Oral History of Tsugio Makimoto

Interviewed by:
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Remacle: This is Rosemary Remacle, and I'm here talking with Dr. Makimoto. Welcome to the Computer History Museum.

Makimoto: Thank you.

Remacle: Why don't we start with who you are today, and then we'll work backward from that, and talk about how you got to be who you are today. So today, you're working as a consultant?

Makimoto: Yes, that's right.

Remacle: And to whom do you consult?

Makimoto: Well, I work for maybe three, four companies, including Elpida Memory (Japan), and PDF Solutions in this country, and some Japanese companies.

Remacle: It doesn't sound like they are all semiconductor companies.

Makimoto: Well, yes. They are all somehow related to semiconductors.

Remacle: Isn't that the truth of computing? Somehow it's all related.

Makimoto: Oh yes. That's right.

Remacle: So where were you born, and where did you grow up? What did your parents do? A little bit of family background….

Makimoto: I was born in a small island in Japan, the most southern part of Japan. It's a small island. It's famous for one thing. That's the place where the first gun was transferred from Portugal to Japan. That happened on that island.

Remacle: The name of the island is?

Makimoto: Tanegashima Island. So my father was a school teacher, so he was very enthusiastic about education, and he taught me how to study and encouraged me to study and to go to a good school-- high school and college. Then I went to the high school called La Salle High School, located in Kagoshima City in Japan.

Remacle: How far was that from where your parents lived?

Makimoto: It's beyond the sea, so it's quite far.

Remacle: So you were at a boarding school.

Makimoto: Oh yes, that's right. I had to go by ship to that high school.

Remacle: And you had brothers and sisters?

Makimoto: Yes, I have five sisters, two brothers. So eight children all together.

Remacle: And did they all go away to boarding school?

Makimoto: Well, all different. Some went to very local schools and some of them went to other schools.

Remacle: Where were you? Were you in the middle age-wise, or were you the oldest or ???

Makimoto: I was just in the middle-- number four. Number four out of eight sisters and brothers.

Remacle: Did your father encourage you to study particular subjects, or just to study hard?

Makimoto: Well, especially he asked me to study one thing is mathematics, English, and Japanese languages. <laughs>

Remacle: Those are three very...

Makimoto: Very fundamental type of subjects.

Remacle: Where did you go to college, and how did you decide which college you were going to go to?

Makimoto: I went to the University of Tokyo. Mainly, it was supposed to the best.....college in Japan. So that was my target. I went there in 1955.

Remacle: It's still today. And, what did you major in?

Makimoto: The first two years is a kind of general education, oriented towards science and technology. And then after two years, I took the applied physics, especially in the semiconductor physics [courses].

Remacle: Do you recall when you first became aware of the term “semiconductor,” and then, what did “semiconductor” mean when you first became aware of it?

Makimoto: The first time I heard about semiconductors is 1955 when I entered the university. In that year, Sony introduced the transistor radio-- very nice portable radio. In that time, radio was big, but Sony’s transistor radio was portable, and it’s a new fashion. So I was very much impressed how it could be realized, and I learned that it was semiconductor used in that transistor radio. So I decided to choose the semiconductor as my subject. So after two years in college, I specialized in semiconductor research.

Remacle: What kinds of things did you work on in college in doing semiconductor research? What kinds of problems did you work on?

Makimoto: Well, the teacher who taught the semiconductor [course] was doing research on the cooling using semiconductor device, with PN junction. So I was doing research on compound semiconductors, how it efficiently works for cooling the thing.

Remacle: We talked earlier about the research that was going on in Bell Labs at the same time. Were you aware at all about research outside of Japan relative to semiconductors?

Makimoto: In those days, I wasn’t very aware of what’s happening in the world of semiconductor, but later I learned that the transistor was invented at Bell Labs in 1947. But in those days, Japan was in a kind of occupation, so the news of the transistor invention did not come to Japan very quickly. I heard that sometime late 1948, the news transferred to Japan that transistor was invented. So in Japan, the research on transistor started some time in 1949. So that’s the beginning of the transistor research in Japan.

Remacle: Were there particular people who were very influential in bringing it into Japan, or working on some of the key problems in Japan?

Makimoto: I heard that there are three persons who caught the news of transistor invention. One is Professor Watanabe at Tohoku University, and two other are scientists at government research institute. I heard that these are the...

Remacle: The influential...

Makimoto: Yes. Yes.

Remacle: Did any of your professors at Tokyo University, were they involved in that? How did the information pass from the original three, kind of core, people in-- what did you say, forty...?

Makimoto: ’48, ’49.

Remacle: ...'49-- to get to the point where they were teaching classes in Tokyo University in 1955? Do you have a sense of how that developed?

Makimoto: I heard that including those three persons who got the news of transistor invention, there were the kind of groups to study about transistors. So the transistor group became larger and larger.

Remacle: I'm having to imagine here. I don't know factually, but it would seem that there must have been some government-- the government was slowly becoming more independent from the U.S. occupation forces. Was there government sponsorship of some of this research in the semiconductor area?

Makimoto: Well, it's not the government sponsorship, but government research institution was one of those activities, and the other, the university, and also the individual sectors, companies, like Hitachi or Toshiba, or Sony.

Remacle: And they were attracted to the concept of transistors and what they might be able to do in making products, rather than [attracted] to the semiconductor companies?

Makimoto: You mean the device or systems?

Remacle: Yes. Were they interested in semiconductors and transistors because they thought they could use them in some of their products?

Makimoto: Oh yes.

Remacle: They didn't want to be like a semiconductor company.

Makimoto: That's right. I think so. The major companies who showed a strong interest include Hitachi and Toshiba and Sony, and they started the basic research of their own. But very shortly, they got a license from American companies. For example, Hitachi and Toshiba got license from RCA. I believe it was 1952. And Sony got a patent license from Western Electric, and I think that was 1953. So that's the real beginning of the transistor as the industry in Japan.

Remacle: Let's talk about some of the key milestones, as you look back on it, that allowed the semiconductor industry to take a strong hold in Japan, and there to be a very strong semiconductor industry in Japan. These licenses would have been perhaps the foundation?

