RGIT ASSESSMENT #1
CRITICAL TECHNOLOGY

SEMICONDUCTORS, INDUSTRY UNDER STRAIN

Masters in Innovation and Research for Sustainability
RESEARCH, INNOVATION AND GLOBAL TRENDS

Sandro Mendonça, 11 March 2024

Instituto Superior de Economia e Gestão
UNIVERSIDADE TÉCNICA DE LISBOA

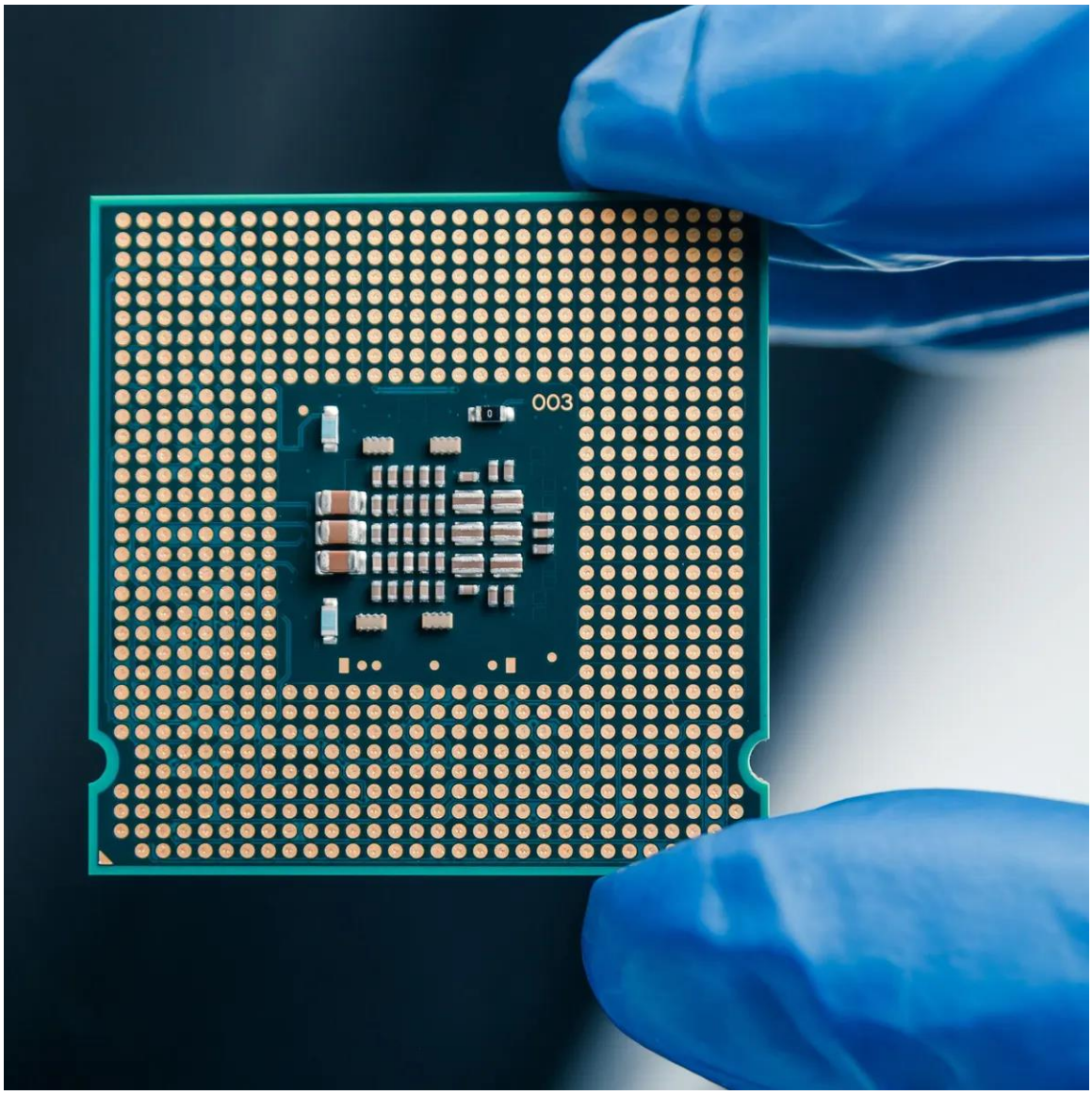

003

TABLE OF CONTENTS

INTRODUCTION

This report provides an assessment on **three issues**:

