Chapter 7

Commercialization of ZTAT Microprocessor

What is ZTAT Microprocessor?

One of the major factors in promoting semiconductor innovation is the continuous conflicts between old technology and new technology. Companies that conduct their business depending mainly on older technology products try to extend the life of conventional technology as much as possible, but companies that challenge with products of new technology do not have anything to lose, and they challenge the old technology with a bold strategy.

When its momentum is intense, it becomes “Disruptive Technology” which replaces the product of the old generation technology. The high-speed CMOS technology introduced in the early 1980’s was just this innovative technology suitable to be called “Disruptive Technology”. It won the position of mainstream replacing NMOS technology which had been the mainstream until then. With this background of replacement of old technology by new technology, the “CMOS strategy conflict” between Hitachi and Motorola occurred, as I described in the previous chapter.

Another disruptive technology led by Hitachi in the field of microprocessor was ZTAT microprocessor. A new conflict occurred between the two companies once again with regard to the introduction of this product, and it eventually led us to the definite break.

ZTAT is an abbreviation for “Zero Turn Around Time”, which I named to mean that TAT is zero. In ordinary microprocessor, program memory is written by changing mask ROM, but the time from start to finish (called TAT) ranges from several weeks to a month on a mass production basis. It is always required to shorten this as much as possible, and “Q-TAT” was the keyword of the time. Q means “Quick”. We positioned ZTAT as the ultimate concept of Q-TAT.

As a side talk, it was in July 1980 when I first came across the word QTAT. It was when I visited East Fishkill factory of IBM. This factory was a base for R&D and mass production of semiconductors mainly for the in-house use. In this factory, there was a prototyping line for realizing extremely short TAT, and it was named “Q-TAT line”. It was close to the concept of today’s single wafer processing, and the goal of the project was to bring the time from start to completion as close to physical processing time as possible. With a strong impression at this time in the background, I regularly tried to appeal to the mind of our employees’ speed consciousness, that is, to shorten the manufacturing TAT.

ZTAT microprocessor uses EPROM memory cells for ROM, and is encapsulated in plastic packages for the cost reduction purpose. Therefore, only one time write is possible in this method, and it is called OTP or “One Time Programmable” ROM.

The ZTAT microprocessor is a combination of existing technologies and has no technical breakthrough or freshness in itself, but it is an innovative concept aiming at shortening the time, like a “Columbus’ egg”.

Project initiated by ICBM

The trigger for the commercialization of this ZTAT was “ICBM (Intercontinental Ballistic Missile)” that flew to me soon after my appointment as a Deputy GM of Musashi Works in 1981. Here, “ICBM” refers to direct telephone calls from the top management of customers without passing through the normal business route, when some big problems have occurred. The first ICBM I received was from an in-house VCR factory executive.

The content of the phone call at that time was that a bug was found in the program of the control microprocessor of the VCR and it had to be reworked very quickly, which was an emergency situation. It would be a serious problem if the VCR product, whose price was much higher compared to microprocessor devices, could not be shipped because of the problem of a single microprocessor.

I would quickly gather responsible persons from the relevant departments and discuss “How can we deal with this in the shortest Q-TAT?” I would reply to ICBM person after filling up to the best point possible, but of course we would not be able to get complete satisfaction of the customers. However, since they would also understand that this was the best we could do, they would accept it unwillingly.

However, after a while, I received another fly of ICBM from a different customer. Every time, we would hold an emergency meeting, picked out the shortest Q–TAT arrangement, and answered to the customer side. This kind of thing was repeated many times

It’s just an aside, but this topic reminds me of a man who was working very earnestly on the Q-TAT challenge. He was a hot-blooded man who could be said to be “a master of shortening delivery time”. Yutaka Yamawaki had joined the company in 1964, and was then the chief of development management section. His ordinary mission was to manage the progress of the product development and to take measures against bottlenecks so that the delivery date would be on time. He had deep connections with people in each process of development work, and he had grasped each situation firmly. And the trust from both his subordinates and his boss was great, and he would play the role of rubricating oil among the different teams in the development work.

Every time ICBM flew to me, I would call him at the very beginning, and have him organize the countermeasures. Things would go much smoothly by adopting his proposal than giving my order from higher position to each section.

His talent of winning the hearts and minds of people was extraordinary, and I sometimes felt that he had something overlapping with the image of Kakuei Tanaka when he was young, who was a prime minister of Japan at one time and was from Niigata Prefecture, same as Yamawaki.