Makimoto: Yes.

Remacle: And then after that, what were some of the key product milestones or breakthroughs?

Makimoto: I think the biggest milestone would have been the introduction of transistor radio from Sony. Firstly, it was a great hit-- big hit.

Remacle: I remember.

Makimoto: You remember. And not only Sony, but many Japanese companies followed Sony's introduction, including Hitachi and Toshiba. So the transistor radio became a very important item of electronics-- not only in domestic [markets], but it became [important] also in the export markets. Following the transistor radio came many, many different kind of consumer products, including black and white TVs, VCRs, and also the Walkmans-- those kind of consumer electronics based on transistors. Before the age of transistor, Japan was not very much advanced compared to America or Germany in terms of consumer electronics. But Japan was very advanced in applying transistor technology to those consumer electronics. So in a sense, the Japanese semiconductor industry was very much driven by those consumer electronics.

Remacle: I can remember my first trip to Japan, which would have been in about 1973, and Akihabara was already in existence.

Makimoto: Oh yes. That's right, that's right.

Remacle: When was it "born"?

Makimoto: I don't really remember, but when I was in college, it was already there.

Remacle: So you were in college in 1950?

Makimoto: I graduated in '59. But in those days, it was an electronics cluster so to speak.

Remacle: I remember just being amazed when I first [visited Akihabara]-- I just never had seen so many things.

Makimoto: Yes, yes. It's a concentrated area. Right. It's still there.

Remacle: What about calculators? You didn't mention calculators.

Makimoto: Oh yes. The first one was consumer electronics, including radio, TVs and so on, and another big milestone is the calculator. The calculator was introduced in 1964 from Sharp. The first model was a very big one, like this, and very expensive.

Remacle: When you say “very expensive,” can you...

Makimoto: Five hundred thousand yen. Five hundred thousand yen. That was the same price as a new car. About the same. So that’s the beginning of calculator. And it was based on the germanium transistor. The calculator innovation occurred in the following 10 years from germanium transistors; next model was silicon transistor, and then came the bipolar IC model, and then came MOS IC model, and finally the LSI model. PMOS. PMOS LSI. And the very last one was a CMOS one chip LSI. So all these innovations happen in just in about 10 years. So the calculator was the big driver for Japanese LSI industries.

Remacle: So it was always smaller, faster...

Makimoto: Oh, yes. Smaller, faster, cheaper. In 10 years. Yes, that was very revolutionary.

Remacle: What was the foundation for Japan’s memory prowess? Because I know Hitachi, which you became associated with, clearly...

Makimoto: I’d like to talk about a couple of things. In the case of Hitachi, we started the new type of memory based on the CMOS. The first CMOS product we introduced was 4K, 4K static RAM, called HM6147. That was the very high speed of 4K static RAM. In those days...

Remacle: It’s hard to imagine that 4K was a high speed.

Makimoto: Intel was much leading in that area. Their type number was 2147, and their device was based on NMOS structure. So we were doing a lot of research on how to improve the performance of CMOS. In those days, CMOS was a niche device only for low power applications, such as watches or calculators, not suitable for the high-speed applications. But we were doing re-engineering of CMOS technology and applied it to the high speed memory, which has a very compatible pinout with Intel’s 2147, but with CMOS.

Remacle: Now, you were involved with this project at Hitachi?

Makimoto: Yes, yes.

Remacle: What was your role?

Makimoto: Well, the basic invention was done by people at Central Research Laboratories. So my role was how to make it into the business, and how to expand its areas of applications. So the first product we chose was the 4K static RAM, followed by the 16K static RAMs. So we have finally achieved same level of speed with about one-tenth of the power, compared to the NMOS counterpart. In the 16K static RAM, about the same kind of achievement-- same speed, one-tenth the power. So we believed that this

is a way for the future, for the high-speed applications. But there were a lot of arguments about CMOS or NMOS-- which is the mainstream? My belief was that CMOS was the way, and I think-- our first paper was presented to ISSCC in '78 from our Central Research people, and I think it took about five or six years that CMOS is recognized as the mainstream device, some time around 1985. In those days, when there's a conference or a meeting, customer visit, I always told them that CMOS is the way to the future. Some people called me "Mr. CMOS".

Remacle: So you were the CMOS prophet?

Makimoto: Yes, that's right. So it took maybe five or six years that CMOS is recognized as mainstream.

Remacle: Let's step back, and let's talk about how did you get from college to Hitachi, and your first couple of years at Hitachi. What were those like?

Makimoto: I liked Hitachi when I was graduated, since Hitachi was recognized as the technology company, not the marketing company or something like that. Technology is very important in Hitachi, and they had a nice research center, and I wanted to work at Hitachi in the field of semiconductors. So my first assignment at Hitachi was the transistor engineer, not research, but it's a little bit different from my wish. It was okay. So I started as a type of engineer of germanium transistors. Today, germanium is all gone, and you cannot see it except in a museum.

Remacle: We have them [here at CHM], as you saw. Then give me a little bit of progression in your Hitachi career. What were the two or three key projects that you worked on? You mentioned the memory.

Makimoto: Before memory, before I go to Stanford, I was assigned the development of very high-speed germanium device using...

Remacle: And this would have been when? What timeframe?

Makimoto: When I joined Hitachi in 1959, and then I got the high-speed device assignment in next year, so 1960. So that was based on mesa transistor, germanium mesa transistor. And the purpose of the development was to utilize this device for the TV, TV receiver, for tuning. So it needed very high performance at higher frequency. So my assignment-- three things-- how to improve the cut-off frequency-- number one; how to reduce base resistance, and how to reduce the collector capacitance-- three things. But all three factors are mutually related, so I need to find some optimum conditions.

Remacle: You were making tradeoffs.

Makimoto: Yes. That's right. So I made one big discovery in this program: that is today called Kirk Effect. Later, I developed an experiment about the same phenomenon as Kirk Effect. And I sent my

letter to the *Journal of Applied Physics [*Japan], and it was published. And later, I found that the paper of Kirk is three months ahead of my paper. So today it's Kirk is...

