assembly and testing services, capturing 30% of the global OSAT market in 2021.
- **OEM (original equipment manufacturers)** and contracted **EMS (electronics manufacturing service)** companies integrate the packaged chip into devices. ASE Global is also a leading EMS provider, and over the course of the company's history, has helped manufacture more than three trillion chips.
- Devices are then sold by the **fabless companies** and **electronics manufacturers** at the start of the chain.

Considerations by end users

What chip do we need?

- Speed
- Cost
- Task specialized
- Power usage
- Matching the chip to the component

Functional classification

A pure insulator or a pure conductor?

- Basically, there are 3-4 categories
- Memory chips
- Microprocessors
- Standard chips (commodity chips)
- Complex systems-on-a-chip (SoCs)
- Based on the type of integrated circuitry used, chips can be categorized into 3 types - analog, digital, and mixed

Functional classification explanations

Chip providers have different end users

- Memory chips store data and programs
- RAM (random-access memory) provide temporary workspaces whereas flash memory holds information until it is erased
- Microprocessors contain one or several CPUs (those used in PCs or servers today are based on the x86, POWER and SPARC developed decades ago.)
- Smartphones typically use the ARM chip architecture.
- GPUs (Graphics Processing Unit) were introduced in 1999. Before the GPU, graphics/ video was a drag on CPU performance.

Functional classification explanations

Continued

- Commodity integrated circuits (CICs) are simple chips used for repetitive tasks (think of barcode scanners) and typically low margins
- An integrated circuit for a specific purpose is an ASIC (application specific integrated chip) are often customized to a client's specifications.
- SoC (system-on-chip) is the newest and where much of the focus is now. An SoC contains all of the components needed built into a single chip. It will combine CPU/RAM functionality as well as integrate graphics, camera, and audio/video processing.

Where are semiconductor chips used?

2020 TOTAL GLOBAL SEMICONDUCTOR DEMAND SHARE BY END USE

Computers		32.3%
Communications		31.2%
Consumer Products		12%
Industrial		12%
Automotive		11.4%
Government		1%

Where are chips manufactured?

Semiconductor Industry Association 2021

“While the U.S. leads in R&D intensive activities, it has fallen behind as a location for manufacturing technology. Government policies have played a major role in the strong growth of cutting edge manufacturing technology in Asia.

