Chapter 6

Controversy over CMOS Strategy

Conflict within Allied Forces

The partnership with Motorola in the microprocessor business was strongly felt by both parties as “allied forces” in the beginning of 1977, and there was an implicit oath that “We will raise 6800 series as the mainstream in the world, competing against Intel by the cooperation of our two companies.” Hitachi was also expected to make an appropriate contribution to strengthen the camp. In response to such expectations, Hitachi worked on two major technologies to strengthen the 6800 series.

One was to apply high-speed CMOS technology to microprocessors, and the other was to adopt ZTAT (standing for Zero TAT, one type of field programmable microprocessor) technology. Later, we would confront with Motorola concerning the introduction of these two innovative technologies, and I will first describe the movements of both companies over CMOS technology. I will describe ZTAT situation in the next section.

In 1978, Hitachi developed the world’s first high-speed CMOS technology (Hi-CMOS) and applied it to 4K and 16K bit SRAM, and they made a great success. HM6116 secured the world’s top share in 16K SRAM at the end of 1981. And we set an 8-bit microprocessor as the next product to apply this technology to, and we developed HD6301 as the CMOS version of 6801 (NMOS) of the Motorola architecture, and the product was announced in October, 1981.

This was a breakthrough product as a CMOS microprocessor, and it became a product that would lead the semiconductor technology trend of the world. Fig. 6.1 shows a chip photo of 6301V.

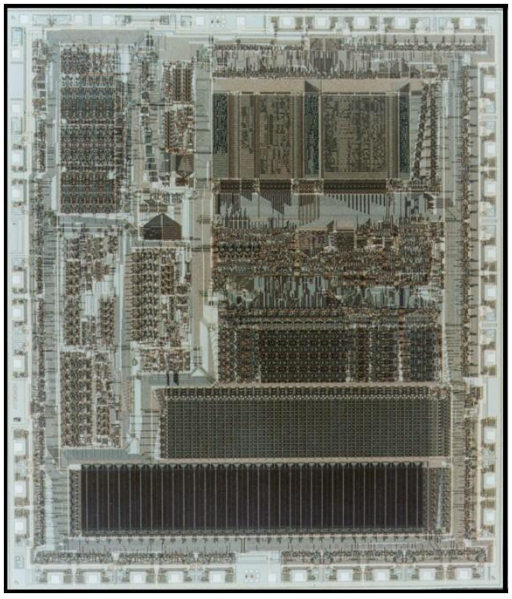

Fig. 6.1 Chip photo of CMOS microprocessor 6301V

This development project was executed in an astonishing speed by “Special Research Project” scheme in which integrated efforts of research laboratories and the factory operations were effectively organized. The result was published in the December 1983 issue of IEEE MICRO, and

the authors of this paper were Hideo Maejima and Akihiro Katsura from Hitachi Research Laboratories, Hideo Nakamura from Central Research Laboratories, and Toshimasa Kihara from Musashi Works. They can be called pioneers of CMOS microprocessors. Yasushi Akao, former President of Renesas Electronics, was also the one who joined this project soon after he entered Hitachi and thereby nurtured his capability.

The world's first handheld computer

Let me introduce an episode about the first user of 6301. This is about Koichi Nakamura, a director of Shinshu Seiki (later Seiko Epson), who later became President of Taito.

He was waiting impatiently for the birth of 6301. Since he was also my junior alumni of La Salle high school (Kagoshima prefecture), we had good friendship. He visited me in March 1981 for some confidential talk with me.

It was about his product plan of all-CMOS PC in which he wanted to use 6301 as the main processor. He asked me to deliver a sample as soon as it became ready. Although 6301 was still in the stage of paper specs without any physical entity at that time, I felt his extraordinary enthusiasm and accepted his request. I was then carefully watching the state of development progress.

The first cut sample was completed in early August, and I got a report on the result. Although it was not perfect, the report was that it would operate properly if a minor modification was made by laser cut in three circuit points. As a first cut sample of such a breakthrough new product, it was really an amazingly good result!

We provided Nakamura with the first sample with laser cuts. It should have been a surprise to Nakamura, since the sample delivery was much sooner than the promised schedule, in which we included two-putting margin (two-putting meaning modification of two times). In-house debugging of 6301 was progressed smoothly, characteristics qualification was completed in October, and the official product announcement was made during the same month.