Remacle: It's the Kirk Effect. Not the Makimoto….

Makimoto: No. Unfortunately. It was in Japanese, so. But it's the same effect, and that is the base of my doctoral thesis.

Remacle: You've just raised an interesting point. Let me think of how I want to ask the question. You said early on the news didn't travel to Japan too quickly, but now we're into the '60s. How was the information exchanged and shared from Japan to the US to Europe about advances in semiconductor technology at that point?

Makimoto: Let me talk a little bit about my experience at Stanford.

Remacle: And this would have been 1960...

Makimoto: '65 to '66. Yes. Just in the middle of 1960s. So we had the company program to send employee to overseas university, and I got that program, and it was combined with Fulbright Program for flights back and forth. So I went to Stanford in 1965 in [the EE program, electrical engineering, and finished my study by '66, next year, with MS degree. In those days, studying abroad was one of the way of technology transfer. Other thing is the technical meeting, such as ISSCC, or IEDM. I think that played a lot of big roles for the transferring semiconductor technology. Not only for Japan, but worldwide. And number three is the resident engineers. For example, from Hitachi to RCA, some engineers stayed there many month, or even one year or so. That's a way how to transfer the technology based on the licensing agreement.

Remacle: So when a company would license a technology or a design or whatever from RCA, there would be engineers sent to RCA to understand the application and the core technology.

Makimoto: That's right. Yes, process technology, equipment, materials.

Remacle: So the overhead associated with those people, the cost, would have been paid by Hitachi.

Makimoto: Oh yes.

Remacle: The licensing company, not the….

Makimoto: Yes, Hitachi. Or Toshiba. Or Sony. Yes.

Remacle: Did you ever have a sense in the early years that there was-- when I say the early years, I'm talking '60s now-- was there any residual animosity from World War II as you were growing up. And both ways-- Americans occupied Japan, and resented [WW II Japanese activities] also-- it worked both ways… Did you feel that at all, and when you came to the United States and started studying here, or as you started traveling for business, did you experience that at all?

Makimoto: Well, in 1960s, I found that if we take the semiconductor area, [there was a] big difference in the technological level—the U.S. was much advanced. Not only for the semiconductors but for computers—the U.S. was much advanced. For motorization [there was] a big difference between Japan and the U.S. The American people were very open in those days. Very open, very kind, and I was impressed. I liked it very much to study here, staying here, and it was the great time for me.

Remacle: What made it such a great time, besides the personal interface, the people? How did your mind open up or change as a result of that experience?

Makimoto: Well, I learned many things. Especially at Stanford, there were many shining stars in the semiconductor field, including John Linvill, Pearson, John Moll, Pritchard, and even Shockley. Many, many shining stars, and they gave me a lot of good influence.

And one thing I was very much impressed was a time when I attended the ISSCC while I was at Stanford. In those days, the ISSCC was in East Coast, and in 1966, in February, it was in Pennsylvania, and I attended that conference. And the keynote was made by Jack Kilby, and in his keynote, he said that age of IC is over, so to speak, but now the age of LSI is coming. That was first time I heard about LSI, the word "LSI." So this gave me a big surprise. Basically I came here to study about IC. IC was just coming -- it was [a] time of transition from transistor to IC. So I wanted to study more about the IC. But his speech said that age of IC is over, and the LSI is coming.

So when I went back to Hitachi, my report to my boss was that we should start research on the LSI. So they understood and they assigned me-- "You do it." So shortly after, I was transferred to Central Research Lab for the research on the LSI.

Remacle: So this would be 1967?

Makimoto: Yes, that's right-- '67 to '68. Yes. Then again, I came back to the semiconductor division.

Remacle: Can you talk a little bit about how the semiconductor division in Hitachi, specifically-- since that's where you were-- but in general the structure of Japanese companies and where the semiconductor division fit in to their overall structure.

Makimoto: Well, in most cases, the semiconductor operations in Japan were inside the big companies, like Hitachi or Toshiba or NEC. In the case of Hitachi, we had maybe more than 10 divisions. So the semiconductor division was just one of those divisions. But in the early days, it was somehow

advantageous, since there were internal customers-- such as in the case of the Hitachi, there was a division for making consumer products, and a division for computers, and some other divisions, who are the customers for the semiconductor division. And that portion [internal sales] was big in the early days-- maybe something like 20 percent or so, inside customers. But this situation now completely changed. Internal customers is very small. So I think the basic structure of semiconductor company as a part of a big company was somehow advantageous [only] in those early days.

Remacle: Well, I know that at Intel there was always a struggle between being a semiconductor company, and should we have a systems group? Should we make systems so that the semiconductor people can learn from...

Makimoto: That's right. That's right. That's very important, I think.

Remacle: So the Japanese companies had the advantage certainly....in those days, of having internal customers that they could work very openly and closely with.

Makimoto: Yes, that's right. But as time goes on, that situation changes. It's quite different now.

Remacle: What kind of training were you given when you got to Hitachi? Or did they just say, "Here's a table to sit at. Here's a project to work on," or did you get some kind of training to bring you into the company?

Makimoto: Actually, when I joined Hitachi, it was a time when the semiconductor division was officially organized. Before that, there was an informal research or small activities. But when I joined, it's the first time it was formally organized. So we are the first employees who started fresh with semiconductors. So there's no senior people who are familiar with semiconductors. They all came from other divisions, mechanical divisions or tube divisions or communication divisions, consumer divisions. So there are no people who know about semiconductors. So it was not very systematic.

Remacle: My experience is that Japanese organizations tend to be very seniority oriented, based upon how long have you been there.

Makimoto: Yes.

Remacle: That [the youthful Hitachi Semiconductor group] must have been very unusual--

Makimoto: That's very unusual, only in semiconductors.

Remacle: How did that feel?

