Oral History of Ikuo Anada

Interviewed by:
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Recorded: December 14, 2014
Tokyo, Japan

CHM Reference number: X7372.2015

[Editor's note: the interviewee speaks Japanese. This interview was conducted via a translator and the interviewee's answers were transcribed to English.]

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Stanley T. Myers: Today is the 14th of December, 2014, and I am Stan Myers. We are discussing with Anada-san his experience and what he has learned throughout the years he has spent within the industry. He was born on October 20th, 1937 in Toyama prefecture.

Ikuo Anada: Yeah.

Myers: He went to elementary school and junior high school in Himi City, Toyama. Mr. Anada was a very athletic boy, and played baseball and table tennis throughout the junior high school years. He graduated from Takaoka Technical High School in 1956, and entered Tokyo Institute of Technology majoring in Physics. After he graduated from Tokyo Institute of Technology in 1960、 he joined Oki Electric Industry, Inc.(OKI) He held various positions in OKI, including General Manager of LSI Design Department of Electronic Devices Group from 1979 until 1986; General Manager of the IC Division of Electronic Device Group from 1986 to 1988, and Director of the Board from 1988. Chief R&D Center from 1991, and General Manager of Electronic Components Group in 1993.Anada-san has become President of Tohoku Oki Electric Company Ltd., in 1995. So, with that introduction, Anada-san, I'll start us off with asking the first question. When and how were you first exposed to semiconductors?

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Anada: I was in a professor's research lab for preparing my graduation thesis. My professor brought a few transistors to the room to show them to us. That was the first time I saw transistors.

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Myers: Who were the most influential people in your career and your choice of a career?

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Anada: I think it was Ikegame-san.

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Myers: And how did he relate to you in life?

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Anada: When I entered Oki, Ikegame-san was not my direct supervisor, but he was my boss for years since he recommended me to be the development team leader of MOS (Metal Oxide Semiconductor) IC.

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Myers: Okay. That would lead me to the next question. What was your early professional history, as you recall, as you went to work, and worked through OKI?

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Anada: If I briefly explain the trend of the semiconductor industry when I entered OKI, I think that would help you understand what position I had in the semiconductor technology development back then. So, let me explain that first. I entered OKI in 1960 right after I graduated from the university. At that time, I believe OKI was conducting research and development of germanium devices for semiconductors. There are several types of germanium devices, and we were about to implement mass-production of germanium alloy transistors. There was a developmental group which was improving the transistor performance, and I was assigned to that group. I learned manufacturing processes such as diffusion, how to use a furnace for the process to diffuse antimony element into germanium wafer, how to remove contamination from germanium wafer before putting them into the furnace, mixing chemicals, and inspection of completed transistors to make sure they met the specifications. The group was very small, and I received on-the-job training in the group.

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Myers: Learning as you worked with the products, like germanium or silicon or that kind of thing. You were learning on the job. Did I understand that right?

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Anada: Yes, I think so. For first 2 years after I entered OKI, I learned technology on germanium transistor as I mentioned before . But, my senior colleague who was back from the US questioned us why we're working on germanium transistors. It was obsolete. He told us that the US was working on silicon transistor. We stopped development of new germanium products. I moved to the section in which new products such as high speed silicon transistor and high power silicon transistor were being developed. I learned the technology of silicon transistor in this section for 2 years. .

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Myers: And that was mostly with materials like gallium and silicon at the time?

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Anada: No, it was only germanium back then. At that time, we mostly collected information from the US that was available or went to the US for gathering information. With the collected information, we made our own devices. We also made joint ventures occasionally. In this case, I didn't, but my senior colleagues discussed with engineers of semiconductor factories in the US and brought the information to Japan. At that time, the raw material of semiconductors was being changed from germanium to silicon. Earlier germanium transistors were point-contact types and very unstable. We started making the alloyjunction types germanium transistors in Japan. That was when I entered the company. We felt the US was always ahead of us whenever we obtained information about the US. When we almost completed developing the geranium transistor, n-type transistors. Catching up with U.S. technology was all we were able to do at that time, so we became very busy. We had to wait for a while to know which transistor would be the main device. That was the situation at that time.

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Myers: Well let's move to the question of: what was the first semiconductor related project with which you have been associated with during your career? What was the first project?