As the new year started, Nakamura visited us at the end of January 1982, and gave us a detailed explanation of the new product using 6301. It was the concept of the world's first handheld computer. With two 6301 processors, the system was in all CMOS configuration with 8-KB RAM and 32-KB ROM. Firm support was requested to us, since all of these CMOS devices would be supplied from Hitachi.

And in July of the same year, a product announcement of "HC-20" was made. This product was a pioneer of mobile computers, so to speak, and it made a great success in the market by the advantage of its features suited for sales persons and others. In January of the following year, Nakamura came to visit us again to express his gratitude for our cooperation on this matter, and he said that the purchase amount of semiconductors from Hitachi in December of the previous year reached 400 million yen. It was the accomplishment by kit business with 6301 as the core product.

In order to show the power of CMOS technology, I decided to use this outstanding product as an actual example case in my presentation material. Fig. 6.2 is a page from the many documents at this time, and it shows the performance and specific figures of HC-20 of "All CMOS system", compared to ENIAC, the world first electronic computer.

The superiority of HC-20 is in orders of magnitude for all items. We emphasized that "the future is CMOS era", by using it for explanations to customers and in various occasions of speeches.

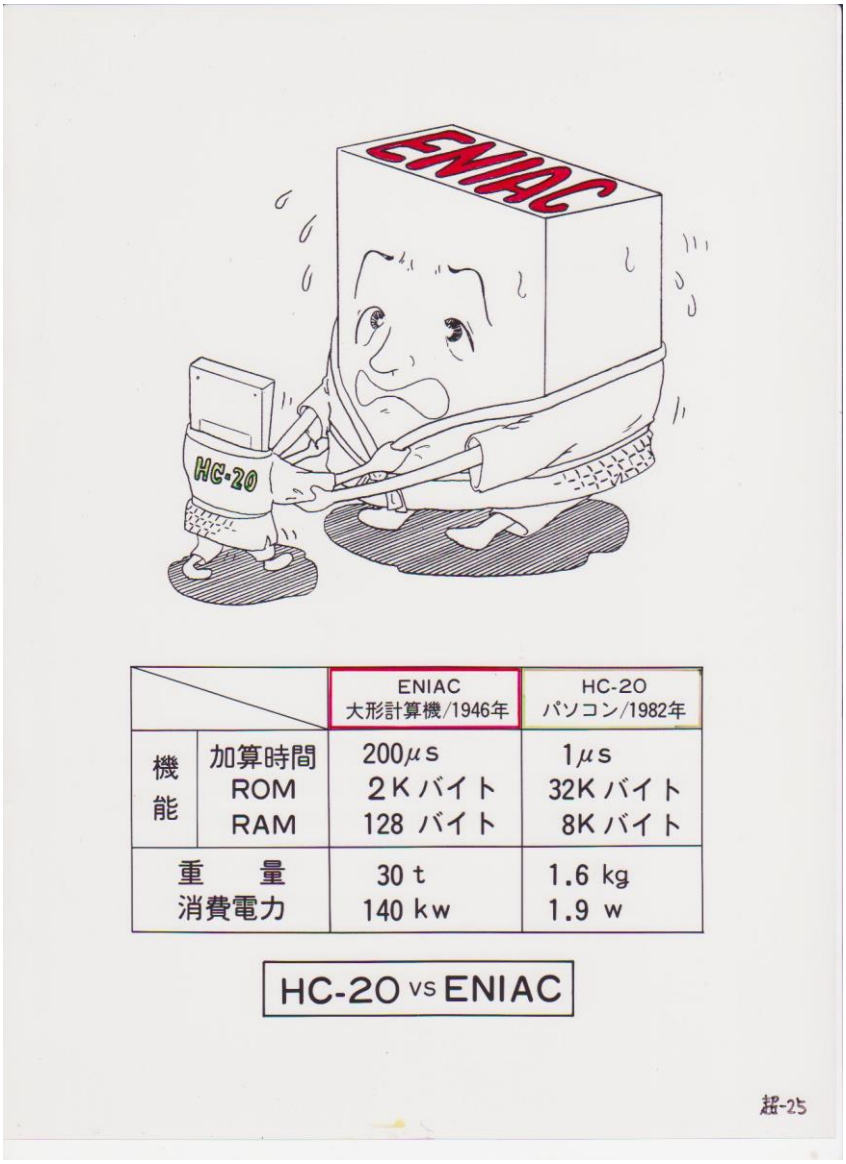

Fig.6.2 Presentation materials (around 1982) used to show the power of the handheld PC “HC-20”, using CMOS microprocessors, compared with ENIAC.