1. *The reaction and future cooperation prospects of European countries, especially those in the EU, to limiting the development of China's chip industry;*
2. *European companies' considerations for expanding into the Chinese market, and their attitudes and reactions to the relocation of China's semiconductor industry to Southeast Asia;*
3. *The attitude of the European industry, especially the semiconductor industry, towards China's semiconductor industry following the release of Huawei's new mobile phone.*

The **methodology** is based on the review of four sources of evidence:

a) Scientific research (journal articles);
b) Grey literature (official reports);
c) Technical events (programs);
d) News and views (press).

CONCLUSIONS IN A NUTSHELL

On the basis of 15 pieces of evidence, ranging from structural knowledge of academic nature (scientific research) and from up-to-date practical information (business press), we now provide **our best estimate** related to the three points of interest:

(1) European countries, and the EU (and of course the US), are interested in gaining autonomy in the whole chain of supply. The emphasis is **reshoring processes to "like-minded" places** and countries (but that includes Taiwan, South Korea, and Japan).

There is no evidence of intentions regarding partnering with China.

(2) No business plans regarding expanding sophisticated manufacturing in digital/electronics industry surface in relation to China. But **business leaders seem more pragmatic than policy-makers when they prioritize expertise and compliance with quality levels rather than "geography"** as a risk mitigation strategy.

No information regarding the "relocation of China's semiconductor industry to Southeast Asia" were found.

(3) There seems to have been **generalized surprise** upon the news of the latest Huawei flagship model, as if China already succeeded in what the "West" also wants for itself.

Doubts are raised about the sustainability of Chinese progress toward advanced 3nm chips.

SCIENTIFIC LITERATURE

A search for **formal journal articles** (peer reviewed research contributions) and **conference proceedings** (faster-to-print type papers) using a widely trusted database (Scopus) using a simple protocol ("**microchips AND China**") yields the following insights:

- small number of results (36), which is surprising given the importance of the theme
- within the results only a very small number are of primary relevant, since the others are off-topic, too old, written by Chinese scholars, or are too technical.

One article stands out. The author is Erik Jones, the is Director of the Robert Schuman Centre for Advanced Studies at the European University Institute (EUI). This academic institution is very influential within the European Union ecosystem. The author has published opinion articles in newspapers like New York Times, Financial Times, etc. He this academic article Erik Jones supports the views that the **aggressive US efforts to restrict and constrain China's access to advanced microchip technology are unlikely to be effective, actually they may "backfire".** As a parallel: by 2023 it could be said that the biggest ever sanctions to Russia had failed, and by 2024 it could be even be said that they have favoured Russia's independent development.

Survival ›
Global Politics and Strategy
Volume 65, 2023 - Issue 3
Review Essay
The Choice for Sanctions
Erik Jones

Source:
https://www.tandfonline.com/doi/full/10.1080/00396338.2023.2218705?scroll=top&needAccess=true

Broadening the search protocol ("**semiconductors AND China**"), we find a further 24 articles.

Just one article stands out. The first author in an influential US scholar from Berkeley. The article establishes significant argument: the **Chinese government acts as an orchestrator of other entities (State-owned enterprises, privately-owned companies, and foreign firms) to drive the innovation performance of entire industry.**

R and D Management • Volume 51, Issue 3, Pages 247 - 259 • October 2020

Open innovation with Chinese characteristics: a dynamic capabilities perspective

Chesbrough, Henry ; Heaton, Sohvi , Mei, Liang

Source:
https://onlinelibrary.wiley.com/doi/10.1111/radm.12438

GREY LITERATURE

A look to “grey literature” means that we probe official reports to have a grasp of the major debates in policy circles. Here we discuss emergent findings from three recent such outputs published by the European Commission:

- a flagship foresight study published in October 2023.

- a major report on industrial R&D published in December 2022.

- a reference report on European microchips published in July 2022.