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Anada: Before I talk about that, I would like to mention about how we got transistor technology. OKI had its own silicon transistor technology to a certain extend. But OKI decided to make a contract agreement for licensing technology with GIC (General Instrument Company) and got the technology of silicon epitaxial transistor. Later, that transistor became the main product of bipolar ICs. However, I myself was not actually involved in the bipolar type IC. I was involved with MOS type IC which GIC was also developing. We decided to have two development groups to pursue both of them. I was in charge of the MOS type whereas another colleague who entered OKI at the same time as myself was in charge of the bipolar type, as each type is suitable for different applications. That was my first time to work as a team leader. The year was 1965, so I became the team leader of the MOS IC group, and I would say that event affected my career at OKI. Since then, I was always engaged in development of MOS ICs. As I was promoted to management roles, other developmental segments including the bipolar segment were consolidated into mine, but basically I started and developed MOS ICs at OKI.

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Myers: So GIC was your first licenser in this area?

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Anada : Yes Incidentally, GIC was one of the advanced companies of the MOS type IC in the US. The company was one of the leading companies of the MOS type. Do you know GIC? Its full name was General Instruments Company. They had the MOS technology and we talked about technology licensing to OKI. However, because we already started developing the MOS type at OKI, we determined ourselves that we would be able to develop it without the technology license. In the end, we did not get the technology license.

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Myers: So you were working with both germanium alloys and silicon epitaxy wafers at that time? Or was germanium first, and the silicon epitaxy the second product you were using?

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Anada: We did germanium first. We mass-produced the alloy type first. When we were about to start its mass-production, GIC told us that the semiconductor technology was shifting to the silicon epitaxial technology, and the germanium alloy would not be the main technology. That was the time we quickly imported the silicon epitaxial planar technology and started development by ourselves. Other Japanese leading manufacturers had similar situations of shifting from germanium to silicon. Orders of germanium transistors were decreasing.

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Myers: I see. I have a follow-up question. What were the key semiconductor related projects with which you have been associated with over your career? What were the important ones? You had the IC manufacturers, the MOS was coming in, what were the key projects that you had coming in within that time frame?

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Anada: We started researching the MOS type in 1965.

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Myers: The US manufacturers started the development of the device, in around 1960. And I was just trying to figure out what are the key projects in that timeframe that you at OKI were working on.

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Anada: We started the development of MOS IC in1965. We commercialized MOS IC in 1966, which was about one year after we started the research. In the following year, 1967, we started its mass-production. Therefore, it took us two years from starting the MOS IC research to implementing the mass-production of MOS ICs to introduce commercial grade of MOS ICs. We also started mass-producing bipolar ICs at the same period.

At OKI, the importance or the purpose of the bipolar IC was clear from its developmental stage. Since OKI used to deliver the mechanical type automatic exchange to Nippon Telegraph and Telephone Public Corporation, we absolutely needed the bipolar IC to make the electronic type automatic exchange. On the other hand, because MOS had a simple structure and was easy to increase the degree of integration, we decided to conduct some research and development for future applications.

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At that time, MOS transistors, generally, had very unstable characteristic.   Because of their instability, some predicted the market of MOS would not grow. Even at the company, other colleagues suggested that it would be better not to have two parallel projects of bipolar and MOS, but rather consolidate them into one project which was the bipolar type. However, the bipolar transistors were critical parts of OKI’s products, so we were unable to terminate the research and development of bipolar transistors. Our team faced with the proposal of closing the project several times. However, Mr. Ikegame, who was my boss since I entered the Company, continued convincing the corporate management to continue the MOS project.

While we had such management issue, we realized that Takasaki plant of OKI was using MOS IC in information processing terminals for computer or PBX (Private Branch Xchange) . With this application, we started reconsidering applications of MOS ICs. MOS ICs are rather slow devices, but equipment such as a computer requires fast devices. That is why we used bipolar transistors in computers. However, for peripheral terminals, the device speed is not the primary requirement.

For any part to be used for such equipment, we had to receive approval from Nippon Telegraph and Telephone Public Corporation. We accomplished that in 1969, first in Japan. The approval process required us to pass strict product tests and plant assessment. That became a huge task on us. As a result, we succeeded in getting approval of MOS IC.

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Anada: There is another type of MOS which is called CMOS, and it has low power consumption. We started development of CMOS in 1968 for consumer applications including calculators and watches in Japan. The consumer market was very large, and we thought it would be necessary to develop CMOS for the market. We started the project in 1968 and commercialized it in 1971. OKI commercialized CMOS for the first time in Japan, and CMOS played a critical role in semiconductor devices from that time onwards.

That was beginning of the IC age. Because there was a large domestic market, OKI put forth a lot of effort to develop CMOS. We also got more personnel. Our motto was “Replace machines with semiconductors.” In other words, we wanted to replace mechanical parts with MOS IC, and in particular CMOS IC. In the Japanese domestic market, there were many companies demanding that. With this trend, we increased production rapidly in 1970s.