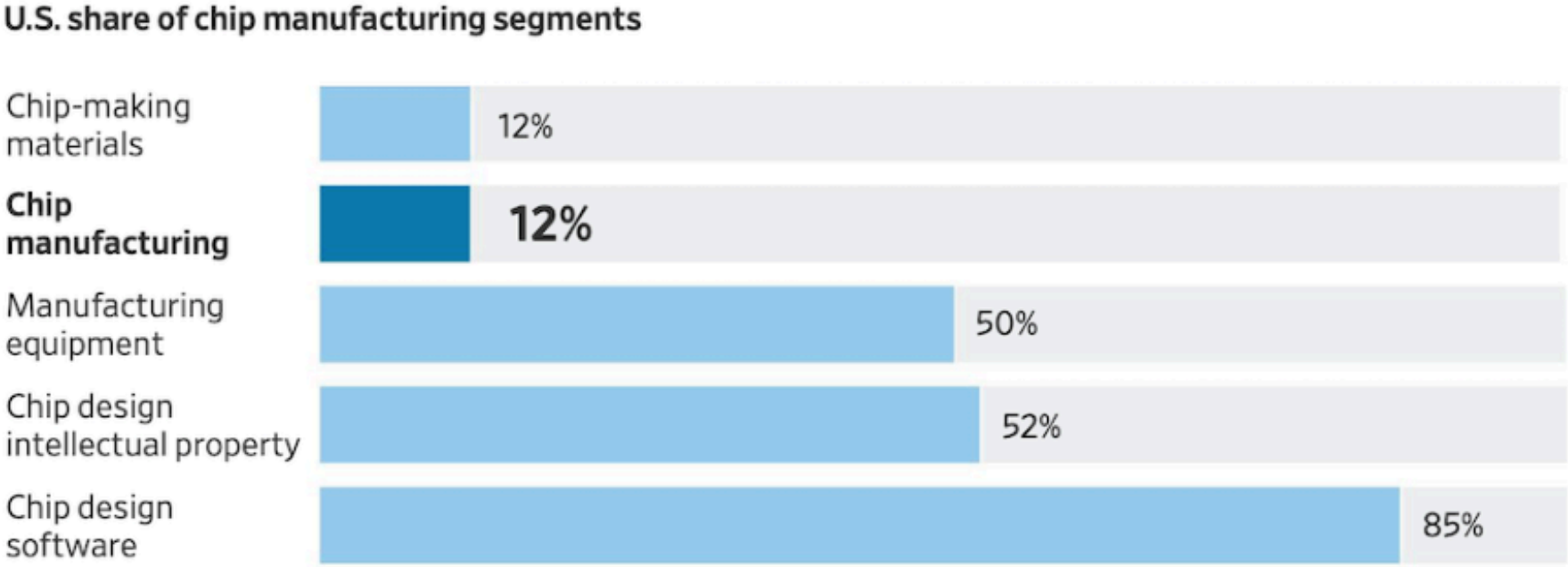
The U.S. has fallen behind Asia in manufacturing technology particularly for logic. There is currently no cutting edge logic capacity below 10 nanometers being done in the United States. It is all being done in Asia where 5 nanometer process technology has been achieved and 3 nanometer technology is on the horizon.

In memory manufacturing technology, the United States has regained competitiveness in DRAM and 3D-NAND, and U.S. firms are fully embracing EUV. U.S. firms are also at the cutting edge of advanced packaging technology using 3D-heterogenous integration.

The U.S. industry is leading the way in a number of the emerging manufacturing technologies such as compound semiconductor manufacturing technology and silicon carbide (SiC).”

