Chapter 3

Birth of Microprocessor

In the history of the progress of semiconductor technology, the development of microprocessor in 1971 is such a big event that is paralleled with the invention of transistor in 1947 and IC invention in 1958; one of the three major events.

The unique thing in the microprocessor development process is that it was achieved at Intel, a young venture company, not a place with a huge research organization like Bell Laboratories or IBM. Moreover, calculators were deeply involved in the birth of the microprocessor, and it may be said that "microprocessor was born from a calculator".

Intel introduced the 4-bit microprocessor 4004 to the market in November 1971, and its development process was very dramatic. Let's describe here the process, starting from the foundation of Intel Corporation, and all the way to the microprocessor development.

William Shockley, one of the inventors of transistors, aimed to establish a semiconductor company to operate by himself, and succeeded in receiving support from Arnold Beckman who ran an instrumentation company. In February 1968, "Shockley Semiconductor Laboratory" was established in Palo Alto near Stanford University. Having scouted nationwide top-notch semiconductor engineers by himself, he started the company with 25 members. Among them were included Robert Noyce and Gordon Moore who would be the founders of Intel at a later time. While Shockley was a person with an extremely excellent brain, he was somewhat extraordinary in the relationship making with other people, and gradually lost the trust of the employees. Under these circumstances, in August 1987, Noyce and other seven people gathered together and left the company. They were labeled as "Eight Traitors", but they would later become the central figures of the Silicon Valley, contributing to the prosperity of the semiconductor industry. Noyce was 28 years old at that time.

They established "Fairchild Semiconductor Company" in October 1957 with the support of a millionaire Sherman Fairchild who was the owner of a camera company for aircraft. At the time, military-related demands such as missiles and space satellites were strong for semiconductors, and the performance of Fairchild Semiconductor rapidly expanded. They introduced IC to the market first in the world in 1961, and achieved the top position.

However, the business performance deteriorated in 1968, and got into deficit for the first time since the company started. There was a sweeping change of top officials by the initiative of the headquarters in New York. In opposition to this personnel affair, Noyce decided to leave the company and confided it to Gordon Moore. Moore also left the company in sync with the determination of Noyce, and his subordinate Andy Grove also followed them.

Noyce was 40 years old, Moore 39, and Grove was 32 years old. A new company was founded in July 1968 by these three people as the core. The members were 10 or so, and this was the start of Intel, which would reign as the biggest semiconductor company later on.

The company worked on memory as their first product. The magnetic core memory was used in the computer at the time, but the speed was slow and there was difficulty in miniaturization. Intel aimed

to replace core memory with semiconductor. The first product was 64-bit bipolar memory, but the product that gave a huge impact to the semiconductor industry was the 1 Kbit DRAM, 1103, released in October 1970. The selling price was 10 $, which was sufficient to compete with core memory. The memory business including SRAM and EPROM hit a great success, and it became the driving force of the development of Intel Corporation.

Now as for the process of microprocessor development, the first trigger was an order of calculator LSI from one of the Japanese calculator manufacturers, Nippon Calculating Machine Corp. (commonly known as Busicom) in 1969, soon after the foundation of Intel. Busicom requested the development of 13 kinds of custom LSIs for their product line up, but Intel, still soon after the start of the company and with insufficient engineering resources, was unable to develop these LSIs in parallel.

Ted Hoff was assigned to this project and he worked on this problem from a different angle. That is, rather than separately developing all the chips as the custom products, he thought it would be possible to cope with the different specifications if he could make suitable combination of memory and processor, where the processor operated as defined by the memory content, and by changing memory content (that is, rewriting ROM) to cope with the different calculator models.

The product which was commercialized based on this concept was 4004 (Photo 3.1), on which he worked together with Toshimasa Shima dispatched from Busicom.
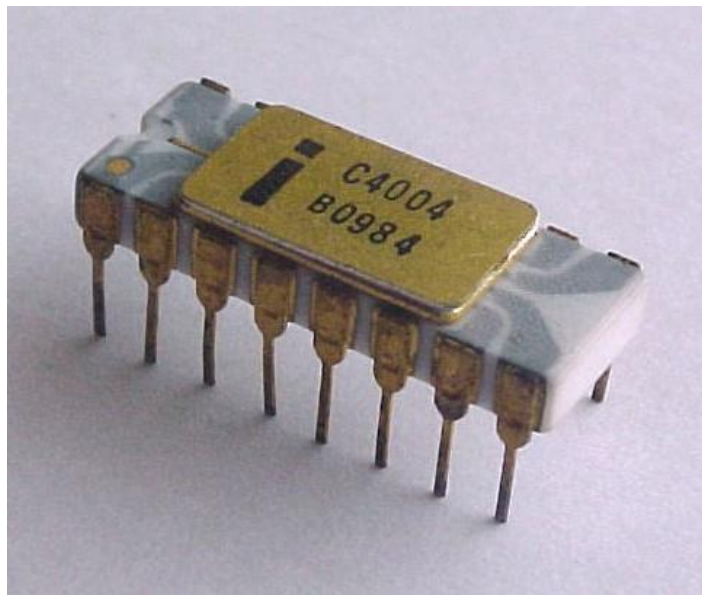

Photo 3.1 First microprocessor in the world, 4004, developed by Intel in 1971
http://www.dentaku-museum.com/hc/computer/intel4004/intel4004.html

Busicom had its exclusive marketing rights because the cost of development of this LSI ($100,000) was carried by them. But ironically, then the calculator market became a fierce brawl pattern. The business condition of Busicom became extremely difficult and they decided to sell all the sales rights to Intel. As a consideration, Intel made a contract to pay 5% of chip sales to Busicom.