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Commercial products that had mechanical parts were, for example, calculators, watches, cameras, transceivers, taxi meters, and audio equipment. They had many mechanical parts. We attempted to replace them with electric parts. OKI was the company that provided such electronic parts, and we attempted to use MOS for the electronic parts. For us, it was easier to use MOS for commercial products. However, the semiconductor-based calculator market was very competitive among manufactures. In the US, they started design of calculators using integrated MOS chips for reducing chips, and Japanese companies were competing with them. OKI did not get into the calculator market because of the severe competition. However, there was another huge market, and that was watches. We expected huge demands for electronic watches.

As a result of developing many kinds of product, OKI had a very large share in the market. Our CMOS technology was improved steadily by the demand.

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Myers: Was that about the period of time when the DRAM became a big part of the market?

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Anada: In 1971, Intel gave us a big shock in the Japanese semiconductor history with two commercial products. One was a 1-Kbit DRAM announced in 1971, and the other was a 4-bit microprocessor introduced in 1972. Our engineers of DRAM investigated this, and realized it was a critical technology that was needed for Japan. We also started developing DRAMs from there.

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The RAM before the DRAM was the SRAM (Static RAM). That consisted of 6 transistors per bit. The DRAM of the first generation consisted of 3 transistors per bit. Finally 1 transistor per bit. This was an epoch-making technology. Capacity on a chip was increased more easily.

So, the memory chip market was expected to become another huge market in future.

Many makers including OKI started developing DRAMs. 4K bit DRAM was commercialized in1975. We were also involved in the DRAM market.

While we were also making effort to expand market world-wide and develop lots of devices for consumer products such as watch, camera, audio and so forth. The production volume rapidly increase. Especially OKI was the leading company in the watch parts market at that time.

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As for the 4-bit microcomputers, Intel was developing it with a Japanese calculator company. At that time, they did not think about making calculators with the microprocessor technology. For each calculator model that a customer company specified, they designed a specific circuit and commercialized it. As such requests became numerous, they realized that if computerized parts were used, the required function would be implemented easier – otherwise, the development efficiency was very poor. Intel's 4-bit microprocessor was actually a byproduct while they were building calculators requested by the Japanese company. That 4-bit microprocessor became 8-bit models, and then became 16-bit models, which grew a huge market.

DRAMs are getting faster and more capacity. In my opinion, Intel's products impacted us to drive the semiconductor market.

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Myers: This was all transpiring in the late 70s, early 80s timeframe?

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Anada: Intel introduced the products in the early 70s. I think DRAM was in 1970, and the 4-bit microprocessor was in 1971. The DRAM was 1-Kbit. We no longer have such a chip with the memory capacity in the market because the memory capacity has been continuously increasing from 1-Kbit, 4-Kbit, 16-Kbit, and so forth, in response to the market demand. In the personal computer market, Intel made an 8-bit microprocessor for personal computers because they did not work well with the 4-bit processors, and then proceeded to increase the bits. They started development and introduced the products in the 70s, which still continue even now. At that time Japanese makers developed the microprocessor and microcontroller compatible with Intel products. That brought intellectual property issue between Intel and Japanese makers including OKI. After long and hard negotiation with Intel, we got the approval to commercialize Intel compatible products. Those were 3 processors(8_bit,16_bit) and 2 controllers. CMOS technology was applied to those devices developed in 1981 to1984. I was involved in this negotiation,

Besides, OKI commercialized OKI original 4-bit microcontroller in 1978, 8-bit in 1988

16-bit in1989. Demanding microcontroller increase for automobile, audio, watch, household appliances and so forth.

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Myers: So that transition period between the early and mid-70s to the mid-80s – what was happening in the technology at that time?

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Anada: At that time, structures of transistors and ICs, which were an integration of transistors, were being changed. Also, the device speed was being improved. The technology called the silicon gate was already applied to the 1-Kbit DRAM. That had a totally different structure from the prior transistors. With the silicon gate, the device speed and the degree of integration were improved. Another technical change was the use of the N-channel MOS transistor from the P-channel MOS transistors, which accelerated the degree of integration and the speed. From the mid-70s to the end, there were many technology developments such as this. Those technology was widely applied to other devices.

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The next epoch occurred in early 1980, which was also a starting point of a new product. We got information that IBM was designing semiconductor devices to be used in a computer system for future systems, improving the degree of integration and the device speed. This information impacted Japan significantly. We called this the “IBM shock.”