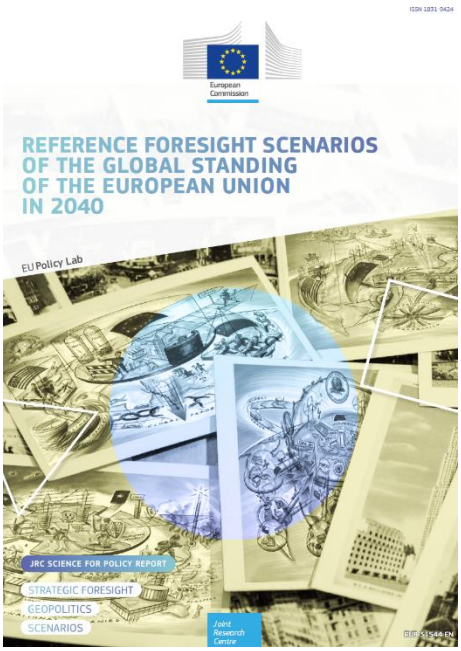
*

In the flagship foresight study a number of megatrends are analyzed in the horizon of 2040. The major question is how competitive and geopolitical shifts will impact strategic dependencies and the EU’s “Open Strategic Autonomy”. It is acknowledged that:

- **China is already a global in leader in a number of digital and green technology segments.** (p. 12)

- **There is a movement toward “glocalisation” of supply chains and, in this context, an insistence in boosting of domestic semiconductor production in the EU**. (p. 29)

- **China may limit the exports of critical raw materials to gain economic competitive advantage.** (p. 29)



Source:
https://publications.jrc.ec.europa.eu/repository/handle/JRC132943

*

The EU produces a major report every year on R&D investment in which data from original sources are used. A number of key points are advanced in the latest report:

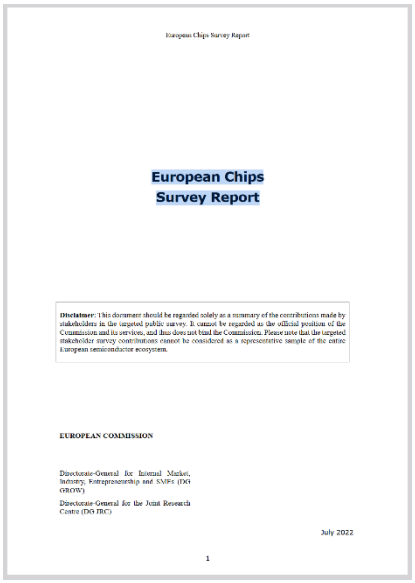
- **China is emphasized to have shoot up in the ranking, now only below the US in terms of the number of firms in the world's top 2500 highest R&D spending firms.** (p. 9)
- **In particular China is pointed out to have the largest number of Information & Communication Technologies (ICT) producers in the ranking.** (p. 12)
- **The top ICT producers of China are Huawei, ZTE, Xiaomi and Lenovo.** (p. 22)
- **Semiconductors only appear when the Taiwan's firm TSMC is referred to be among the world's top 50 R&D companies. The company is mentioned to produce about 50% of the world's microchips and 90% of the words most advanced chips.**

Source:https://iri.jrc.ec.europa.eu/sites/default/files/contentype/scoreboard/2022-12/EU%20RD%20Scoreboard%202022%20FINAL%20online_0.pdf

*

The EU produced a rare report on the demand for chips and wafers, the complexity of the value chain, industry prioritisation for chip fabrication activities, the impacts of the chip supply crisis on European industry and the industry calls for public support. The major conclusions of this work are:

- **Companies establishing new chip fabrication facilities attribute importance qualified labour and compliance with government regulations for selecting location, but not to geographical proximity and "derisking" through geographical diversification.**
- **Corporate users of chips prioritise the technical aspects of the chip itself, quality of service, delivery time and price when selecting a supplier to manufacture chips.**
- **A projection of increased demand for smaller chips and an exponential growth for the smallest technologies (5-7nm).**


European Chips Survey Report

European Chips
Survey Report

Disclaimer: This document should be regarded solely as a summary of the contributions made by stakeholders in the targeted public survey. It cannot be regarded as the official position of the Commission and its services, and does not bind the Commission. Please note that the targeted stakeholder survey contributions cannot be considered as a representative sample of the entire European semiconductor ecosystem.