Makimoto: Well, anyway, we were the first, so we didn't know too much about the other divisions, so we took it quite naturally. So we have to work by ourselves. In those days, we had a reading group, using a textbook. In those days, the best textbook was "Transistor Technology" written by the staff of Bell Laboratories. So we used that as a textbook and we had a group reading. So that's a kind of self education system.

Remacle: What about things like management? How did you learn to manage yourselves?

Makimoto: It's all on the job. But sometimes, as the time goes on, Hitachi has a corporate program, not as a division but a corporate program, for providing off the job education to the candidates of the managers. So we need to take that kind of courses.

Remacle: What kinds of things did they teach you?

Makimoto: Many things: the economics, financing, marketing, world politics, operations research, many, many different kinds of subjects.

Remacle: Let's go back, step away from Hitachi, and go to the semiconductor industry in Japan. At what point did the US-Japanese competition heat up? What was the impact on you at Hitachi?

Makimoto: I think that was after the oil crisis.

Remacle: '74.

Makimoto: '74-'75 timeframe. Before that, Japanese companies were mostly engaged with consumer products, calculators, those kind of devices, so not so much conflict with other countries. But after the oil shock, many of the Japanese companies recognized the importance of memory products, so a lot of emphasis has been made and the shift to the memory products, some time from mid 1970s. So at the timeframe, we introduced the high speed CMOS static RAM, and also we concentrated on the 64K dynamic RAM and EPROM as well.

It was reported in the paper that sometime in 1981 timeframe, our 64K DRAM became the number one in the world, and also, 16K static RAM also became number one in the 1981 timeframe. So that's the beginning of the conflict between US and Japan. But still, overall in those days, the market share of US companies was much larger than Japan's. In the middle of 1980s, the Japanese market share grew, and US market share came down. I think it was 1986 timeframe, the share was reversed. So that's the timeframe the US-Japan semiconductor conflict was very, very severe. So it's a timeframe the US-Japan semiconductor agreement was started in 1986.

Remacle: What was the basic premise of that agreement?

Makimoto: In those days, the argument was, the Japanese market was very closed, looking from the outside countries. So probably just about 10 percent is for foreign products; 90 percent was from Japanese suppliers. So the agreement was to increase this 10 percent to more than double, more than 20 percent. That was one thing, to open the Japanese market. And another thing is the anti-dumping procedure, and to the cost and selling price were all reviewed by the government. So these are two basic things on the agreement.

Remacle: I have to plead ignorance, or lack of memory, maybe.<laughter> Was that negotiated government to government, or was it negotiated by representatives of companies? How did it get put together?

Makimoto: Basically this Japanese-US semiconductor agreement was between government to government. But of course, the industries were closely related to it.

Remacle: Was MITI involved?

Makimoto: Yes, MITI and USTR in the US part.

Remacle: How long was that [agreement] operative?

Makimoto: Ten years, 1986 to 1996. For some reason, in 1996, it was agreed between the two governments, Japanese government, US government, that the industry should take the leadership, what should do after the end of this agreement. So I was in charge of this negotiation with SIA people in '96. And SIA side was headed by Pat Weber from TI; and we had very, very hard negotiations, maybe six months or half a year in '96.

Remacle: Was it just you and Pat Weber face to face, or did you each have many people?

Makimoto: Many people. In the meeting, four to four. Four from Japan, four from US. Pat was heading US and I was heading Japan, four to four. In the background, [there were] many, many companies. So it's a very difficult negotiation. If we talk only with myself and Pat Weber, representing TI and me representing Hitachi, it could be done in maybe one day, since we know where is the trade off. But in this case, behind me were many, many companies, not only semiconductor companies, but semiconductor users. And behind Pat Weber, there are many, many American semiconductor companies. So it's not very easy to make any trade off or compromise or that kind. So the progress was very, very slow, slow, slow.

Remacle: What was the agreement you finally came to after six months?

Makimoto: Basically, the agreement was that we terminate the US-Japan agreement. That was a kind of bilateral relationship. So instead of bilateral, we open up the new schemes, which is multilateral system, including US, Japan, Korea, Europe.

Remacle: Because by 1996, the Koreans were quite--

Makimoto: Oh yes, yes. Koreans have a big presence and also Europe was becoming strong. And today,Taiwan and China. So it's now regular meetings, they have the regular meeting each year. It's called WSC.

Remacle: World Semiconductor--

Makimoto: World Semiconductor Council (WSC). That was the outcome of the '96 Vancouver agreement.

Remacle: How well do you think that's working, or has worked?

Makimoto: The WSC? I think it's basically helped mutual understanding of the semiconductor executives. It provides opportunity for knowing each other. So instead of any conflict from misunderstanding or something, it provides good opportunities for everyone to know each other.

Remacle: I think we can all agree, it really boils down to people talking to people, having relationships with people. You have given them a framework in which to do that.

Makimoto: Oh yes, that's right.

Remacle: Let's move back to your Hitachi years. You had the first project. Then you moved onto your second project in Stanford.

Makimoto: Yes, let's see. I did the high speed germanium transistor, then Stanford, and then the calculator LSI, inspired by Jack Kilby's speech. And after the calculator, then I moved to memory.

Remacle: Let's talk a little bit more about the calculator LSI. How long did it take you to figure out how to create an LSI that would be basically the guts of the calculator? What technical obstacles did you have to overcome? Were you working only with Hitachi people, or did you have external customers for the calculator?

Makimoto: It's a very interesting question, since it's a kind of step. For the calculator LSI, I think the biggest hurdle was how to design the big chip. In those days, mostly the custom type of designs, so we had to do it in a very efficient way for serving many customers. So we started with internal customers, since there was a division making calculators. We started the joint project, developing LSI and using it for their calculator. That was the first product we started. The project was started in, I think, '68, '69 timeframe. In the course of our development project, there was big news that Sharp would introduce calculator LSI in 1969, using North American Rockwell's LSI. Rockwell was not very famous LSI manufacturing those days, but they committed to supply LSIs for Sharp.

Remacle: I don't understand the word [that you just used], North American?