Although the concept of “mobile computing” or “nomadic computing” was not clearly defined yet at this time, HC-20 signaled an advent of a new nomadic life style realized by the progress of CMOS technology.

NMOS or CMOS?

Well, based on the contract with Motorola, 6301 V was immediately disclosed to them and technology transfer was carried out. As was described above, the reaction from the market was very good, and I anticipated that Motorola would also highly appreciate this product. But in contrast to that expectation, the reaction from them was negative contrary to my expectation.

At that time, I was in charge of microprocessor business, overseeing it as Deputy GM of Musashi Works, but I had had little interaction with Motorola executives for some time, since I had been Department Manager of Memory Design for three years before that.

In response to a report that the relationship between the two companies was beginning to be shaky,

I decided to visit Motorola in April 1982. The purpose was to talk frankly with the semiconductor executives of the company.

There were all the key members in the meeting, including Gary Tooker, the top of the semiconductor business, Jim Norrin, the top of marketing, Murray Goldman, the top of microprocessors business, and also Owen Williams who was in charge of external liaison.

Although it was a meeting in a friendly atmosphere on the surface, the contents of discussion were actually very severe. The points of their dissatisfaction can be summarized as follows, although not in order of criticality.

① Insufficient efforts of customer development: Hitachi does not provide sufficient resources, such as FAEs or Field Application Engineers, for customer development, and competes with Motorola by selling CMOS version products to the customers which they developed.

② Insufficient contribution to Motorola business: They introduced CMOS process and SRAM from Hitachi, but they have not been successfully manufactured at Motorola and have not contributed to their business.

③ Development delay: Despite Hitachi's shared role of the development of DMA (Direct Memory Access), it has been delayed considerably and has not yet converged.

I argued on each item with my view, and asked for their understanding, but no intention was shown from their side to actively commercialize CMOS microprocessors (6301).

During this period, CMOS was still positioned as a niche technology. The industry consensus was that, "NMOS is the mainstream. CMOS is low power, but inferior in terms of speed and cost." Meanwhile, Hitachi had a firm conviction that "CMOS will become the mainstream" since the success of mass production of 16K SRAM in 1981. It seems that such conceptual gap was one of the reasons for deteriorating the ties between the two companies. At that time, all 8-bit microprocessors from Intel and others were based on NMOS, and Motorola probably did not intend to take the risk to CMOS. I found anew that they had a big frustration about the overall partner relationship with Hitachi, and thought that finer dialogues would be necessary.

At the end of January 1983, Bill Howard, who became a new contractual head, visited us with his subordinate members, and we spent a whole day to pick up all the issues of concern, and discussed how we should proceed to restore the relationship. We could make a big step forward in this meeting, and came to the agreement on the commercialization of 8-bit 6301 at Motorola after confirming the process compatibility. However, it took several more months to the final settlement

From their side, the bigger concern at that time was the commercialization of the CMOS version of the 16-bit microprocessors 68000 (referred to as 63000 or 63K in Hitachi). It took two and half years after this meeting in the negotiations to resolve so-called "63K authorization problem", whether or not Motorola would approve 63K commercialization. Although we had difficult arguments in the day time session, we invited them to a quiet Japanese restaurant, Chinzan-so, as the night session, and conversations sprang up while drinking. We talked about having regular executive meetings twice a year to deepen the mutual understanding.

Well, a few words about Bill Howard. He had a doctoral degree in EE (Electrical Engineering) from the prestigious UC/Berkeley, and had deep knowledge of semiconductor technology, and well

understood about the direction of CMOS conversion. Moreover, he had mild and faithful personality, and was a respectful negotiator.