EUROPEAN COMMISSION

Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW)

Directorate-General for the Joint Research Centre (DG JRC)

July 2022

1

Source:

https://single-market-economy.ec.europa.eu/system/files/2022-07/European%20Chips%20Report.pdf

TECHNICAL
EVENTS

Industry events and engineering community conferences are important and up-to-date sources to understand the sensitivity and prospects by the experts in a given innovation ecosystem. These expert face-to-face trade moments bring together the staff that hold the know-how on which top management will rely to design investment strategy and business development pathways.

Three recent/forthcoming events are explored here:

- ETSI event on Quantum Safe Cryptography, which brings together standard-setting participants on cyber-technologies (13-15 February, 2023);
- SEMICON Europa 2023, which strongest single event for electronics manufacturing supply-chain in Europe (14-17 November, 2023);
- PIC Summit Europe 2023, which is the key get-together in Europe for photonic integrated circuits and their applications (7-8 November, 2023).

*

ETSI is the European Telecommunications Standards Institute. In its event there were a number of expert panels on quantum computer advances that showed the following:

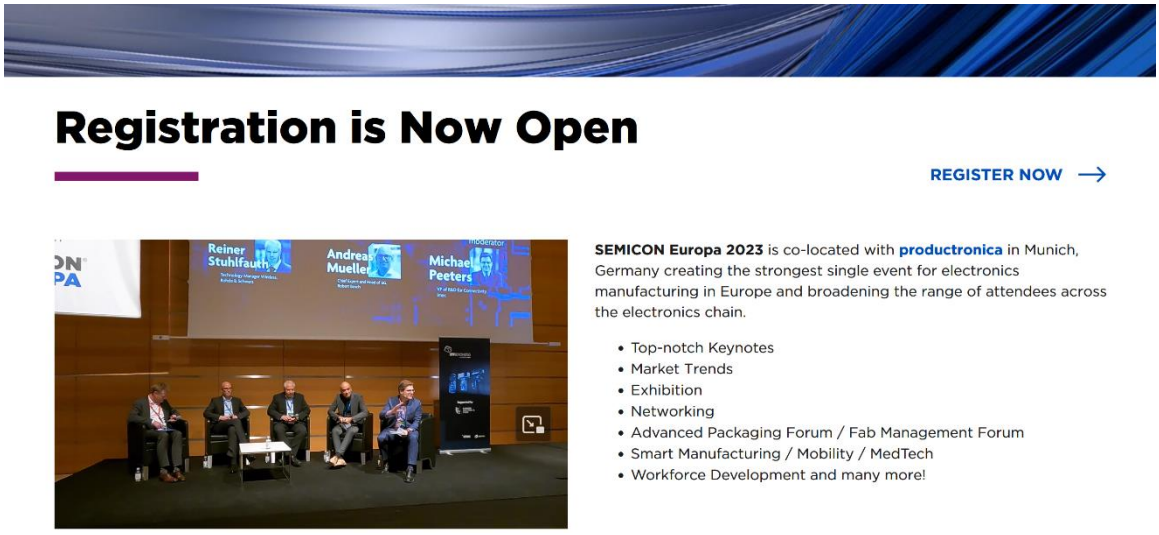
- **importance attributed to government initiatives and policies, including the decision in Germany to give urgent go ahead urgent quantum-safe transitions which ultimately will relying on certified and standardized solutions.**
- **challenge of incentivizing researchers to advance cryptanalysis, including authentication protocols and firmware integrity.**
- **opening up to new categories of stakeholders in the terahertz domain, including the defense sector.**

Source: https://www.etsi.org/committee?id=2191

*

SEMICON Europa 2023 is an event that combines an exhibition with talks. It covers the market trends, Fab Management Forum and networking opportunities around smart manufacturing. From the program we witness the following agenda-setting topics:

