Introduction

I Cold War Chips

From Steel to Silicon

The Switch

Noyce, Kilby, and the Integrated Circuit

Liftoff

Mortars and Mass Production

“I…Want…To…Get…Rich”

II The Circuitry of the American World

Soviet Silicon Valley

“Copy It”

The Transistor Salesman

“Transistor Girls”

Precision Strike

Supply Chain Statecraft

Intel’s Revolutionaries

The Pentagon’s Offset Strategy

III Leadership Lost?

“The Competition Is Tough”

“At War with Japan”

“Shipping Junk”

The Crude Oil of the 1980s

Death Spiral

The Japan That Can Say No

IV America Resurgent

The Potato Chip King

Disrupting Intel

“My Enemy’s Enemy”: The Rise of Korea

“This is the Future”

The KGB’s Directorate T

“Weapons of Mass Destruction”: The Impact of the Offset

War Hero

“The Cold War Is Over and You Have Won”

V Integrated Circuits, Integrated World?

“We Want a Semiconductor Industry in Taiwan”

“All People Must Make Semiconductors”

“Sharing God’s Love with the Chinese”

Lithography Wars

The Innovator’s Dilemma

Running Faster?

VI Offshoring Innovation?

“Real Men Have Fabs”

The rise of foundries like TSMC (Taiwan) made it possible for big chip firms to consider divesting their manufacturing operations and outsourcing to a foundry in Asia.

Jerry Sanders (AMD founder) was committed to his fabs and thought they were crucial to AMD’s success. However, it was becoming harder to make money while owning and operating a fab because each generation of technological improvement made fabs more expensive.

Morris Chang (TSMC) thought the same thing several decades earlier and this is why he thought that TSMC’s business model was superior.

The Fabless Revolution

Gordon Campbell and Dado Banatao (Chips and Technologies) 1984 – their success in producing graphics chips, but outsourcing its manufacturing, was an early example that the fabless business model could work (the starting requirements were a good idea and a couple of million dollars in startup capital – what does this imply for barrier to entry in this business model?)

Nvidia (had its start in a Denny’s in a rough part of San Jose) became the dominant player in graphics processors. Founded in 1993 by Chris Malachowsky, Curtis Priem, and Jensen Huang.

Nvidia chips are largely manufactured by TSMC and are found in most advanced data centers. It’s hard enough simply to design top-notch chips, as Nvidia did. If it had also had to manage its own manufacturing process, it probably wouldn’t have had the resources or the bandwidth to plow money into building a software ecosystem (CUDA).

Qualcomm has made hundreds of billions of dollars selling chips and licensing intellectual property.

Its easy to lament the offshoring of semiconductor manufacturing. But companies like Qualcomm and Nvidia might not have survived if they’d had to invest billions of dollars each year building fabs. As was the case with Nvidia, it was a good thing [they] didn’t have to try to be semiconductor manufacturing experts, too! Thanks to TSMC, Samsung, and other companies willing to produce their chips, Qualcomm's engineers could focus on their core strengths in managing spectrum and in semiconductor design.

The biggest change, however, wasn't simply new types of chips. By making possible mobile phones, advanced graphics, and parallel processing fabless firms enabled entire new types of computing.

Morris Chang’s Grand Alliance

Heading into the 2000s and 2010s the old guard of CEOs was being replaced by CEOs with a balance between MBAs and PhDs. An era of wild wagers on impossible technologies was being superseded by something more organized, professionalized, and rationalized. Bet-the-house gambles were replaced by calculated risk management. The changing of the guard atop the chip industry accelerated the splitting of chip design and manufacturing, with much of the latter offshored.

Apple Silicon

EUV

“There Is No Plan B”

How Intel Forgot Innovation

Nvidia has since bet its future on AI. From its founding, Nvidia outsourced its manufacturing, largely to TSMC, and focused relentlessly on designing new generations of GPUs and rolling out regular improvements to its special programming language called CUDA that makes it straightforward to devise programs that use Nvidia’s chips.