Makimoto: Rockwell, Rockwell. So I think that was '69. It was a great surprise. Even though we started the LSI project in 1968 timeframe, we thought that the transition to LSI would be slow. It may take some time, some years, but surprisingly, Sharp and Rockwell started delivering LSI calculators in 1969. So it was a big--

Remacle: How do you suppose Sharp found Rockwell?

Makimoto: That's a very interesting story. There are a lot of documents about that. Sharp firstly, he says that this is done by Mr. Tadashi Sasaki of Sharp, based on his material. He said that he had talked with mostly all Japanese semiconductor companies, but all of them said LSI is a little too early. So he went to America and he vivited all [the] American companies, including TI, Motorola or some other Silicon Valley companies. But most of them said LSI is too early. And also, he visited Rockwell. At first, they said it's too early, so he gave up his idea of making the calculator LSI. So he was on the way back to Japan and he was in the lounge of Los Angeles airport. Then came the telephone call to him from Rockwell. He went back to Rockwell, and Rockwell said, "Let's talk about the LSI project." So it was a very-- finally, he could find Rockwell as the supplier.

Remacle: You also worked with other calculator companies.

Makimoto: Oh yes. We completed our development in 1970 and then we started marketing our LSIs to outside companies, including Sharp, Casio, Canon and even Sony, Ricoh, many, many companies. In the [peak] I think we have been working with more than 20 customers, mostly all of them the custom type of design. Since calculators were making a lot of very rapid progress in a short period, they wanted to change even small features, so many custom designs were needed. That's the timeframe Intel started a very smart way of developing microprocessors, in 1971 timeframe.

Remacle: At what point did Japanese companies start to think about microprocessors, microcontrollers, more logic, rather than--

Makimoto: Okay. Basically, the calculator design gradually shifted to a more programmable type of architecture in Japan. So even at Hitachi, we had 4 bit microcontroller with our own architecture. But it's very domestic, local type of product. So we tried to expand it to 8 bit microcontrollers and tried to market [them] globally, but in those days, we found that the software portion is very important and design environment for the microcontrollers, very important. And in those days, Intel was already much leading with 8080 type of product. Motorola was very rapidly catching up with 6800. So we had a lot of talks with Motorola executives and we visited each other. They came to our factory, we visited their factory, and we came to the conclusion that we should exchange some of our technology with Motorola's 6800 MCU. So that's how we started the second sourcing of 6800, and that was the beginning of the MCU at Hitachi.

Remacle: Were you personally involved in that project?

Makimoto: Yes, for the second sourcing, I was the department manager, introducing that, developing. So that was the beginning.

Remacle: So how did Hitachi develop its microcontroller business, by building off of the 6800 cross licensing, or second sourcing agreement?

Makimoto: We second sourced 6800 and introduced the technology, the architecture technology from Motorola. And since our strength was in high speed CMOS, we developed the high speed CMOS version of the 6800 and we transferred this technology to Motorola. So we thought it's a kind of win-win project for both companies. But as the time goes on, there's conflict, especially on the market side, so the situation get worse as the time goes on. So the second source agreement terminated some time maybe after ten years later, in late '80s.

So we started our own development of an 8 bit MCU, using our own architecture, but we were sued by Motorola, because of the patent infringement. Then Hitachi countersued Motorola for their patent infringement, so it took about two years for the settlement. Finally, we came to the agreement. So we decided to develop completely different type of architecture originally. Basically, the previous architecture was called CISC architecture, but we chose RISC type of architecture, which is quite different from the Motorola architecture. So that is today's SH (SuperH) micro, now the mainstream product of Renesas company. So that's how we started our own microprocessor business.

Remacle: So it was a good lesson, probably for Motorola too, that at some point, it's better to start from scratch, do your own thing, instead of commingling...

Makimoto: Yes. Initially, working together with Motorola was win-win, but it's a conflict. Then it's much better.

Remacle: Was it a conflict because you were calling on the same customers with a very similar product?

Makimoto: Yes, that's right. We are mostly selling CMOS products and they are mostly selling NMOS products. That was a conflict.

Remacle: How much collaboration was going on, and we're now well into the '80s? How much collaboration, not in a formal sense, not where you had a cross licensing or a second source agreement, but professional conferences, like Semicon.? Did you exchange information with each other, or did each company retain very high walls around its IP?

Makimoto: One thing I should have mentioned is the collaboration scheme in Japan, which started in 1976, as a VLSI project. That's the joint project; government, industry joint project. It was intended for developing very advanced common basic technologies.

Remacle: Among the big Japanese--

Makimoto: The big Japanese companies.

Remacle: So it would be Toshiba, Hitachi, Mitsubishi….

Makimoto: Mitsubishi, Fujitsu.

Remacle: NEC?

Makimoto: NEC. Five companies. And the funding was shared by government, and those five big companies. And in those days, it was a time of say 4 kilobit dynamic RAM or 16K, but the target was to develop basic technology for the 1 megabit. So I think that was the biggest joint project ever in Japan, and it was supposed to be very successful for developing a kind of infrastructure, such as lithographic tools, testing machines, or high quality wafers, those kind of things. Not intended for developing the product, but the infrastructure.

Remacle: Then that was the first of several, which basically has led at some level probably to the consolidation of the Japanese semiconductor industry today.

Makimoto: Yes.

Remacle: Would you say that was the very early first steps of consolidation of the Japanese semiconductor industry, or would that be exaggerating too much.

Makimoto: Yes, I think it's independent kind of things. The first project was a very new scheme. Before that, no competitors did work together, but in this VLSI project, the five companies, all competitors, but they came to the same place, same location, and they did very basic and common subject of study. So that's how they succeeded. But this scheme was named as Japan Inc. methodology, so it was-- since that time, Japanese government did not support that kind of scheme.

Remacle: Was it conceptualized based upon the fact that to develop the infrastructure for new processes and more complex products was such an expensive proposition? What was the thinking behind the consortium….