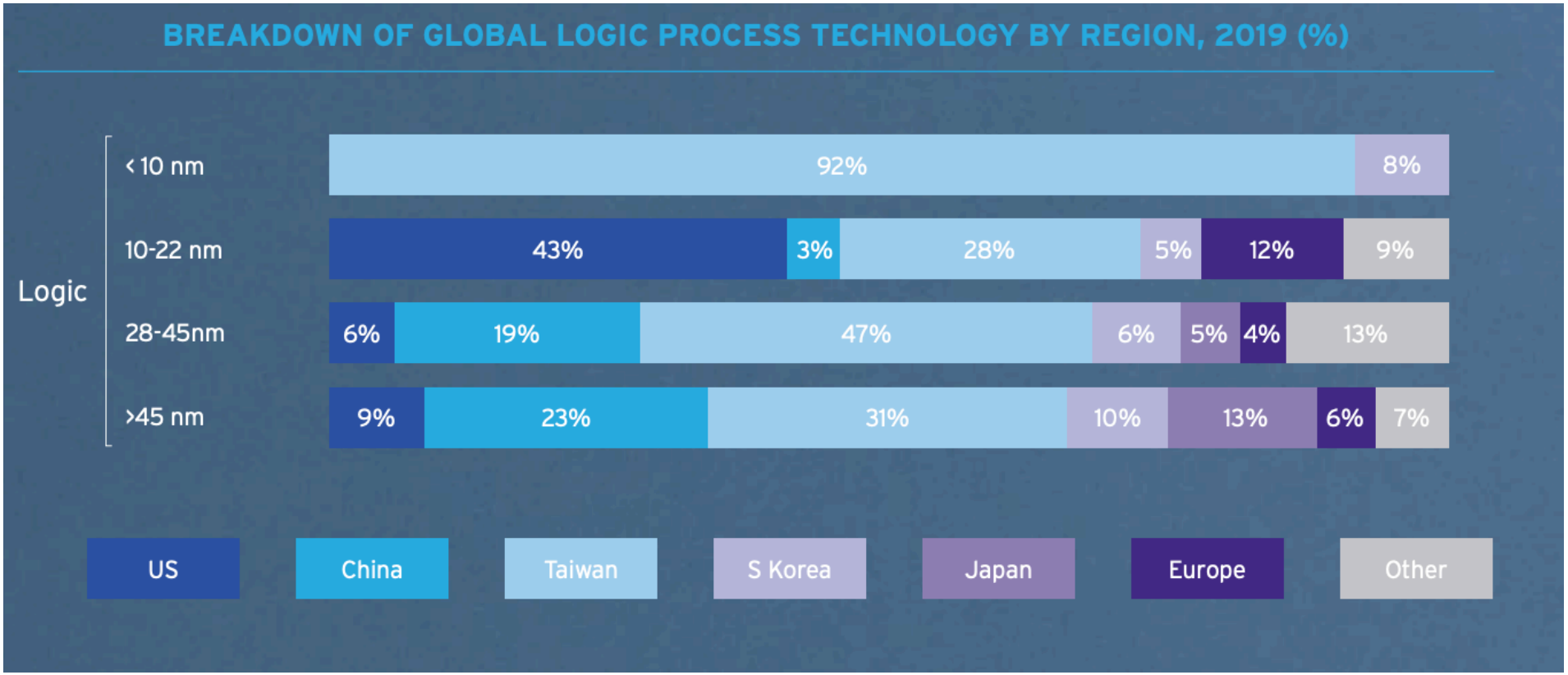
Potential risk to our economy

US leads in design, but has declined rapidly in manufacturing



Sources: BCG analysis based on market data from Gartner, Semiconductor Industry Association (SIA), VLSI Research, SEMI, and company financials.