Because the memory capacity of DRAMs increased rapidly, we suspected that IBM put DRAMS that would have the memory capacity of 64-Kbit or so by increasing the integration degree from a few Kbit in the future systems. Cooperative VLSI (Very Large Scale IC) development team supported by MITI

(Ministry of International Trade and Industry) was launched in Japan. However, in actuality, OKI was not invited to join the team. That was not because OKI had less technology. Out technology level was competitive with other semiconductor manufacturers. That was because OKI was not manufacturer of large-scale computers. Anyway, OKI was out of team, but because the 64-Kbit DRAM was such a monumental device, we decided to develop it by ourselves. We decided to do it because if we were unable to produce it, our technology would not catch up with the emerging semiconductor business. As the target device to demonstrate our technology, the memory device was ideal. Of course, we planned to sell it. For these reasons, we decided to newly organize project for developing the memory chip in 1977. We completed a 64-Kbit DRAM in1980 about the same time the team completed their versions. I myself was not involved in this project directly.

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Anada: As for the IC age, we were getting into the VLSI age. VLSIs were significantly different from LSIs for their technology, integration degree, and speed. We started development and production of VLSIs. The national project drove many applications in the VLSI age. OKI had already manufactured electronic automatic exchange using 4-Kbit DRAM and high speed bipolar LSI.NTT intended to use the 64Kbit DRAM for the next project of electronic automatic exchange.to be delivered to NTT.

That was before computers used the 64-Kbit DRAM. The 64-Kbit DRAM technology became a core technology, which was transferred from electric automatic exchange to other systems. While the degree of integration was being improved more, various technologies and products were advanced with this technology trend, which became minicomputers for consumers and other systems. In the VSLI age, we witnessed such technology movements.

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After the 64-Kbit DRAM, the next degree of integration of a next generation DRAM was increased by four times. The next generation DRAM had the memory capacity four times larger than the previous generation. That means the 64-Kbit DRAM became the 256-Kbit DRAM. Oki successfully developed the 256-Kbit DRAM in 1984. From 1987, we made a 1-Mbit DRAM, increasing the memory capacity from the Kbit order to 1000-Kbit, i.e., 1-Mbit order. Near the end of the 80s, we completed a 4-Mbit DRAM as a commercial product. We used the N-channel MOS at first. However, the device had a power consumption problem, so we decided to use CMOS from the 1-Mbit DRAM. Currently, all memory devices are made of CMOS. By using CMOS, we made devices of low power consumption.

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A question why semiconductor technologies were advanced in Japan was in your question list. What I've said thus far includes the answer, but I will be more specific. One of the reasons was that there was a large domestic consumer market where electrification of parts was demanded. Another reason was the competitive government market where the governmental organizations demanded cutting edge technologies in products to be delivered. For example, the then Nippon Telegraph and Telephone Public Corporation gave us a guidance of devices to be used in the next generation electronic automatic exchange to let exchange manufacturers compete with each other. The delivery date was strict – otherwise, we were unable to deliver our exchanges. The Japanese government procurement system let us work hard, accelerating the pace of product development. That is why DRAM capacity increased so rapidly. Not only DRAM, but other devices used in exchanges gained more and more speed. I think these two aspects played major roles in the progress of the Japanese semiconductor technology.

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I would like to point out one more thing. Semiconductor manufacturing equipment is critical as well. At first, most of the equipment was imported. However, as Japanese companies manufactured domestic equipment more, in 1982, about 70% of semiconductor equipment we were using was Japanese made. Equipment for wafer processes such as ion implantation, chemical vapor deposition, making pattern by lithography were designed and completed by the collaboration between semiconductor manufacturers and equipment manufacturers. That was important. During that collaboration, the knowledge of semiconductor devices was imported into the manufacturing equipment. I think such collaborations in Japan resulted in technology advancement of equipment manufacturers and high quality equipment available to user companies, enhancing overall Japanese semiconductor technologies.

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Myers: Okay what I would like to start on, because we're taking a lot of his time – I want to start on the US trade friction, and have his opinion on it: not only what's written here, but any other opinions. And I'll move into appropriate row for Japanese companies in today's business. But I do want to get his take on…that's a major history event that took place –the trade friction.