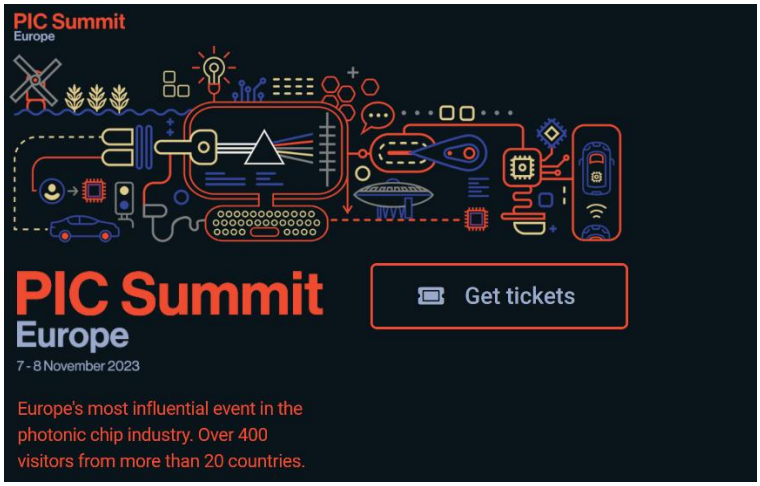
- **EU-funding and international industry collaborations, including other actors.**
- **Materials innovation for atomic-scale dimensions.**
- **Energy-efficiency drive to ensuring minimal power consumption and delivering optimal performance.**



Source: https://www.semiconeuropa.org/

The PIC Summit Europe 2023 has a context that includes established firms, startups, universities and the European Commission. From its program we can see the following themes:

- ***the potential for integrated photonics as 'the next big thing' in scaling, especial when applied to healthcare and agricultur.***
- ***constraints in connecting public and private capital in driving innovation in chips, even in the presence of the EU Chips Act which aspires to make chip supply chains more robust.***
- ***advanced CMOS (currently FinFET) technology seem by far the largest growth driver of the semiconductor market***



Source:
https://www.picsummiteurope.com/the-program-pic-summit-europe-2023/

Recommended reading from tech watchers that were in the event:

https://informatech.turtl.co/story/pcim-2023/page/1

NEWS
AND VIEWS

Here we take the business press as an empirical source to monitor the public debate among experts and the messages sent to targeted audiences. A main authoritative outlet in the West covering business and industries in the ***Financial Times*.** A sample of recent news (journalistic newspaper pieces) and views (opinion newspaper pieces) can be seen below.

*

Recent opinion appears to connect Huawei to new Chinese homeland capabilities in advanced microchips. See article below (FT, 1 November 2023, p. 6) where we can read:

- **foreign brands of high-end gadgets are seen by Beijing as status symbols, and this is a concern that requires domestic answers;**
- **self-reliant designs and manufacturing of the new model Huawei flagship smartphone (7nm chips, which compares to the 3nm of the most cutting-edge iPhones) suggests having been achieved by pro-du-cing advanced chips using older machine-tools and packaging technologies;**
- **this October, the US commerce department "unexpec-tedly" tightened even more existing export curbs, further containing China's access to critical chip technologies.**

Huawei's new smartphone ratchets up rivalry with Apple and US

INSIDE BUSINESS

ASIA

June Yoon

The iPhone has become a status symbol among the youth in China. That has been a driving force behind the sales growth of Apple's smartphone in the country.

Huawei's new flagship phone seemed to be the homemade answer to Beijing's growing concerns over this trend. But, longer term, taking on Apple will come at a steep cost.

The latest figures are encouraging for Huawei. The Chinese technology group's net profit for the September quarter, which included early sales of its flagship Mate 60 Pro smartphone series, more than doubled. The phones, priced at about $1,200, have become a sellout success in China, with sales reaching 1.6mn units in the first six weeks since its launch in late August.

Huawei's local market share increase of 4 percentage points to 13 per cent in the third quarter is a feat in the country's hypercompetitive smartphone market. A 37 per cent increase in phone sales for Huawei, whose smartphone business had been written off as doomed since it was battered by US sanctions in 2019, is a victory for Beijing as well.

Official concerns about the iPhone's increasing dominance in China are on the rise. Beijing has expanded a ban on iPhone use in some agencies and state-owned enterprises. Central government bodies have long recommended employees use locally made devices.

But young Apple fans and the lack of local smartphone models in the premium segment made it difficult to prevent the iPhone's rise to its position as the second-largest market share holder in China, despite being pricier than its local counterparts. In the second quarter, China was the largest market for iPhones, according to research group TechInsights.