Intel, which obtained the sales rights of 4004, sold this product not only to calculator market, but also to various application fields. That is, they proposed an epoch-making method to use standard processor and memory for constructing systems by simply changing the ROM contents of the

memory.

It is a major change from "custom product design method" which was the mainstream at the time to "standard product design method".

Advertisement (Photo 3.2) published in the Electronics magazine in 1971 was a message telling the arrival of the very new era.

Photo 3.2 Advertisement of 4-bit microprocessor published in Electronics magazine of November 1971 issue. A message tells us the arrival of a new era.

http://www.dentaku-museum.com/hc/computer/intel4004/intel4004.html

Introduction of microprocessor triggered a revolutionary change not only in the semiconductor industry, but also in the electronics industry as a whole. It was a change from "custom-product-based design method" to "standard-product-based design method", and its impact expanded widely into the industry.

Hitachi had an overwhelming competitiveness in custom LSI for calculators which had become a major pillar supporting the performance of the semiconductor division in the early 1970's, but the appearance of microprocessor gradually affected the business as body blows.

Now, the time machine flies to 1997. The Kyoto Prize was awarded to the developers of the great products of microprocessor.

The Kyoto Prize is an international award, with prize money of 50 million yen, founded in 1984 by Kazuo Inamori, the founder of Kyocera, and is awarded to those who made a remarkable contribution in science, technology and culture. The winners this time were Federico Faggin, Edward (Ted) Hoff, Stanley Mazor, and Masatoshi Shima, who led the development of 4004. From the faces of the winners, it may be said that "microprocessor was born from a calculator".

As we have seen so far, there are several coincidental factors involved in the development of microprocessor. It is said that "There is no 'If' in history", but "If" questions and answers about the following points are interesting:

Q: What would have happened if LSI development request from Busicom had been made to another company, not Intel? Perhaps a lot of engineers pursued development of custom LSI in parallel?

A: There must have been a good reason for Busicom to choose Intel, and Intel had an excellent computer architect (Ted Hoff), and development was done based on a unique idea, which led to the commercialization of microprocessor.

Q: What would have happened if the market condition of the calculator had not become a rough battle and management of Busicom had proceeded smoothly? Perhaps the sales right of microprocessor would not have been handed over to Intel, would it?

A: As for the world's first microprocessor 4004, the sales right may not have been handed over to Intel, but Intel's development of its own microprocessor would have been a matter of time. Even if it was the development request from the Busicom, the idea of the microprocessor was created by Ted Hoff of Intel.

Well, as mentioned in the previous chapter, the "Special Project" for LSI development for calculators was advanced in Hitachi in 1969, which was incidentally the same year when the joint development of Intel and Busicom started. Also, in order to deal with models of different specifications, we had the same concept of rewriting ROM, instead of using different LSIs. That is, rather than being a complete custom product, it was a product aiming at ASSP (Application Specific Standard Product). In fact, Hitachi's LSI for calculator, the HD 3200 series was announced in the press as "the world's first ROM-based LSI", and its flexibility was the strongest sales point. Although it is a big "if", Hitachi, too, was close to the development of the first microprocessor. That is, in terms of adopting ROM, the gap between these two concepts was very thin, as thin as a piece of paper. However, the "thin gap" was not overcome even with all the Hitachi's expertise.

In the case of Hitachi, our LSIs covered the field of calculators as ASSP, whereas at Intel they aimed to cover the general and larger market segments by computer architecture, albeit a "micro scale computer".

As for myself at that time, recalling it from today's perspective, I have to admit my narrow views and the lack of imagination.

In the early 1970's, semiconductor makers around the world had fierce competition over the development of LSIs for calculators, and it was surely the "fetal stage of microprocessor". And it was Intel that got one step ahead.

Following the commercialization of 4004 in 1971, Intel released 8-bit MPU 8008 in 1972 and 8-bit MPU 8080 based on NMOS in 1974.

Intense competition with Motorola's 6800 occurred in the 8080 generation, and global semiconductor manufacturers were forced to choose which side they would follow. Hitachi chose Motorola's 6800, and I will describe this case later.

Well, Intel is currently at the top of the semiconductor industry, and there are two notable factors to establish that position. Firstly, the 8-bit MPU 8088 which had been developed in 1979 was adopted by IBM PC two years later, in 1981. This was the beginning of the PC standard called "WINTEL" today, creating a huge market.

Another major factor is that the company withdrew from the DRAM business in the memory recession of 1985. After this decision, the company concentrated all the resources on the microprocessor business, and it resulted in the big success of today.

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