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Anada: As for the reason for breaking out the US-Japan semiconductor conflict, that happened when the worldwide shares of the US and Japan in the semiconductor market was reversed in 1986. Prior to that year, the US produced much more production volume of semiconductor devices than Japan, but it was changed. It happened because of DRAMs. The US did not follow the DRAM market because the market prices of DRAMs fluctuated so much that the profit from DRAMs once dropped to one-third in a year. I think that it was unacceptable for the US semiconductor business, and they probably shifted their product lines to something else. The best example was Intel. They terminated their DRAM productions. As a DRAM manufacturing company, if the business produced deficits, that is very bad for the company – even if DRAMS sold well when there were demands. As a result, the company totally focused on MPU. After that transition, the company became very stable and steadily growing. On the other hand, Japanese companies stacked to DRAMs and were expanding the DRAM business while many US manufacturers were withdrawing from the fluctuating market. Another issue was price dumping. This was the largest issue. The US claimed that Japan sold the products for low prices in the US market, having US companies confront the trade infringement. They also suspected that Japanese companies were able to do that because the Japanese market still had some profit margins. Under these conflicts, the US-Japan semiconductor agreement was drafted in 1986. It was a mutual agreement by drawing certain lines between them to follow. After that the decrease of DRAM production in US and the improvement of demand resulted in the increase of the sales of Japanese maker for some time. But the DRAM market fell and its price went down as usual. The US market share became larger than the Japanese from the mid-1980s to early1990s. These phenomena are called the US-Japan semiconductor conflict.

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Myers: Let's go to that, and then proceed with the next question.

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Anada: I have graphs that I want to show you.

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Myers: Is this where you talk about the silicon cycle?

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Anada: Yes. The silicon cycle is a market phenomenon that shows about 3 to 4 year cycle of sudden increase of sales followed by a sudden decrease, which are repeating whenever a new product is introduced into the market. This is the silicon cycle. The cycle also affects corporate managements substantially. At first when the production amount is small, the semiconductor division is affected, but as a whole company, the small loss can be absorbed. As the semiconductor device production becomes larger, the silicon cycle affects the financial management as a whole company. In fact, there were several cycles in the past. DRAMs as devices affected the market. Since logic devices are relatively stable or their change is modest, they did not affect the market significantly. Therefore, it is a challenge to minimize the change of DRAMs, and we are still unable to solve the issue, thus remaining as an issue.

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Myers: Okay, after discussing the silicon cycle, and all of the many, many things that happened over the last 20 years--

Anada: Yes.

Myers: --my next question to you, would be – what's the appropriate role for Japanese companies in semiconductors, in today's business environment?

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Anada: 1:17:00 Presently in Japan, the business environment amongst semiconductor companies has changed quite differently. Several companies of these competitive semiconductor manufactures jointly invested to establish two semiconductor companies: "Elpida Memory" and "Renesas Electronics." One is a logic device company and the other is a memory device company, in order to avoid conflict with domestic competition. They are examining to overcome the silicon cycle to in order to guard against this. I am afraid their outcomes are not so good. Japanese semiconductor manufacturers are in difficult situations. In fact, Micron Technology Inc, US Company, bought Elpida Memory, and OKI no longer has a semiconductor division. OKI sold its semiconductor division to the company called Rohm, including engineers and plants to assure its management stability. Other companies concluded the necessity of semiconductor divisions. They focused on manufacturing their strong point products. Nevertheless, the most important current issue that we are holding is not technology, but corporate management, as nothing will be solved without stable management. I think avoiding excessive price competition and expanding logic business are the key for stable management.

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Myers: Okay, then I guess we'll go to the last question. What advice would you have for technical students entering the university today?

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Anada: I am not a good English speaker. Based on my experience, they should have good communication skills; otherwise, their activity ranges will be narrowed. I had so much experience of that. These days, some companies give them training, but I think they should have the skills while they are students because they may go abroad right after they start working. I think there will be many ways to acquire the skills these days, and there would be many students who can speak English. Nevertheless, I think our generation feels a lack of communication skills. But this advice is only for Japanese students

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Myers : Well I guess that wasn't the final question. Another one is: What do you think is the most exciting opportunity in technology for the future?

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Anada: Semiconductor devices currently used are downsized in order to increase the degree of integration. But I think it will reach its limit. I am interested in where the limit is, and what will cause the limit. I am not sure if such concern will be worth conducting research. This is one of my interests.

Another interest is wearable devices. Now is said the first year of wearable devices. There are watch-like devices with a built-in computer and a user wears it. I wonder it will be a hit product. I am interested in how the product will be accepted by us. In fact, when I was engaged in digital watches, we put so many functions in a watch. We also put game software in it. In the end, it was difficult to operate it and was not accepted by consumers. Presently, we may have impressions that wearable terminals or mobile devices will be successful. However, it is very difficult to determine how to input data and output information on the display area. I am interested in how wearable devices will grow in the market.

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Myers: Okay, I think we've worked you very hard today. I hope we have a good result to bring back to you in some time, and we look at it to see if it makes sense.

END OF INTERVIEW