The biggest challenge for Chinese smartphone makers wanting to become a serious contender in the global high-end phone market is stable access to advanced chips — which are in increasingly short supply because of US export bans. Even before US export controls went into effect last year, Taiwan's TSMC had stopped making advanced 7nm chips for Huawei in 2020 in response to US sanctions.

> Young Apple fans and the lack of local smartphone models in the premium segment made it difficult to prevent the iPhone's rise

What differentiates Huawei's Mate 60 Pro models from local peers is that it is equipped with advanced 7nm chips that use homemade designs and manufacturing. That suggests a breakthrough in China's semiconductor industry, producing advanced chips using older machines.

The latest chip industry trends are now stacked in Huawei's favour. Growing demand for higher computing speeds from the artificial intelligence sector amid a global shortage of advanced chips has led to the rapid development of new chip packaging technologies. This allows chips to be stacked three-dimensionally in a high-density package offering higher performance while using existing chips.

In the present environment, though, such breakthroughs come with a cost: tighter US sanctions. Relatively few chips are used for military applications — which is the area of most concern for Washington. Just 2 per cent of the global supply is for government use, compared with almost three-quarters for communication and consumer devices. Having enough advanced chips for millions of smartphones would imply there is more than enough for government needs.

This month, the US commerce department unexpectedly tightened existing export curbs, further restricting China's access to critical chip technologies. That would explain why Huawei, which is also China's top chip designer, has been uncharacteristically low-key about recent achievements, vigorously denying rumours of a breakthrough in chip packaging technology earlier this year.

The latest iPhones use the most cutting-edge 3nm chips. To keep up, Huawei will have to continue to use its latest technologies in its new smartphone models. On the flipside, because smartphones are consumer devices, anyone can buy one. A breakdown analysis of its parts quickly exposes the technology being used, showing the US exactly how far China has come in terms of technological advances.

Huawei is caught in a bind. It is finally seeing signs of recovery for what was once its most lucrative business, which brought in $48bn in annual sales before US sanctions hit. But each new model launch now carries a political cost if it introduces new chip technology. It must carefully weigh its ambitions to take on the iPhone against the risk of setbacks to chip development from further US action.

june.yoon@ft.com

*

We can get insight from comments from readers of articles on Huawei's new phone, for instance:

- ***European "lack of vision in its future economy industrial strategy"***
- ***"Huawei 'emulates Apple' and designed an advanced cellphone processor (Kirin 990 5G) in 2019 with 5G baseband integrated. While Apple has been trying for years to design their 5G modem with complete failures. They still have to buy from Qualcomm. What a shame!"***

- ***"Yangtze Memories in China can produce 232 layer DRAM chips. They may need till middle of next year to mass produce (see article in FT on YMTC - Mar 30 2023)."***
- ***"As predicted, sanctioning China has spectacularly backfired. The more restrictive the West is to their development, the more determined they will be to overcome."***
- ***"The US should work with ASML, Nikon, and Canon to put a total stop on any more DUV lithography machine exports. Also a total stop in esports of any chemicals and other consumables and equipment that can be used for below 14 nm."***

Source:
https://www.ft.com/content/11f1c1a3-4ac4-4b2a-99cd-e347928dc51f

*

In the news article below (FT, 1 November 2023, p. 10) we can learn:

- **depletion of chip stocks in the short-run, profit margins increase in the medium-run and AI-applications in the long-run are going to push up prices.**
- **"Samsung has been able to continue operations in China after Washington allowed it to bring in new chipmaking equipment to its factory in the country without seeking US approval."**

Technology

Samsung forecasts end of punishing memory chip slump in next 12 months

SONG JUNG-A — SEOUL

Samsung Electronics expects the memory chip market to rebound next year — drawing a year-long glut to an end — after introducing production cuts to get through an industry downturn.

The largest producer of memory chips and smartphones forecast that semiconductor prices would rise in the fourth quarter with inventories being quickly depleted.

Samsung also declared that artificial intelligence applications would drive demand for high-end chips.

"In 2024, while macroeconomic uncertainties are likely to persist, memory market conditions are expected to recover," the company said yesterday.

The outlook comes after the group reported a 38 per cent drop in third-quarter net profit from a year earlier to Won5.8tn ($4.3bn), much higher than analyst estimates of Won2.5tn compiled by Bloomberg.