Aside from that, there was an occasion when he brought back the agreed matters between us and reported to the Motorola executives, and was refused. At that time, Bill Howard came all the way to visit us only to explain the matter. I was moved by his serious and faithful attitude which made me think of Samurai. After a while, he was transferred to the headquarters from the semiconductor sector, and did not join our semiconductor negotiations since then. Photo 6.1 is when we dined with Bill Howard.

Photo 6.1 Bill Howard who negotiated with us on the technical collaboration agreement of the microprocessor business

Settlement with CMOS 8-bit microprocessor

Based on the meeting with Bill Howard in January 1983, I visited Motorola in the autumn of the same year in Austin where they had their MOS operation base, with Hatsukano, the marketing manager, and Tsukada, overseas business manager at the headquarters. We had a meeting with Murray Goldman and others who managed microprocessor business. Many people who were engaged in practical work joined the meeting and there were many lively discussions, and among them the CMOS yield problem was strongly appealed. The trial manufacturing of CMOS microprocessor, 6301, and 16K bit CMOS SRAM, 6116, had already been started, but they were suffering from not being able to improve yield. They must have been suffering so badly that they even made a request to “assure the yield improvement to x-% by when.” Since Mortorola was a top-class company as a semiconductor manufacturer, we felt like “You are kidding!”. But we listened to further details of their situation and decided to give better support to them, because if their CMOS production would not succeed, the technical cooperation would face a serious situation. The meeting lasted for two days, and we had a big step forward. An agreement was reached on the pending CMOS microprocessor issues, and they decided to commercialize and second source 6301. After a year and a half of long negotiations, it finally was resolved. However, it took more time to start up the manufacturing at Motorola, and the official product announced from them was made in December 1984.

Murray Goldman held a doctoral degree in Computer Science and was a leading expert on that path. He had a high-level insight in microprocessor architecture and I got a lot of enlightenment from him. Moreover, he was a respectful gentleman, being a quiet talker, with good sociable manners.

In the evening after the meeting on the second day, he invited us to “his most favorite restaurant in Austin.” We were curious as to what kind of restaurant it might be. Actually, it was an elegant French restaurant in a quiet place out of the town. Surprisingly, his daughter worked there. “I see! I’m sure his mind must be rested there,” I thought. The daughter lady came out immediately to greet us and said, “We prepared a special dish this evening, and we have plenty of delicious wines, too. Please relax all of you.” We enjoyed the hospitality from both the farther and the daughter. In this restaurant, we talked about various topics ranging from public and private, and we could finish in a very good atmosphere by concluding to accomplish the result of “win-win” that would be beneficial to both companies, by solving the problems by cooperating with each other.

His attentive attitude is still a good memory in my mind. After this meeting, every time a difficult phase between the two companies came out, we had face-to-face discussions, and we deepened our relationships. Photo 6.2 is at the time of dinner with Murray Goldman.

Photo 6.2 Murray Goldman who negotiated with us on the second source contract of CMOS microprocessor

Is 16-bit CMOS version an Unwelcome Guest?

In 1984, it was reported that the top management of Motorola semiconductor was increasingly frustrated about the partnership with Hitachi. At the end of February, both Owen Williams and Buzz Bemus, the contractual contacts, came and we had discussions on the breakthrough for two days.

It seemed that they were extremely skeptical against making the conversion of microprocessors to CMOS. In particular, they opposed to the market entry of 16-bit CMOS microprocessors, stating that the 16-bit CMOS microprocessor 63K is “unwelcome guest”. A request was also made that if Hitachi wanted to maintain the partnership relationship with Motorola and wanted to promote the conversion of microprocessors into CMOS, then the technology transfer of a “big item”, like 1 Mbit DRAM class, based on the state-of-the-art 1.3-micron technology would be necessary. After that, various practical negotiations were held between the companies, and the balance sheet of

technology exchanges was examined. And finally we reached to an agreement in reasonable terms.
However, as a result of taking it back home, *a* message came back from Motorola that their top management said “No!”