Makimoto: Very interesting question. In those days, the computer industry or information industry was supposed to be the most important industry segment in Japan, not the semiconductor, but computers. In those days, the Japanese government people and computer people learned that IBM was doing much advanced semiconductor development for the next generation. So if we do not have that kind of advanced technology, the computer industry in Japan would be destroyed. So the major purpose was to protect the computer industry, not the semiconductor. But the semiconductor is very important device, or means to develop computers. So those five companies, incidentally semiconductor companies but they are basically all computer companies, so they donated the funding. So that's how it happened, to increase, to improve the competitiveness of the computer industry in Japan.

Remacle: After the calculator project, what was your next project? I keep going back to the Hitachi experience…

Makimoto: Okay, after the calculator, there came the oil crisis, and my job transferred to memory products, and I managed high speed static RAM and 64K DRAM, and EPROM. I concentrated just three parts. And these three parts all became number one in the world sometime in 1981-82 timeframe. So it was a good time for me.

Remacle: I bet it was a very challenging time.

Makimoto: Very challenging, yes. It's interesting, especially the leader[ship] of dynamic RAM [market] changed every time. The first was Intel 1K, and then, maybe 4K was led by TI, and 16K was Mostek. For three generations, all American companies took their lead. And it's the first time Japanese companies took the lead with the 64K and then, let me see, and one Megabit with Toshiba. So in all generations, each generation changes the [market] leader.

Remacle: And then it went to Korea.

Makimoto: To Korea. Now Samsung, it's changed.

Remacle: So how long a period of time did that cover, that you were dealing with or leading the memory group?

Makimoto: Let's see. I think I was now promoted upwards to general managing.

Remacle: And this was about, again, what time frame?

Makimoto: The memory, as a department manager, from '77 to about ten years.

Remacle: To about '87 timeframe?

Makimoto: Yes, yes.

Remacle: And then what happened?

Makimoto: Well after that, I was-- There came another recession, you remember the '86 recession?

Remacle: Yes.

Makimoto: Yes, it was the overcapacity of memory, pricing came very much down, and I was in charge of a P&L for memory, and so I lost a lot of money. So I was demoted for two years.

Remacle: Moved to the side?

Makimoto: Moved to the side, to a minor role. So at that time I was thinking how semiconductor industry is so…goes up and down.

Remacle: It's cyclical….

Makimoto: Yes, so cyclical. So I was thinking and I came with idea of Makimoto's wave, when I was in demoted role.

Remacle: You had time to be creative.

Makimoto: <laughs> Yes, I had some time to think.

Remacle: And how did you explain the Makimoto Wave and how did you take it to the larger population?

Makimoto: I looked back, my career, at first, and then I looked for the industry trend in general. The first part of the industry was based on transistors, and that was very much standardized, and it was replaceable. And the reason for that is that in those days, the leaders of industry were-- all came from tube manufacturers, and tubes were already kind of standardized, replaceable. So the lessons came from tube to transistors, the period of standardization, and then came the IC and LSI for, for example, calculators. All custom designs, so about ten years of customization followed, and then came the invention of Intel's MPU.

The standardization led the industry trend, and sometime in 19.. late '80s, 1980s, came the concept of ASIC, for providing better cost, low power, high performance and low cost. So that's the concept of ASIC. So that was, just starting when I thought of this idea. But I thought in that ten years after that would come new wave toward the standardize---**-** Beyond late 1990s, would be the standardization wave with programmable devices. So it was a kind of prediction. So that was my basic idea.

Remacle: Did you publish it in a paper, article, or..

Makimoto: No, it was, I got the idea in 1987, but I was just —verbally talking.

Remacle: 1987, or 1997?

Makimoto: '87, the idea….and I was given an interview from the UK journalist, Electronics Weekly, by the name of David Manners. He gave me-- I got the interview of David Manners, and I talked about my wave concept, and he wrote a big paper on the top page of Electronics Weekly, and that was '91, 1991, and in that time, he gave the name of Makimoto's Wave. I was surprised to see that, Makimoto's Wave, and I think since that time, many people have been referring to that concept, especially the people who are engaged in programmable devices, or configurable devices, or a non-volatile memories, those kind of things. But I was a little bit surprised to have gotten the invitation from the Computer Society, since they are doing reconfigurable computing, is now a big trend. And last year I got an invitation from a communication conference in Japan, talking about the configurable type of cell phones. So it's a concept that's now expanding, not only for semiconductors, but for other industries.

Remacle: Where did you get your PhD?

Makimoto: I, after I went back to Hitachi from Stanford, I did a kind of dissertation to the University of Tokyo, so this is not PhD taken by course, but dissertation.

Remacle: And what was your dissertation?

Makimoto: It was the high frequency transistor. The major part was the Kirk Effect. <laughs>.

Remacle: It's terrible when your invention is somebody else's name. <laiughs>

Makimoto: <laughs> But actually, his paper was three months ahead of me.

Remacle: But isn't that the nature of innovation, though? Because if it's a serious problem, many people will be working on it in parallel, and don't even know it.

Makimoto: That's right, that's right.

Remacle: So let's go back to the Stanford experience. You said you worked with some of the big names in semiconductor academics. Who was most influential in that group?

Makimoto: Well I think that John Linvill.

Remacle: And why would you say that?

Makimoto: Well, before I joined Stanford, he visited Hitachi, and I had a little time to talk with John Linvill, and he gave me the advice that what they are doing at Stanford, yes, so basically I followed his advice, and instead of staying there just as a visiting researcher, his advice was to take the course, the basic course for a Master's Degree. So it was just one year, but I had to work hard, but finally, I could take the

B.S. degree based on his advice. And since that time, from time to time, he's a kind of mentor for me, not only that time, but since I graduated from Stanford, I meet with him sometimes.

Remacle: How would you assess, I asked the question earlier in a different way, but how would you assess your experience at Stanford? How would you assess its impact on your, both personal and professional development?

Makimoto: The.. I think the most precious experience for me, was that I got some very basic understanding of the semiconductor, and especially IC. Before that, in my time in the University of Tokyo, the semiconductor education was not very common. Only my teacher, Professor Aoki was in that research. But at Stanford, many courses are related to the semiconductor devices and ICs, including applied physics, circuit theory, and..