Spot prices of Dram chips used in smartphones, computers and servers have fallen this year, forcing the chipmaking division to suffer an operating loss of Won3.8tn in the July to September quarter. But it narrowed from a Won4.4tn loss in the previous quarter as Dram prices began to rebound in early September.

Intel forecast sales to grow in the fourth quarter on improved personal computer demand.

Last week, SK Hynix said Dram demand was being driven by an AI boom and the impact of memory chip output cuts was beginning to be felt.

Samsung slashed more output in the third quarter to reduce inventory after first announcing an output cut in April, joining rivals such as SK Hynix and Micron Technology.

Samsung hailed a boost from artificial intelligence applications

"Samsung has expanded its output reduction since August, shifting its strategy to boost profitability," said Kim Dong-won, an analyst at KB Securities, in a recent report, forecasting that Samsung would raise Dram and Nand chip prices further in the fourth quarter.

Samsung plans to devote a record Won53.7tn to capital expenditure this year, with Won47.5tn of that going to semiconductors.

Shares of Samsung have gained more than 20 per cent year to date on growing expectations of an industry recovery.

Samsung is trying to boost margins by focusing on higher-end Dram chips such as DDR5 and high bandwidth memory chips, which are components in AI systems including OpenAI's ChatGPT.

Demand for HBM chips used in AI processors remained strong but Samsung's tech was behind that of SK Hynix, analysts said.

Samsung has been able to continue operations in China after Washington allowed it to bring in new chipmaking equipment to its factory in the country without seeking US approval.

*

A few other pieces show the following:

- **Germany is preparing to offer TSMC and Intel big-ticket subsidies for planned plants, and France the same for GlobalFoundries and STMicroelectronics. Financial support for the massive investment in in the region of multibillion euros.** https://www.ft.com/content/592a3227-8bf3-4270-9833-ea4e3f194498
- **Suppliers to world-leading chipmakers (for instance, Japanese) are planning to open factories in Europe, as bulk electronics-level materials and chemicals are crucial to develop the chip technology in Europe while building**

European supply capabilities is a "long-lasting and expensive challenge requiring a lot of capital expenditure." https://www.ft.com/content/761b5b1b-c09b-463f-bc0c-73d682eddb33

- **"The most ambitious funding round launched to date by China to support its semiconductor industry is struggling in the initial phases to raise its target of Rmb300bn ($41bn), with the difficult economic climate being blamed, according to three people familiar with the situation."** https://www.ft.com/content/521c8ac3-1933-4077-88b9-e9086a0196ca

*

This video (28 September, 2023) stresses the following (by now very well-known) themes:

- **with globalization no chips are manufactured in the US.**
- **industrial policy, allied with science policy, is back in the west.**
- **reshoring the semiconductor supply-chain.**

Source:

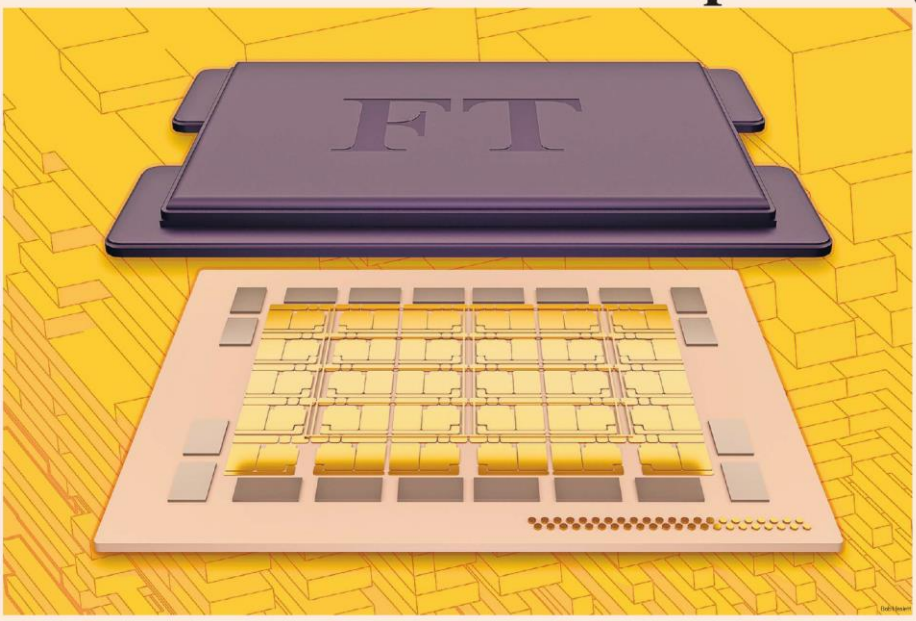
https://www.ft.com/video/24643c72-4cd7-4a52-86ae-54c1e43eddac

The contemporary semiconductor business is contingent on sophisticated dynamic capabilities and complex supply chains.