Semiconductor Industry Association



Global Supply Chain for Chips

Stage 1

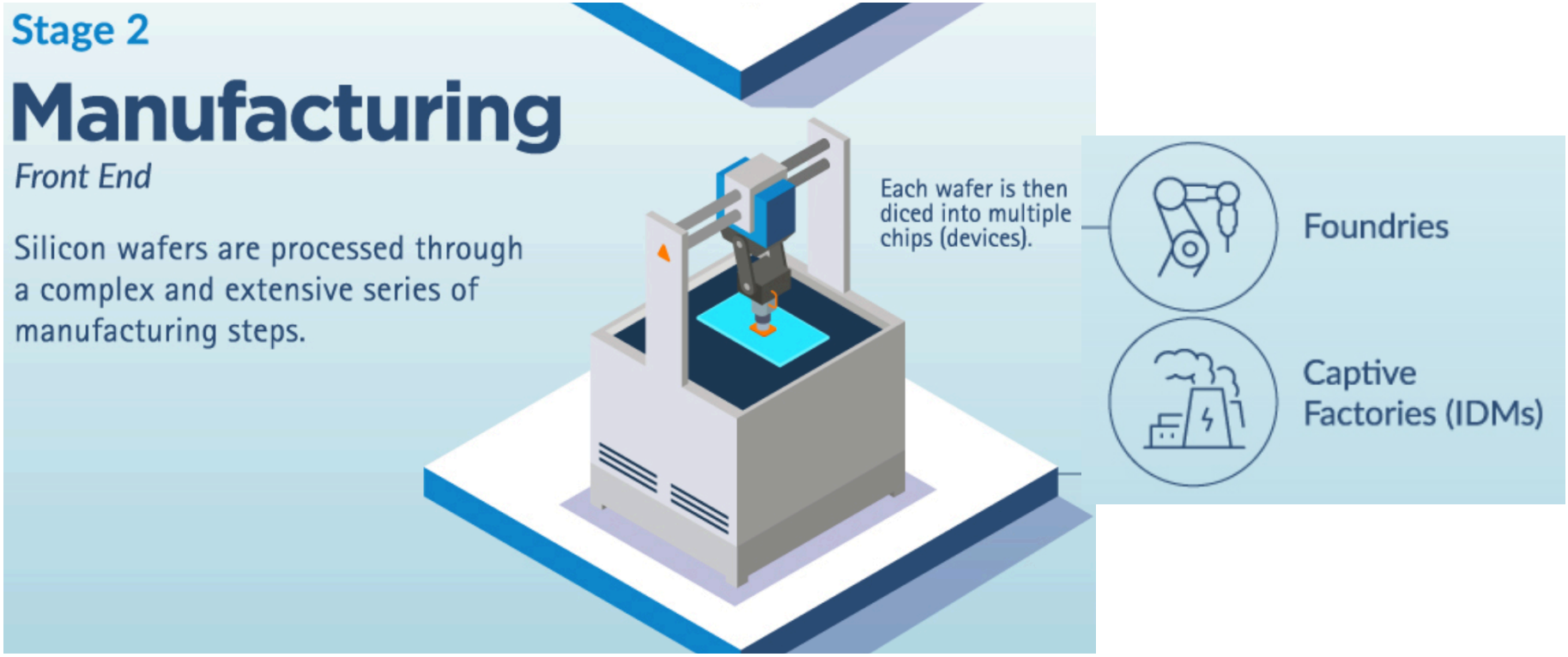
Design

Semiconductor chip designs are created for either specific or general product usage.