Remacle: Materials?

Makimoto: Materials, and many courses are related to that. And also, one thing is the computer program. In my day, at the University of Tokyo, no education for the computer programming, but at Stanford, it was a kind of a prerequisite for all engineers. All engineers have to take this computer programming course. So since I did not take that in my undergraduate, I had to take that computer programming course at Stanford. There is a big Burroughs machine in the computer center, and we prepared very thick punch card, so it was a kind of, you know, homework assignment. So it's a very -- I had to study very hard.

Remacle: So did you have family with you when you were at Stanford, or were you there by yourself?

Makimoto: Myself, yes. My family was in Japan.

Remacle: So you left them behind in Japan, and concentrated on your studies.

Makimoto: That's right. <laughs> In a sense, yes. In those days, maybe, that was the most common way of studying abroad.

Remacle: At what point did you marry?

Makimoto: Well I married in '59, as soon as I graduated, yes.

Remacle: And your wife was somebody you met at the University?

Makimoto: Oh yes, university. <laughs> Not in the same university, but you know.

Remacle: But during the university years?

Makimoto: Yes, yes.

Remacle: Which university did she go to?

Makimoto: It's called Ochanomizu Women's University. It's a women's university.

Remacle: And did she go on and work professionally, or did she stay and raise family?

Makimoto: Yes, she stayed at home, raising children.

Remacle: A perfectly noble activity as far as I'm concerned.

Makimoto: Pardon me?

Remacle: I said, it's a very noble activity, very noble.

Makimoto: <laughs>

Remacle: So, in '86, 87, 88, you were set on the side.

Makimoto: Yes, three years.

Remacle: And then what happened?

Makimoto: Yes, again the mainstream.

Remacle: Was that proscribed by corporate culture? In other words, if you were in charge of an organization within Hitachi that didn't do very well, and was it normal that then you took a couple of years and went sideways?

Makimoto: Yes, it really depends on the company to company, I guess, and in the case of Hitachi, it's very severe about the operational output. So if you lose money, that's a big trouble. So in my case, it's 1986, so I was demoted in 1987, because of a big loss, and in normal case, that would be the end of my career. Then I would go very slowly. But this is a case of semiconductor, very dynamic, things change very rapidly. So again, after three years, maybe I was needed to do this kind of job. In other cases, maybe if you're once demoted, it's very, very rare situation to come back to the main--

Remacle: Do you have to have a sponsor or a mentor to argue your case, or did just your own, who you were, and what your accomplishments were, that's what overcame?

Makimoto: Well, there's no mentor to consult.

Remacle: You just did it.

Makimoto: Yes, I just did, yes.

Remacle: So when you came out of “exile”, then what?

Makimoto: <laughs> Okay, after that, I was -- new organization was established in the semiconductor division, and that new organization was in charge all R&D, and design activities of the semiconductor, so that's a big responsibility. So I was in charge of that. And, in '92, I was promoted to the General Manager of Semiconductor Division, top of the semiconductor operation in '92.

Remacle: And in '92, memories were still a big portion of--

Makimoto: Yes, memory was a big portion, and also at that time, my focus was more on the microprocessor. As I said, SH Micro based on the RISC architecture, that was my most important segment of the product.

Remacle: And how long did you hold that position?

Makimoto: Well I stayed there about three years, at the head of semiconductor operation, and then I was [moved] one more [level] up, to be responsible for all electronics portion including display devices. So in that case, but actual responsibility is taken by the head of semiconductor division, and display device division, so I was just, you know, overseeing those activities.

Remacle: And at what point did you leave Hitachi?

Makimoto: Year 2000.

Remacle: So you were over all electronics for how many years?

Makimoto: Uh.. '98, yes, two years.

Remacle: And you left Hitachi to go to Sony.

Makimoto: Yes.

Remacle: Can you talk about that transition? How did that happen?

Makimoto: Yes, actually..

Remacle: That's a little unusual for Japanese companies, for somebody as senior as you.

Makimoto: Yes <laughs> very new. Not only for me, but the Japanese culture, it's a new thing. Actually, in 1999, it was in a very severe recession, and again I was demoted. And I was not very happy in those days, but my title in that day, was Corporate Chief Technologist. So the title itself was not very bad, but you know, I didn't like that, and in those days, Sony was doing much activities in semiconductors, especially they were very aggressive with their game machines, PlayStation. PlayStation, then PlayStation II was just beginning, and in that time, Mr. Idei was the President of Sony, and I knew him before, maybe two or three years before I have known him. So he calls me, a direct call on the phone, and how about coming to Sony, and please help me to improve the semiconductor operation. So I agreed.

Remacle: How hard a decision was it to leave Hitachi? Because you had been there for almost 40 years.

Makimoto: Yes, that's not very easy decision, you know. It's very rare, especially for the management type of people to move from company to company, especially among the kind of competitors, you know, both electronics company, and Sony is a rival of Hitachi, so to speak.

Remacle: But Sony has always been a more.. less traditional.

Makimoto: That's right, that's a difference, yes. Hitachi is weighted more heavy type of machinery, Sony is more electronics, so there is a big difference. So, I thought what to do about the offer from Idei-san and talked to some of the senior people at Hitachi, and they advised me, now it is the new time, a new age is coming, don't hesitate, go to Sony. So I talked to some of them--

Remacle: What did your family think?

Makimoto: Well they supported. When I told my decision, they supported to go to Sony. So this was a big surprise for many people, and many newspapers and magazines wrote about my transition. But I think that I had the kind of, you know, idea that in Japan, people's mobility is very slow, compared to the US. US has a very, too much mobility in this country. <laughs> Too extreme. Japan's movement is very slow, but I think that more mobility would be better, even for Japan as a whole. So that was one of my--

Remacle: So you're a role model in that respect.

Makimoto: Yes, right.

Remacle: So what did you do at Sony?