Shrinking the computer chip is one of humanity's greatest scientific feats. After coming up against the limits of physics, engineers are rethinking semiconductor architecture like never before.

By Lucy Rodgers and Sam Joiner

The miracle of modern chipmaking



Working in chip innovation was not always the plan for Min Cao, vice-president of pathfinding at Taiwan Semiconductor Manufacturing Company.

Cao had dreamt of a career in physics, but after graduating from Stanford University at the end of the cold war, an abundance of out-of-work physicists meant he cast his net more widely. His desire to understand how the world works led him to the rapidly developing field of microchips.

"There are still a lot of mysteries," says Cao, whose work on chip performance continues to push the limits of physics. "It's getting harder, but it doesn't mean we are going to stop."

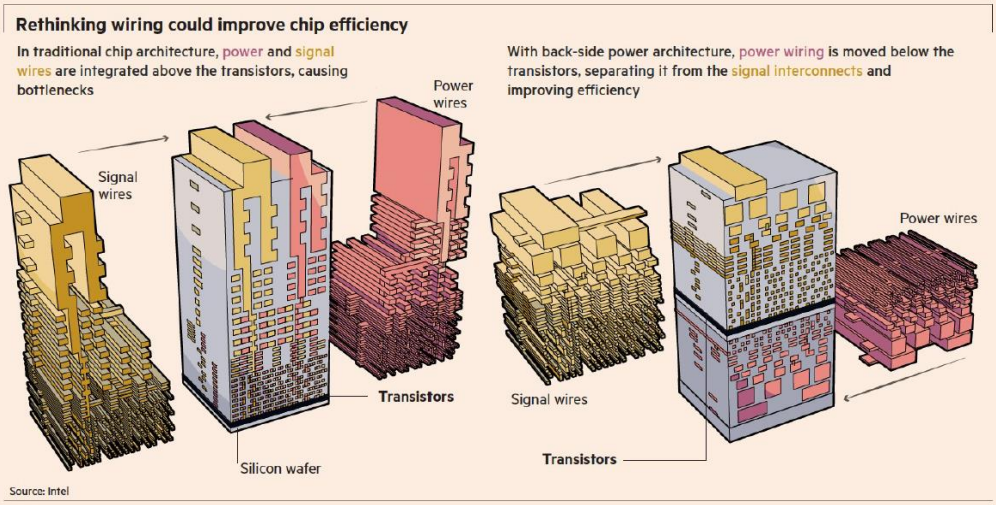
Only three companies in the world — Intel, Samsung and TSMC — are capable of mass producing chips powerful and small enough for today's advanced mobile technologies.

With parts of transistors reaching atomic levels of scale, engineers are having to come up with increasingly innovative ways of ensuring progress, such as vertical, tower-like construction and rethinking the way chips are packaged. Many believe that bundling together chips with different functions is where future semiconductor battle lines will be drawn.

Some of the newest smartphone chips, such as those in the iPhone 15 Pro, are manufactured with what is called a "3 nanometre" process — a name given to a generation of processors with the smallest transistors. Although this no longer references their physical dimensions, it does allude to the shrinking scale of their components. These tiny switches, which control the flow of electrical signals inside every digital device, are the workhorses of microprocessors and the basic building blocks of modern electronics.

Driven by demand for increased computing power, the scaling of chips over time has for decades followed Moore's Law, the observation by Intel co-founder Gordon Moore that the number of transistors on an integrated circuit would double every two years.

'Engineers are really starting to expand that third dimension, which is something that hasn't been used in the first 60 years of transistor technology'



Source: FT, 2024, 29 Fev, p. 13