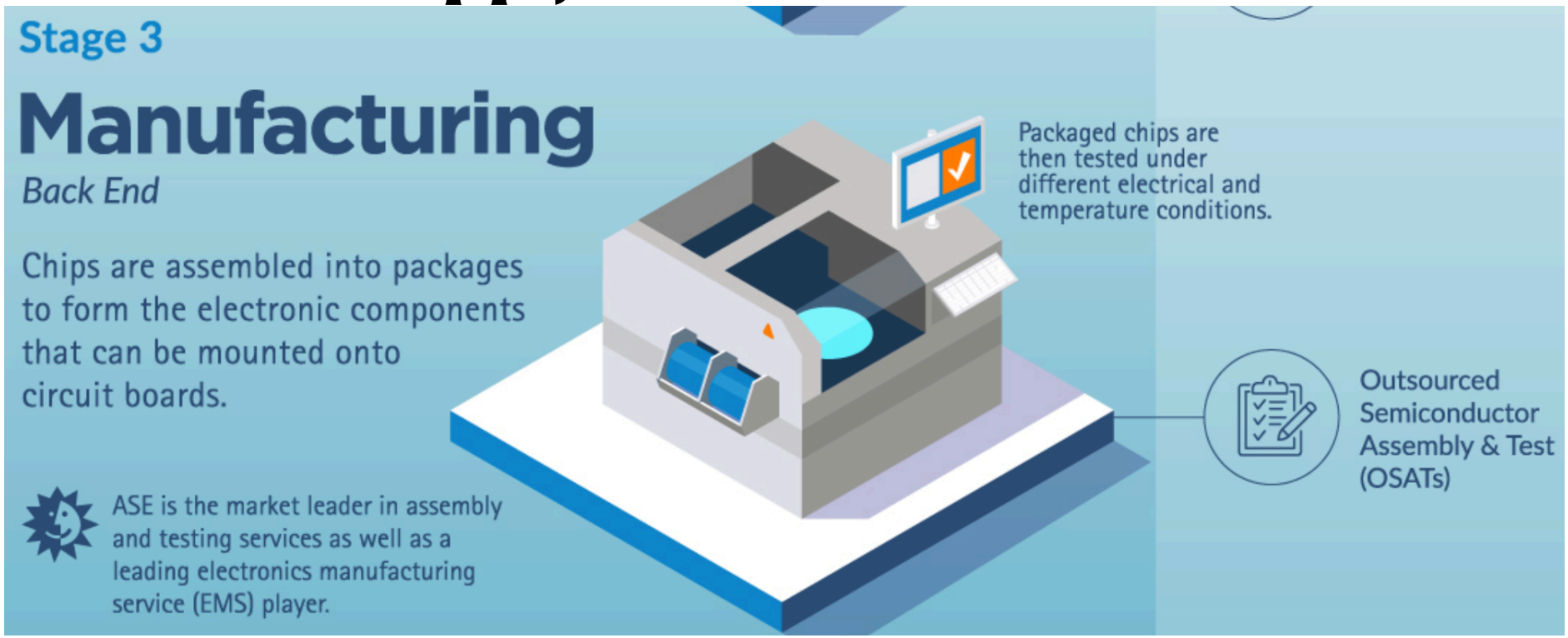
Location

- Fabless semiconductor companies
- Electronics manufacturers
- Independent design companies

Supply Chain (continued)



Supply Chain (continued)