However, what a heavenly setting! He suddenly passed away in 1988 when I was at Takasaki Works as GM. At the time when Hitachi semiconductor was aiming at the world top by breakthrough products, he worked with a passion like a fireball and burned out. At the age of 42, I cannot regret enough his young death. Photo 7.1 was taken when I was invited to a dinner with Wakashimazu, a Sumo wrestler from Tanegashima, Kagoshima prefecture (his rank was Sekiwake then and Ozeki later), with Yamawaki.

Photo 7.1 Dinner with Wakashimazu in the center, Yamawaki at right (May 1982)

Well, after having these kinds of ICBM situations several times, I felt that Q-TAT was just Q-TAT after all, and there was naturally a limit to it, no matter how hard we put our efforts. I thought that we would get a fundamental solution if we made it “field programmable”, and I came to focus on the OTP-ROM scheme. And in order to establish this system as the brand of Hitachi’s microprocessor, the marketing team proceeded in registration of the name “ZTAT” as a trademark. The registration application was made in April 1984 before products were made, and it was registered in October 1986.

It was 1983 when we started developing the world’s first ZTAT microprocessor. The Microprocessor Design Department became the center of the project; with Hajime Yasuda, Dept. Mngr., Toshimasa Kihara, Senior engineer, Tsuneo Sato, Kiyoshi Matsubara et al. Furthermore, the talented engineers also joined from process development, prototyping section, manufacturing and quality assurance. As the most important project, it was advanced in the form of a rush work, and every process step was given priority. The target date of the first cut sample was the end of the year. However, the difficulty level of the ZTAT microprocessor was higher than expected, and we could not obtain an operating sample in sufficient manner in this first cut trial. After that, failure analysis was carried out and it took six more months until fully operational samples were obtained. The final version lot came out in June 1984, and the yield of the probe test was 42%. We got the feel that we could move ahead with this result. We pushed forward to make WS (working samples), and 1,000 samples were ready at the end of August.

The step following WS was the certification of ES (Engineering Sample) including reliability tests. Although it was scheduled to be completed at the end of October this year, unexpected difficult problems occurred. A particularly serious problem was that “write yield” was very low and “data retention characteristics” was insufficient. Due to the nature of the product as OTP, it cannot be written or erased at the stage of the finished product, so all kinds of screening tests must be completed at the probe test stage.

For this reason, a vast number of samples were subjected to various combination tests, and precious know-hows were accumulated. After these processes, the certification ES was completed at the end of December, and the activities of expanding sales and increasing production were accelerated from this point.

Fig. 7.1 is a chip photo of the 63701X which became the world's first ZTAT microprocessor. It was based on the state-of-the art 2μm CMOS technology at the time.

