“Chip War: The Fight for the world’s most critical technology”, Chris Miller , Simon & Schuster, (2022). Pp 431.

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On December 16, 1947, Walter Brattain and James Bardeen working at Bell Labs, demonstrated a device which would go on to change the world. They had made the world’s first transistor. They had based their device on theoretical work done by a colleague at Bell Labs, William Shockley. All three of them would go on to win the Nobel Prize, with Bardeen being the only person till date to win it twice in Physics.

The humble transistor is what underpins most of our modern technology- from microwave ovens to missiles; from smartphones to the stock market- life would be unthinkable without them. Although they were initially used for replacing vacuum tubes in computers and other devices, it was only with the invention of the integrated circuit or the microchip that the technology started its exponential development. An integrated circuit as the name suggests, is a device in which large numbers of transistors and other electronic components are integrated on a slab of silicon or a chip. It was developed in 1958 by Jack Kirby at Texas Instruments and Robert Noyce at Fairchild Semiconductor.

Chris Miller’s “Chip War” traces the development of semiconductor chips from the beginning till today. However, this is not just a book on the history of technology- its main focus is in fact the use of this ubiquitous technology by nation states for their strategic goals. Miller demonstrates how economic, political and technological factors shaped the semiconductor industry. His central argument is that for a technology that is so central to our civilization, the global chip industry is actually extremely fragile.

The development of the microchip was the relatively easy part- the hard part was how to produce them reliably, in sufficient numbers and to market them. This was done in by a handful of firms located south of San Francisco, in what came to be known as the Silicon Valley. The men- they were all men- responsible for this were visionary entrepreneurs like Gordon Moore and Robert Noyce who went on to start Fairchild Semiconductor.

Gordon Moore, who later founded Intel, is of course better known for the eponymous law which he proposed in 1965. In an article in an obscure journal called “Electronics”,

Moore predicted that the number of transistors that could be integrated onto a single chip would double every two years. Till very recently, this prediction has proved to be astonishingly true. The first chips had less than 10 transistors. 6 decades later, the most advanced chips have more than 10 billion of them. This kind of growth is rarely seen in any other technological field.

While the science behind semiconductors was fairly well known by the time Fairchild began operations, it was the manufacturing part which was challenging. The basic problem was reliability- even the smallest impurity could render the chip useless. It took several innovations to finally come up with a design which was not only more reliable but also easier to miniaturize. This was critical since smaller transistors would mean more of them on the chip which would make them more powerful and hence more useful in a variety of applications.

Making better chips more reliably solved the supply problem. However, the demand for the chips was an issue- there was simply no consumer market for them. As it happened, the Soviet Union launched the Sputnik followed by sending Yuri Gagarin into space. The American political elite panicked. Suddenly the scientific and technological lead which they had assumed they had over their Cold War rival was in question.

Increased outlay for the space program and the military was what kick started the semiconductor industry. The space program provided the initial leg-up to many of the companies. As Miller writes, "Chip sales to the Apollo program transformed Fairchild from a small startup into a firm with one thousand employees. Sales ballooned from $500000 in 1958 to $21 million in 1960." The military also was gradually convinced to replace the antiquated and inaccurate guidance systems in their missiles with more reliable ones based on microchips. By 1965, military and space applications represented over 95% of chips made by Fairchild.

The underwriting of semiconductor production by NASA and Department of Defense also allowed the companies to reduce the prices for other consumers. Cheaper chips expanded the market and let to various innovations in the consumer electronics sector.

It was the Japanese who first saw the enormous potential of the integrated circuit in consumer electronics. In 1946, while Japan was still in ruins after the war, Akio Morita, heir to one of Japan's most distinguished sake distillery founded Sony. Sony started making tape recorders and rice cookers. In 1953, he managed to get AT&T , the parent company of Bell Labs, to issue him a license to produce transistors. The AT&T executives who agreed to give him the license told him "to expect to manufacture nothing more useful than a hearing aid".

The Japanese semiconductor industry, like the American one, was also made possible because of government support. In the case of Japan, it was low interest rates and easy finance. Companies like Sony were soon making huge investments in production facilities and coming up with innovative consumer products like the transistor radio and later, the Walkman.

It was not as if the Soviet Union was not into the chip game. They were as keen to use the technology primarily because of its military applications. Miller describes the various methods by which they tried to develop the technology. These included not just innocuous academic exchanges but also cloak and dagger operations of spying and smuggling. However, the top down approach favored by the bureaucratic culture of the Soviet Union did not encourage innovation and focused instead on copying the technology. The copy cat approach "condemned them to backwardness" as Miller comments.

Although semiconductors are generically referred to as chips, in fact there are several different kinds of chips. These include memory chips, processors of various kinds as well as specialized chips for niche applications. Various geopolitical and economic factors have led to a handful of firms dominating the market for different kinds of chips. Thus memory chips are dominated by Korean firms like Samsung while the most advanced processor chips are manufactured by TSMC founded by Morris Chang.

Morris Chang was trained in the US and worked at Texas Instruments before coming to Taiwan in the eighties. Over the next few decades, he steered the semiconductor industry in Taiwan to its dominant position in the global chip production. His brilliant idea of separating chip design from manufacturing in "fabs" was primarily responsible for this growth. These are huge factories, costing tens of billions of dollars, which make

chips for others- thus Apple would design the chip for its iPhone and TSMC would manufacture them.

The stranglehold of a few manufacturers of chips (as well as the machines used to make them) on the chip industry is amazing for a developed industry- TSMC produces more than 35% of the computing chips, two Korean companies produce more than 40% of the world's memory chips and a little known Dutch company, ASML produces 100% of the most advanced machines to manufacture chips. Paradoxically, this concentration also makes them pawns in the geopolitical arena specifically between China and the US. Given its history, Taiwan, though being the epicenter of the semiconductor industry is the focus of this rivalry between China and the West.

Chris Miller's book is a thrilling account of the history, business as well as importance of semiconductors. Divided into "byte" sized chapters, 54 in all, this well-researched book is as fast paced as the evolution of the technology which arguably defines our times, much like the 1950's was defined by the atomic technology.

The digital universe for most people has come to mean software firms like Google, Facebook or Microsoft. Rarely do we stop to wonder about the foundation of this amazing world changing innovations. The foundation of all digitalization is the humble chip which powers Google search or allows you to connect with your long lost school friend. "Chip War" is a very good place to start to understand the chip industry and its role in the modern world.

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