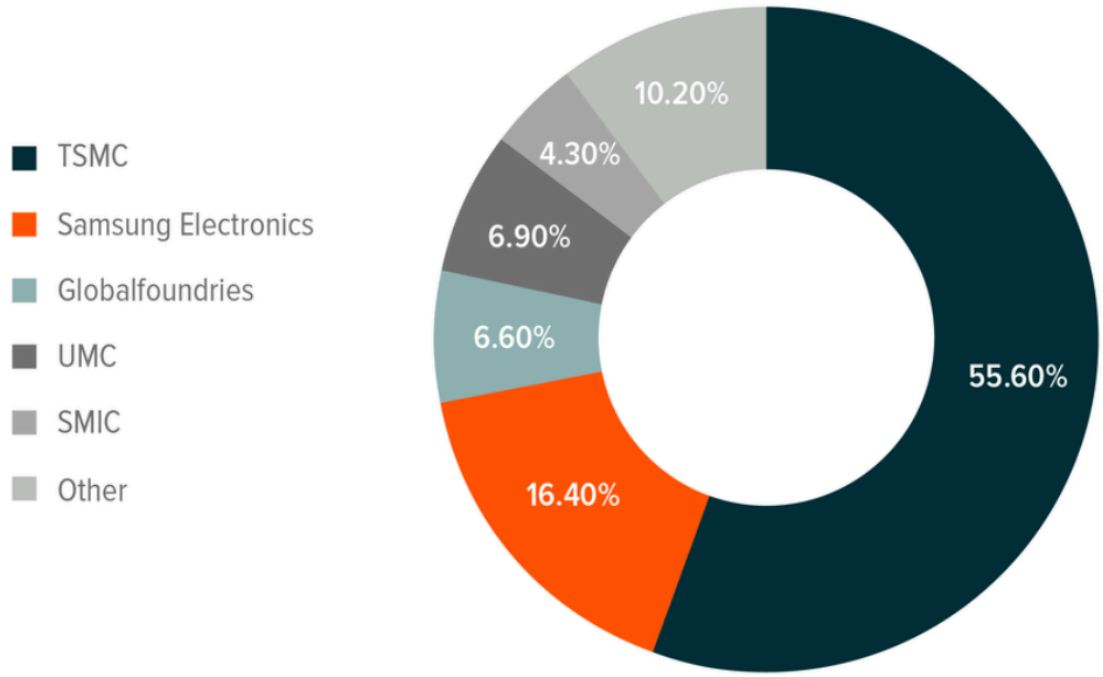


Last step before we use the product

Foundry leaders

FOUNDRY WORLDWIDE REVENUE SHARE, Q4 2020

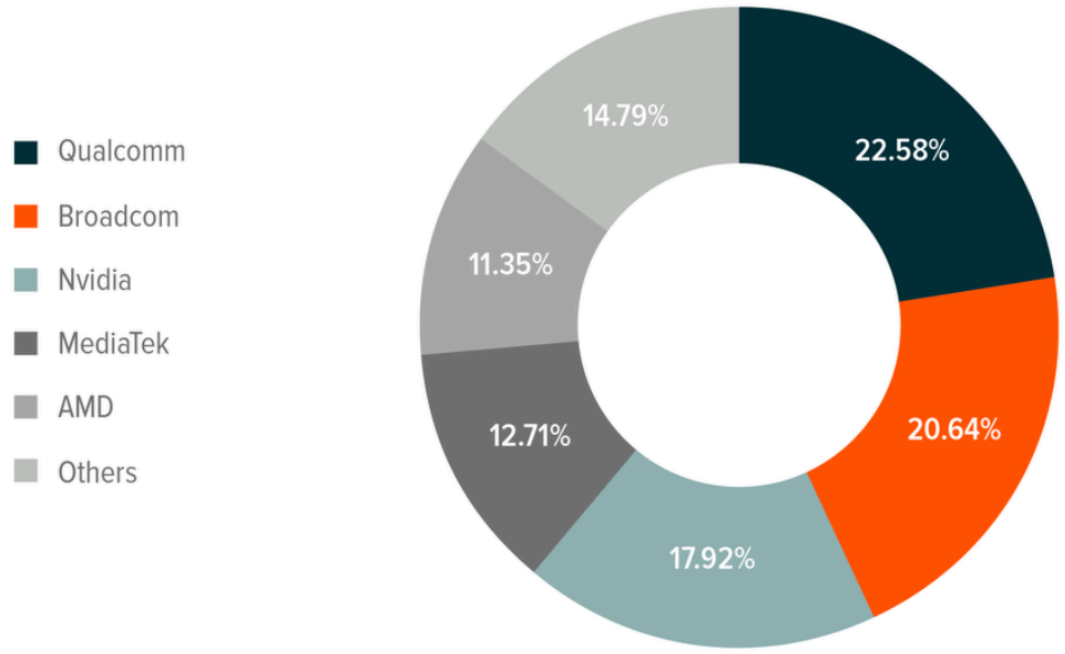
Source: TrendForce.



Chip Design Leaders

FABLESS DESIGN WORLDWIDE REVENUE SHARE, 2020

Source: TrendForce.



TSMC Annual Meeting

From Bloomberg's Tim Culpan / April 2022

"It takes a lot of **guts to spend $42 billion in a single year on factories and equipment j**ust as global interest rates are rising and economies are slowing. Even Taiwan Semiconductor Manufacturing Co.'s investors had started to doubt the world's biggest chipmaker. But the company's confidence was on display again Wednesday when Chairman Mark Liu told shareholders it expects revenue to climb at least 30% this year, two months after forecasting a figure in the mid-to-high 20s. TSMC has a good track record of hitting its targets, so it wouldn't have tweaked those numbers if it wasn't sure it could get there.

And this optimism isn't short term. With a customer list that includes Apple Inc., Qualcomm Inc., Intel Corp., Nvidia Corp. and Advanced Micro Devices Inc., the company has greater insight to both short and long-term semiconductor demand than anyone else on the planet. That's why it raised its capex budget by almost 40% from the $30 billion it spent last year. In fact, as Liu and Chief Executive Officer C.C. Wei outlined at the annual general meeting, its expansion is for the long-term while economic slowdowns are temporary."

Stratechery's Ben Thompson

May 2022 (Ben is based in Taiwan)

"Today smartphones no longer drive growth, but they do provide volume; what is also apparent from TSMC's capex commitment is that high-performance computing of the sort that drives not only servers generally but machine learning specifically is very much the next wave, and that TSMC is determined to not simply maintain its position, but to extend its advantage through the current economic challenges. TSMC already owns the Apple and AMD portfolios, and has recently brought Nvidia back into the fold. What is notable is that Intel is getting sucked in as well, and the scale of this commitment makes it increasingly unlikely the would-be TSMC competitor will be able to fully extract itself. "

Note that TSMC's 3nm chip comes online at the end of the year.