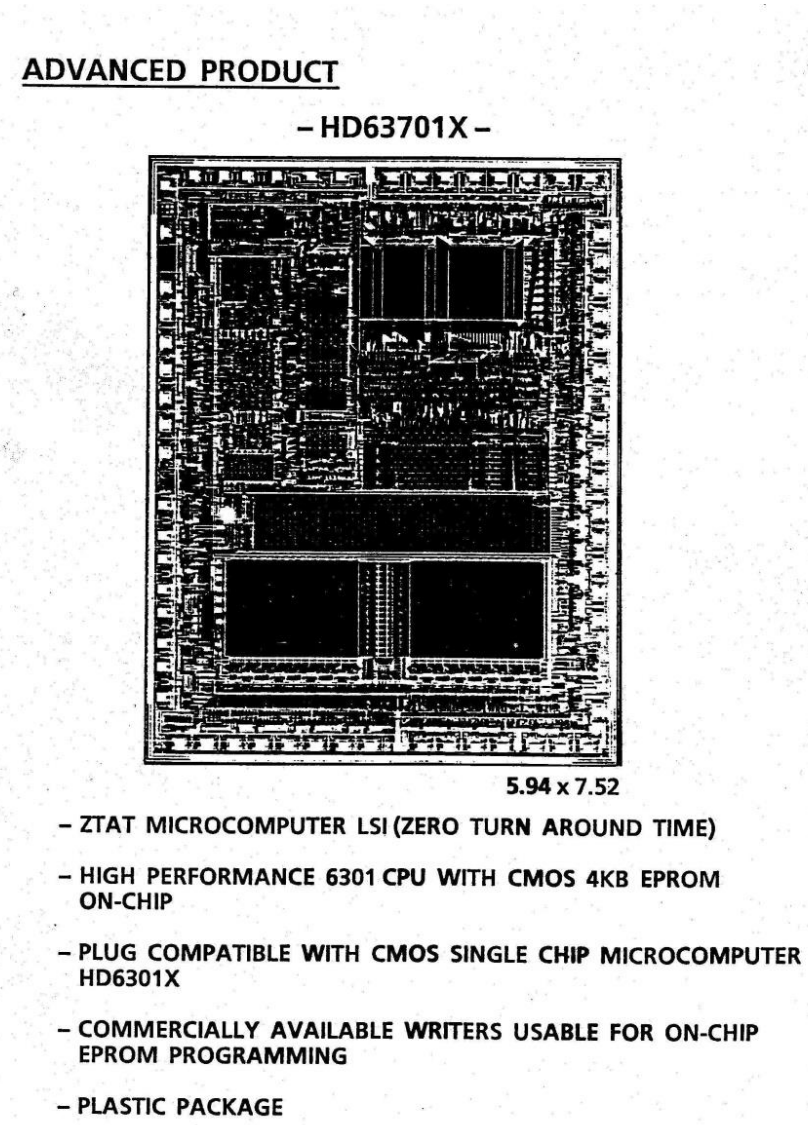

Fig. 7.1 Chip photo of the 63701X which became the world's first ZTAT microprocessor based on the state-of-the-art 2μm CMOS technology with the chip size of 5.9 × 7.5 mm
Source: T. Makimoto, "Products and Technologies 1986".

Press release of the ZTAT trio.

The first major user of the ZTAT microprocessor was Odawara Works of Hitachi. The factory was handling storage products such as magnetic disks, and the ZTAT microprocessor was the best choice for small modifications to the specifications for each customer. Since they played the role of a beta site customer, we offered samples with top priority. At the end of January in the new year, a sales caravan to US, the largest market, was dispatched as the first step of expanding sales of ZTAT.

In March of 1985, working samples of 63705V and 63701V were completed which were being developed concurrently, and more than 100 samples were accumulated respectively. The trio of the ZTAT was now ready. The press release of the ZTAT microprocessor was made on May 16, 1985. It was an announcement with the line-up of 3 products, and basic concept and technical contents were explained. Since the press release, the name of ZTAT gradually expanded both domestically and abroad, and the interest of sales force also became stronger.

In parallel with the preparation for the press release, we decided to launch the “WIN project” to promote market introduction by a proposal from Serve Sucker of HAL (Hitachi America). It goes without saying that WIN is “Design Win”. A team of six members in full time engagement was formed in April, and a special training on the ZTAT microprocessor was conducted. It was late May when they left for the US after finishing the training and it was a long business trip for 4 months. In addition, a domestic version of WIN project was started in August to further promote the market introduction, and also seven members for the second North American WIN project were dispatched in October for the long business trip.

As domestic and overseas sales activities became active, purchase orders also increased sharply. In the process of launching such a breakthrough new product, the most difficult thing is the matching of demand forecast and production volume. Because both have uncertainties, we often face to unexpected inconsistencies. The delivery problem from June to July in 1986 occurred in such a situation. Demand far exceeded expectations, while the production side fell short of the plan due to sluggish yield. Customers scolded us that, “You call it ZTAT, and yet it is not ZTAT if we cannot get the product.!”

As a result of failure analysis which was carried out by the mobilization of many process and device related engineers, we could finally catch the main cause of the failure. It was the yield deterioration caused by insufficient control of etched shapes of the floating gates. As all the measures were taken, the yield improved steadily, and the total production of the ZTAT microprocessors reached 240,000 pieces (about 500 million yen in sales) in August. This sort of rapid increase of sales was unprecedented as new microprocessor products, and we had strong expectation that the new promising large scale products were born.

Star of hope

As the momentum of this launch shows, ZTAT was a new technology indeed which deserved the name of Disruptive Technology. Although it was made by the combination of existing technologies and by many accumulated know-hows of reliability and yield improvement, for that very reason, it could establish an overwhelming leading position among world microprocessor manufacturers.