Makimoto: I was assigned to be Chairman of Semiconductor Technology Board. That is, to establish a total strategy among semiconductor, supply side and demand side. Sony is a very big user of semiconductors, and they have also a semiconductor manufacturing division, and my role is to combine these users group and semiconductor manufacturing group. That is the role of Semiconductor Technology Board. So basically, I was Chairman until I retired from Sony in 2005, after five years.

Remacle: And now you're consulting.

Makimoto: Yes.

Remacle: And did you even think about just retiring and playing golf and going on vacations, or what drew you back into working?

Makimoto: That's a very interesting question. Many people ask me why-- by the way, this year is my 50th Anniversary, just the same as IC's 50th anniversary, since I started my career in 1959. So some people ask me, "Why you have stayed so long in this crazy industry. So many ups and downs every time." So my answer is, there's nothing like the semiconductor [business], [it is] so dynamic, and so exciting, and I like it, and I enjoy it. So that's my answer.

Remacle: And it makes life much more interesting.

Makimoto: Yes.

Remacle: You haven't mentioned the “Digital Nomad” book….

Makimoto: Oh yes, yes. That also, one of my interesting ideas. The book has been published in '97, but the idea was '94,'95 timeframe. That two things were in background. One thing is that we have strong belief in CMOS, for low power, for portability, and number two is the development of SH Micro, based on RISC architecture, doing the very high speed operations with low power. So the device is already there, at least the basics of the devices are already there for providing very high performance, high intelligence and low power capability. And there are also the trend of electronics equipment getting smaller and smaller and smaller. If you take the case of cell phones, coming from very big ones to very tiny ones, and the computer is the same thing, from ENIAC, to IBM 360, mini computers, PCs to now the net-book, very smaller and smaller. So I think that someday people will carry very highly intelligent mobile terminal, and it will be connected to the communication infrastructure through the world, so we would be freed from the constraint of time and location. We'd have a lot of freedom from that. So that is the basic idea of Digital Nomad, published in '97. The first version was in English, and the second version was in Chinese,

published in Taiwan, and third version was in Japanese. The reason was, I had a lot of difficulty to find a publisher who could publish the very strange title of the book, since “Digital Nomad” is very--

Remacle: It's not very intuitive.

Makimoto: Yes, that's right, very strange. So I took some time to find a publisher in Japan. But in those days, the concept of the Digital Nomad was just coming up, but not very common. But now, today, many people say to me that, "Oh, the time has now come." So it took maybe more than five years, ten years.

Remacle: Yes, inextricable linkage of, we need to be connected more, and then we've got these smaller and smaller devices.

Makimoto: Right.

Remacle: And it's kind of hard to say, chicken and egg, which way?

Makimoto: Yes, yes, that's the way, yes, chicken and egg, yes.

Remacle: So, let's stand back. You've had a 50 year career to right now, and just clearly adding some more onto it.

Makimoto: <laughs> I hope.

Remacle: But at this point, what has been the most exciting and rewarding challenging part of your career?

Makimoto: Well many things, but I should raise one thing that I would say. I was awarded the Bellwether award from Semico Research. I think that was in 2004, and that award is given to the one executive, for the outstanding contribution to the semiconductor industry. And the award is a hanging bell, like this size, a hanging bell. It's hand made by Paolo Soleri, he's a very famous person in architecture and a great artist.

Remacle: Arcosanti…

Makimoto: Arcosanti, yes, that's his project. And in the side of the bell, there is a sign of Paulo Soleri, so that is my great, big prize for me.

Remacle: It's very wonderful. What, other than that, what period in your career were you the most energized, or can you pick a time, even?

Makimoto: Well, one time, of the time we put the CMOS product, then the DRAM, number one, number one time, and then the contribution to WSC, the Bellweather award. Those are some highlights.

Remacle: Do you consider yourself an entrepreneur?

Makimoto: Well, my career is mostly inside a big company, so it's very different from the entrepreneur in its real meaning. But I think, inside a big company, I was sort of-….entrepreneurial, yes.

Remacle: Okay. If you could change or redo any event or project, or.. .in your life, what would you redo, what would you change, if you could edit your life?

Makimoto: Well, maybe, this is in the case of our age in Japan, that we devoted our life mostly to the company, less time to the family or relatives. So maybe that kind of balance would be a little bit modified.

Remacle: So a little less work, and a little more--

Makimoto: And a little more enjoy it.

Remacle: What advice would you give to young engineers, who are just starting out as you were in 1959, somebody could have given you advice, what would you like to-- What would you think would have been helpful to hear?

Makimoto: Well I think, for the younger generation, I think it's very important to have a kind of curiosity for the future, and the semiconductor technology has been the enabler of the very much, a lot of dreams which was just curiosity in the beginning. But sometimes it can be realized, so sometimes it's important to have a kind of dream or a curiosity toward the future, and try hard through that--

Remacle: Persevere.

Makimoto: Yes.

Remacle: We've covered a lot of territory. Is there something that I didn't ask you about, or we haven't talked about that you would like to talk about that we haven't have included in the transcript?

Makimoto: Well I think I have mostly covered, yes.

Remacle: Okay, so a couple of CHM, the History Museum questions. How important is taking these oral histories and giving them a home in a museum. How important is that, do you think, in the large scheme of things?

Makimoto: I think that semiconductor technology is very rapidly changing together with computer technology, so I think it's very, very important to preserve the past history of this changing technology. And there is a saying, old saying, "In order to see the future, we need to see the past history," so if we understand the past history better, it provides you the better perspective to the future. So in this way, I think this is very, very important to keep the--

Remacle: You also mentioned, when we went and looked at the silicon engine, you said that it was good for young people to see something like that.

Makimoto: Yes, yes.

Remacle: Why do you think that?

Makimoto: Well they will get a feeling that they are already familiar with those small items such as cell phones, or PCs, and they will get a feeling how it came from, and then they would know of where it would go in the future.

Remacle: Well thank you so much for taking the time to sit and talk. I know you've got a lot of other things to do this afternoon, so we can call it quits now.

Makimoto: Oh, thank you very much.

Remacle: Thank you.

Makimoto: My pleasure.

END OF INTERVIEW