Memory chips

From Bloomberg / March 2022

“The memory chip industry has been caught in a brutal survival contest for decades. **Samsung Electronics Co., SK Hynix Inc. and Micron Technology Inc**. — companies that together have market value of more than half a trillion dollars — are the last remaining contenders in a sector of the global semiconductor market that’s particularly vulnerable to the volatile rises and falls in demand.

In the semiconductor world, **memory chips are unique. They’re made to industry standards,** meaning that a product from one company can be replaced with one from a rival without changing anything else in the computer or phone they go into. That means the chips have been treated like commodities in secondary markets. And, like commodities, the price swings have been dramatic, often leading to gluts where chips sell for less than the cost of production.”

Micron

Barron's May 2022

"Micron Technology Chief Executive Officer Sanjay Mehrotra told investors last week that there were 82 zettabytes of data created last year. That's 1 gigabyte per hour, per person on earth. By 2025, that number will double, he forecast.

Obviously, Mehrotra is hoping the explosion of data will translate into a lot of demand for memory chips. If he's right, there will also be a lot of other gear—processors, computers, networking—and a giant amount of software and artificial intelligence needed to move it around, store and make sense of it."

AMD / Advanced Micro Devices

Bloomberg May 2022

“Advanced Micro Devices Inc. gave a strong sales forecast for the current quarter, indicating that the chipmaker continues to make strides in its most lucrative market: data-center processors. AMD predicted second-quarter sales of roughly $6.5 billion, compared with an average analyst estimate of $6.03 billion. That helped send the shares up as much as 8.3% in late trading Tuesday.

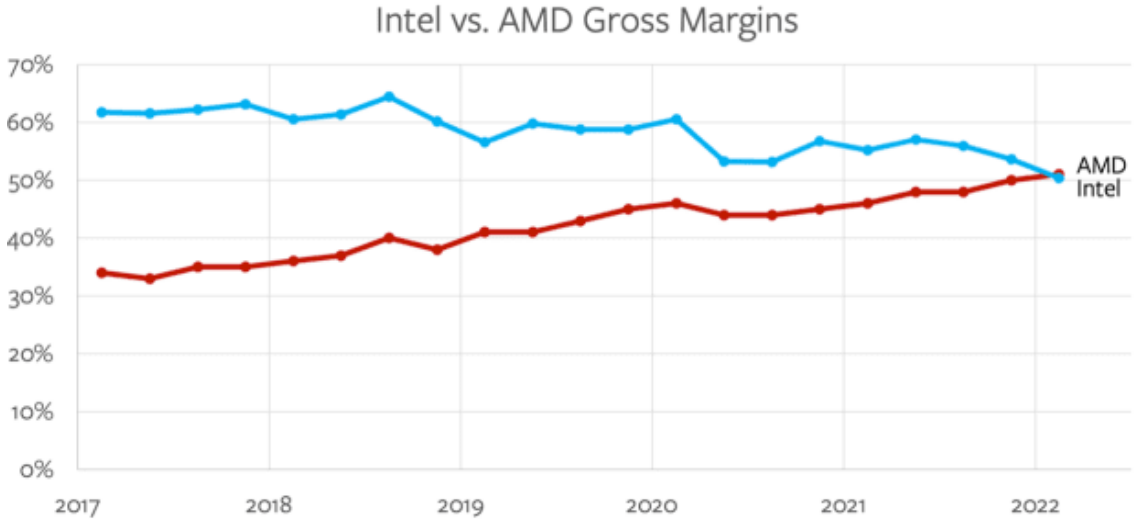
The outlook helped allay concerns that the chip market is slowing — and signaled that AMD is making further gains on Intel Corp. The company, which for years lagged far behind Intel in computer processors, is on pace to end 2022 with almost four times as much revenue as in 2019. New products and better execution have helped AMD win over customers who were once skeptical about its capabilities…”

“AMD is gaining ground at the largest buyers of computer processors, owners of the giant data centers that are the backbone of the internet. Some 48% of all new processors installed in these data centers were bought from AMD in March, according to Jefferies & Co. analyst Mark Lipacis.”