Fig.7.2 is a page from the presentation materials for customers, “Products and Technologies 1986”, that I used when I was GM of Musashi Works. It compares Hitachi ZTAT products with Intel’s counter product (8751). Hitachi products was CMOS and Intel products was NMOS, and I chose 8751 as the comparison which was the highest performance product at that time. The speed of our product is equal to or higher than that of the Intel product, and the power consumption is about 1/15 in operation and about 1/10 in standby. The package of Hitachi products is plastic (ZTAT), while Intel products are CERDIP (ceramic). From this comparison table, we can read out the marked difference between the two.

ZTAT MICROCOMPUTER FAMILY v.s. 8751

ITEM		ZTAT MICROCOMPUTER FAMILY					8751	NOTE
		HD63701X	HD63701V	HD63701Y	HD63705V	HD63705Z		
PROCESS TECHNOLOGY		2μm CMOS EPROM	2μm CMOS EPROM	2μm CMOS EPROM	2μm CMOS EPROM	2μm CMOS EPROM	NMOS EPROM	
PROCESSING SPEED (μS)		1.0 0.5*1	1.0 0.5*1	1.0 0.5*1	1.0 0.5*1	1.0 0.5*1	1.0	MIN. INSTRUCTION EXECU-TION TIME *1 2MHz VERSION
POWER DISSIPATION (MAX.)	ACTIVE (mA)	10	10	10	10	10	150	
	POWER SAVE (mA)	2 / 0.015	3 / 0.015	3 / 0.015	5 / 0.015	5 / 0.015	20	
ON-CHIP MEMORY	ROM (K BYTE)	4	4	16	4	8	4	
	RAM (BYTE)	192	192	256	192	384	128	
SERIAL I / O		UART CLOCKED SI / O	UART	UART CLOCKED SI / O	CLOCKED SI / O	UART CLOCKED SI / O	UART CLOCKED SI / O	
TIMER / COUNTERS		2	1	2	1	3	2	
I / O PORTS		53	29	53	31	68	32	
PACKAGE		DIP 64S (PLASTIC CERAMIC)	DIP 40 (PLASTIC CERAMIC)	DIP 64S (PLASTIC CERAMIC)	DIP 40 (PLASTIC CERAMIC)	FP 80 (PLASTIC)	DIP 40 CERDIP	

Fig. 7.2 Table showing ZTAT microprocessor products

The right side shows NMOS based Intel products (8751). 63701Y and 63705Z in the table were not put into market because of the dispute with Motorola (described later). Source: T. Makimoto, “Products and Technologies 1986”

Here, I would like to introduce the phrase I used as the concluding words in customer presentations and lectures in order to express the future of ZTAT. “Someday, all micros will be made this way: ZTAT”

In the common sense of those days, the mainstream of microprocessor was based on mask ROM, and EPROM on chip was limited for debugging and prototyping. Therefore, the above-mentioned phrase was transmitted with a big impact as an idea of reversal.

Actually, this expression is not my original. When I was reading a flight magazine while traveling by air in the United States, there was a commercial page of Seiko’s electronic watch (quartz watch) on an accidentally opened page. I found the following sentence. “Someday, all watches will be made this way: Quartz”. I modified this phrase as a microprocessor version and made the most of it. For watches and microprocessors as well, it was an expression which might take people by surprise, but as far as I see today’s situation, we may say that it was quite right. The ZTAT microprocessor was the forerunner of the “field programmable device”, and the fact that this product was rapidly accepted by the market shows clearly how important the programmability in the field was to the users.

At a later date in “Makimoto’s Wave”, I expressed the “standardization-oriented cycle” since 1997 as the era of “field programmability”, and the strong experience of this time became a firm background to this.

By the way, since the latter half of 1985, memory product business, which had been the central pillar of Hitachi semiconductors, fell sharply due to the deterioration of market conditions, and the sales were in a severe situation underperforming the budget target.

On the other hand, sales of microprocessors were strong mainly in ZTAT products, and the microprocessor business in October, 1986 achieved a new record of 4.7 billion yen.

This year was the year when the Japan-US Semiconductor Agreement was concluded. The memory products were placed under the supervision of the governments of both the US and Japan, and its freedom in business operations was completely lost. The time had come in which the microprocessor became the center of Hitachi semiconductors to drive business in lieu of memory. Among them, the ZTAT microprocessor became “the star of hope” and its production got up while gathering a lot of expectation, and it made sharp penetration to the market

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