Nvidia’s assent isn’t assured, however, because in addition to buying Nvidia ships, the big cloud companies (Google, Amazon, Microsoft, Facebook, Tencent, Alibaba, and others) have also begun designing their own chips, specialized to their processing needs, with a focus on AI/ML (example Google and tensor processing units [TPU]). Does Nvidia have first mover advantage here?

Since 2015, Intel has repeatedly announced delays to its 10nm and 7nm manufacturing processes, even as TSMC and Samsung have charged ahead. Most experts believe these problems stem from Intel’s delays in EUV adoption tools. (Why would a company that so heavily funded EUV R&D lag so behind in EUV adoption once the technology was shown to be viable in the manufacturing pipeline?)

By the time Intel shuttered its foundry business, only TSMC and Samsung remain that global foundries. Now the entire world’s production of advanced processors was taking place in Taiwan and Korea – just off the coast from America’s emerging strategic competitor – China.

VII China’s Challenge

Made In China

When Japan, Taiwan, and South Korea wanted to break into the complex and high-value portions of the chip industry, they poured capital into their semiconductor companies, organizing government investment but also pressing private banks to lend.

Second, they tried to lure home their scientists and engineers who’d been trained at US universities and worked in Silicon Valley.

Third, they forged partnerships with foreign firms but required them to transfer technology or train local workers.

Fourth, they played foreigners off each other, taking advantage of competition between Silicon Valley firms – and, later, between Americans and Japanese – to get the best deal for themselves.

“Call Forth the Assault”

China’s leaders were counting on a mix of market and military methods to develop advanced chips at home.

Many facets of Xi’s economic agenda, from industrial restructuring to financial market reform, remained stillborn, obstructed by Communist Party bureaucrats and local government officials who preferred the status quo.

Semiconductor demand trends were dangerous (from China’s perspective). Chips were becoming even more important, yet the design and production of the most advanced chips was monopolized by a handful of companies, all located outside of China.

Second paragraph (page 249) very important!

The x86 server chips that remain the workhorse of modern data centers are still dominated by AMD and Intel. There’s no Chinese firm that produces a commercially competitive GPU, leaving China reliant on Nvidia and AMD.

The more China becomes an AI superpower, as Beijing’s boosters promise and as China's government hopes, the more the countries reliance on foreign chips will increase, unless China finds a way to design and manufacture its own.

China's government set out a plan called “Made in China 2025”, which envisioned reducing China's imported share of its chip production from 85% in 2015 to 30% in by 2025.

The “Big Fund”

China was disadvantaged, however, by the government's desire not to build connections with Silicon Valley but to break free of it. This vision of semiconductor independence promised to upend globalization, transforming the production of one the world's most widely traded and most valuable goods.

China’s import of chips in 2017 -> $260B China spends more money buying chips each year than the entire global trade in aircraft. No product is more central to international trade than semiconductors.

CHIP DESIGN 🡨🡪 TOOLS 🡨🡪 FABRICATION SERVICES

Technology Transfer

“Mergers Are Bound to Happen”

The Rise of Huawei

The 5G Future

The Next Offset

Georgetown University’s Ben Buchanan has noted that a “triad” of data, algorithms, and computing power are needed to harness AI. With the exception of computing power, China’s capabilities may already equal the United States’.

The 1970s offset was driven by digital microprocessors, information technologies, new sensors, and stealth. Today’s offset will be driven by advances in AI and autonomy (AI and autonomy [as in autonomous vehicles] will have to work hand-in-hand]).

“The battle for the electromagnetic spectrum”

The warfare of the future will be more reliant than ever on chips – powerful processors to run AI algorithms, big memory chips to crunch data, perfectly tuned analog chips to sense and produce radio waves. In 2017, DARPA launched a new project called the Electronics Resurgence Initiative to help build the next wave of militarily relevant chip technology.

VIII The Chip Choke

“Everything We’re Competing On”

Fujian Jinhua

The Assault on Huawei

China’s Sputnik Moment?

Shortages and Supply Chains

The Taiwan Dilemma

Conclusion