After all, the 63K authorization problem did not reach agreement. Although there were various movements in this year, there was no meaningful progress, and the time passed helplessly.
However, at the end of the year, they officially announced that “they will second source 6301V”, probably because the CMOS yield made some improvement. Three years had passed since Hitachi announced it in 1981. It was the first time for our CMOS microprocessors to have a second source, and marketing activities were accelerated. However, the authorization problem of the 16-bit microprocessors (63K) remained deadlocked through the year, and the breakthrough of this problem was the task of the next year
As the middle of 1985 was approaching, a meeting with Murray Goldman was set in Anchorage on June 4th. Anchorage was chosen with the aim to discuss the matters thoroughly, staying away from the both companies. Moreover, since the temperature of Anchorage was low, expectation was also included that it might help to have good discussion by cool down. Together with Goldman, Owen Williams (negotiation window) and Tom Gunter (16-bit microprocessor) were present from their side. From Hitachi, besides me, Hatsukano (microprocessor marketing), Kita (16-bit microprocessor), Yasuda (8-bit microprocessor), and Tsukada (head office/overseas department) attended.
The members had known well each other, and the meeting proceeded in a friendly atmosphere, and we achieved a big step forward. It was agreed that Motorola would acknowledge the commercialization of CMOS 16-bit microprocessor, 63K, which Hitachi had long wanted, and that they would second source the product.
It was a settlement through a long way. I assume that the recognition was firmed up within Motorola at this point that CMOS was an unavoidable route into future. The conclusion of the Anchorage meeting was reported to the top of both sides and was accepted without objection. The administrative procedure of the contract was completed by the end of August, and in Hitachi it was approved by the Board of Directors in September. The product announcement took place on September 13, 1985, right after the approval. The product name was set as 68HC000 with the request of Motorola. Although it was the result of long negotiations over two years, the CMOS 16-bit microprocessor finally got into the limelight.
As mentioned earlier, this product was developed mainly by HMSI, and it is the world’s first CMOS 16bit microprocessor, making the new trend of device technology decisive.

Although we crossed over a mountain ...
Why did the negotiations with Motorola get into such a difficult situation? As I previously touched a little bit, one of the reasons was the conceptual gap between the two companies about “NMOS or CMOS?”
Masuhara of Hitachi CRL presented on the 4K CMOS SRAM at ISSCC in 1978, and Yasui of Musashi Works presented on the 16K CMOS SRAM in the following year, and they created big discussions in the academic conferences. I had confirmed the successful manufacturing of 16K

SRAM, and had a firm conviction in myself that “future mainstream will be CMOS, replacing NMOS.” I presented that view at the Dataquest meeting in the fall of 1981. The top leaders from semiconductor companies including Intel’s Robert Noyce were present at the conference, and this statement created a sensation, triggering the argument of “NMOS or CMOS?”
Hitachi expanded the results of mass production of SRAM to other devices such as microprocessor, and set a trend of new semiconductor technology. Meanwhile, as for the industry as a whole, the discussion on whether NMOS or CMOS was converged around 1985, and it was the timing when the commercialization of CMOS 16-bit microprocessor (68HC000) was agreed.

Another factor in the difficult negotiation was that the top level personal network between the two companies was lacking. We lacked in the company’s top-level channels. As I mentioned earlier, it was Yoshinobu Imamura who first contacted the top of Motorola and opened up the path of technical cooperation regarding microprocessor. He stayed as GM of Semiconductor Division for two years since 1973, and he paid careful attention to maintain the good relationship between the two companies. However, the successor GM from the heavy electric machinery division treated this relationship coldly, and the pipe between the tops was completely broken. The bigger the partnership relationship, the top person network, that is, the relationship of trust as the company, naturally becomes more important.
Well, although there were twists and turns, the conflict about the strategic direction of the CMOS microprocessor was finally resolved, and the major issue was cleared. On one hand, I felt a sense of relief that we finally crossed over a mountain, but on the other hand, the sense of crisis which I had kept in my mind from some time before grew more and more. It was a question about the operations which depended on an outside company with respect to the microprocessor architecture. It may not be possible to develop our own technologies and to expand the semiconductor business into the future.
“No matter how hard it might be, we must have an original architecture that we can completely control by ourselves”. This kind of feeling would come to be shared among all Hitachi microprocessor engineers. And this built up the energy of “challenge to original MPU architecture”.

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