Stratechery on AMD

Ben Thompson / May 2022

"AMD is actually expecting to *grow* its client revenue even as the category declines as a whole because it expects to take share in the higher ends of the market. AMD just makes better chips now, and its increased pricing power reflects that; for the first time in a long time, AMD (ex-Xilinx) had better gross margins than Intel:



Intel

Barron's June 29, 2022

"Intel Should Slash Its Dividend. The Chip Maker's Future May Depend on It."

"committed to massively increasing its capital spending investments by tens of billions of dollars. But with a rapidly slowing global economy, repeated product delays, rising competitive threats, and political uncertainty, it might need more help to fund its ambitions."

Qualcomm

Recent news

"Qualcomm Spikes on Report It Will Remain iPhone 5G Modem Chip Supplier in 2023" Barron's June 28, 2022

"Qualcomm's Apple Slice Still Has an Expiration Date" WSJ June 30, 2022

Qualcomm, the main developer of the digital cellular technology most widely used in today's networks, has dominated the market for years, accounting for 51% of baseband revenue in 2021.

Broadcom

Broadening beyond chips

- The historical strength has been in networking chips/data centers/cloud.
- Acquisition of VMware increases software revenue to an estimated 49% (if approved....)
- The company has made other acquisitions in the last few years - WSJ “The goal: find companies with deep links into large corporations’ information-technology setups that would be difficult for them to abandon. Then cut costs and get the most out of their products by “cross-selling and up-selling” them.”

Nvidia

Slowing demand for it's strength

- Expensive GPUs used in video games and crypto mining (but clearly deemed the best)
- Weakening demand in these spaces
- Expanding in the cloud space as well as software
- #1 semiconductor pick by BoA (June 2022)

Texas Instruments

IDM (like Intel)

Texas Instruments designs and manufactures semiconductors and various integrated circuits, which it sells to electronics designers and manufacturers globally.

Motley Fool July 1, 2022 - “Texas Instruments produces analog and embedded chips. These semiconductors do not receive as much attention as higher-end processors made by the likes of **Nvidia** and **AMD**. Still, digital chips can only represent zeros and ones. Analog chips can recognize continuous signals, which means that digital semiconductors need analog chips to function. These processors function as a bridge between the crisply defined digital world and the messy, complex realm of real-world data. This makes Texas Instruments' products essential to the latest technological advancements.”

Many analysts believe this stock should bring long term returns even if faced with a slowing economy.

Semiconductor shortages should change corporate strategy

Harvard Business Review

“The auto and other industries have been brought to their knees by the scarcity of a tiny piece of technology: the semiconductor. Plans for millions of cars have been cancelled and the damage will continue for years to come. How can business leaders prevent this from ever happening again? CEOs need to transform their business by putting suppliers at the center. They need to follow the procurement-centric model of Apple and other Big Tech companies by reengineering and rebalancing the way they collaborate with direct and indirect suppliers taking procurement to a more strategic level. Tesla is an example of a company that has done this phenomenally well. To ensure resilience and success, a systemic approach that puts procurement at the core is needed.”

What's next?

And at what price?

- PC and phone demand is expected to be weaker this year.
- Auto manufacturers are still playing catch up
- Data centers/ cloud were expected to be the focus of high demand in 2022 - does that demand slow with the economy?
- Will Congress pass the CHIPS for America bill currently stalled in the Senate?
- Valuations

“It takes 2,500 parts to build a car, but only one not to.”

Peter Hasenkamp, former head of supply chain strategy for the Tesla Model S.

Harvard Business Review