Taiwanese IT Pioneers: D.Y. (Ding-Yuan) Yang

Interviewed by: Ling-Fei Lin

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楊秉禾英文文字稿

Ling-Fei Lin: This is Ling-Fei Lin. Today is February 23rd, 2011.This is one in our series of oral history interview with Taiwanese pioneers in the semiconductor and computer industry. Our guest today is D.Y. Yang. Please introduce yourself with your name, both in Chinese and English, Mr. Yang.

D.Y. Yang: My current Chinese name is *Bing-Her Yang* [phonetic translation]. People also call me Ding-Yuan Yang. The latter is my former name. My English name is Ding-Yuan Yang, and my friends call me "DY."

Ling-Fei Lin: To begin with, could you please talk about when and where you were born? And where did you grow up? Also, please talk about your family and childhood.

D.Y. Yang: I was born in Nanjing, China in 1948. My parents always said that we were born in a chemical factory located in Nanjing by the north side of Yangtze River. Both my parents were chemical engineers. My family and I moved to Hong Kong after the Chinese Civil War. We lived in Hong Kong for four years before moving to Taiwan. I went to middle school and high school at Kaohsiung Senior High School. In 1965 I got into National Taiwan University, majoring in Electrical Engineering. I then moved to Taipei.

Ling-Fei Lin: How old were you when your family moved to Hong Kong?

D.Y. Yang: I was less than one year old at that time.

Ling-Fei Lin: You spent four years in Hong Kong. So you went to elementary school in Taiwan?

D.Y. Yang: Yes, I also attended elementary school in Kaohsiung. It is called Ai-Guo Elementary School.

Ling-Fei Lin: What are the memories of your childhood like? All the way until you graduated from high school, before you went to college?

D.Y. Yang: I remember clearly that when we first came to Taiwan, we lived in rural Kaohsiung---it was nearby today's Kaohsiung Medical University. Back then there used to be only farmland. Surrounding us were endless rice paddies. We used to catch frogs and snakes in the paddies, and it was fun. After I was admitted to Kaohsiung Senior High School, we moved to Sinsing District. My daily routine was going back and forth between home and school. What I remember most clearly is how I often went to the library to read all the novels there.

Ling-Fei Lin: What type of novels did you like the best?

D.Y. Yang: I often read translated fiction. The books I was most fond of were Greek mythology and Homeric epics.

Ling-Fei Lin: You mentioned that both of your parents were doing Chemistry Engineering?

D.Y. Yang: Yes, they became teachers after we arrived in Taiwan.

Ling-Fei Lin: Did they teach in elementary schools?

D.Y. Yang: No. They taught in middle school. Afterwards, my father worked for the Taiwan Machine Corporation, Taiwan, which was a state-owned enterprise.

Ling-Fei Lin: What subjects were you best at in school?

D.Y. Yang: My academic record was not bad. The most remarkable subjects were physics and mathematics.

Ling-Fei Lin: You mentioned your interest in reading novels; how about your performance in literature and Chinese?

D.Y. Yang: That was only for recreation; they enriched my knowledge in Western history and literature.

Ling-Fei Lin: Did you have any role models?

D.Y. Yang: No, I didn't. A pity, perhaps.

Ling-Fei Lin: You went to National Taiwan University, majoring in Electrical Engineering. What made you decide to study EE?

D.Y. Yang: Both of my brothers were studying at National Cheng Kung University. I was also recommended for the same school. However, I made up my mind that I did not want to go to the same college, so I took the [NTU] entrance exam and set my first choice as the EE Department and I was admitted.

Ling-Fei Lin: Why did you choose Electrical Engineering? Because it was commonly considered the best choice, or was it the subject you were truly interested in?

D.Y. Yang: Probably because all my family majored in engineering-related areas. My eldest brother studied Chemical Engineering. And my second brother majored in Civil Engineering. So an EE major was a logical choice to me.

Ling-Fei Lin: Why did everyone in your family choose engineering-related studies? Was there any special reason?

D.Y. Yang: Due to the overall situation, studying engineering is more practical. For my family, being an engineer was more acceptable.

Ling-Fei Lin: Wasn't being a doctor everyone's dream at that time?

D.Y. Yang: I could get into medical school but I did not want to. For me, being a surgeon and seeing blood is horrifying.

Ling-Fei Lin: At what time were you in the Department of Electrical Engineering?

D.Y. Yang: I studied in the EE department from 1965 to 1969. After I graduated, I did one year of military service in the Navy.

Ling-Fei Lin: And you went to Princeton afterwards?

D.Y. Yang: Yes.

Ling-Fei Lin: Would you like to talk about the education [you had from], and impressions you had of, Princeton? Make a comparison with National Taiwan University, maybe?

D.Y. Yang: I was first exposed to the American style education when I studied at Princeton. I thought it was very... I truly enjoyed the educational process. For instance, I showed my professor some textbooks of Quantum Mechanics that I used while studying physics at NTU. They were stunned, saying even doctoral students could hardly understand the content we studied in NTU. But that was the type of books we used while studying quantum mechanics at NTU. He said they would not understand. So I think I had new perspectives. Since then, I realized the quintessence of education. It is not just teaching and instruction.

Ling-Fei Lin: You just mentioned that taking courses in physics in NTU was not easy. Yet, you also talked about how you were enlightened when you were in Princeton University. Would you please elaborate on that?

D.Y. Yang: When I was a freshman in college I considered switching to physics. After some consideration I decided I could not be a better scientist than many others, so I stayed in EE. I was still interested in physics so I took some physics courses.

Ling-Fei Lin: Compared with the abstruse knowledge you learned in the Dept. of Physics, NTU, was the education in Princeton more practical?

D.Y. Yang: Princeton focuses on letting students grasp the knowledge. At that time, I studied physics of semiconductor devices. I took courses in both the Physics Department and the Chemistry Department. Another important thing is that everyone there was a very knowledgeable expert. It was so intriguing to discuss [topics] with professors and classmates. In Princeton, they discussed one topic from the perspective, from thermodynamics, also from electromagnetic, and from quantum mechanics. In NTU, we only studied the theories in the textbooks. It was very different.

In addition, Princeton attached importance to experiments. I've talked about this experience many times. I took 50 hours non-credit in a machine shop making things. Some of my classmates who majored in chemistry were required to learn glassblowing. That is when I knew that when you get to do truly advanced and sophisticated research, you have to be able to design and make all the equipment by yourself, instead of purchasing existing equipment, machines, and tools.

Ling-Fei Lin: When did you first come into contact with semiconductors?

D.Y. Yang: In fact, I first came into contact with semiconductors when I was a senior student in National Taiwan University. I took a device physics class taught by Dr. Chun-Yuan (Eugene) Tu, now the chairman of Orient Semiconductor Electronics, Ltd. He taught device physics at NTU. And he was an excellent teacher who graduated from Stanford. He used to say how his professors at Stanford University focused on understanding instead of teaching the formulas. His words were quite enlightening to us students. A great part of my classmates chose to work in the field of semiconductors.

Ling-Fei Lin: So what were your feelings towards semiconductors when you first learned about them?

D.Y. Yang: To me, semiconductors were a very interesting world. It was very interesting to me. For the semiconductor is a substance between metal and nonmetal. And it was amazing that it could be used to produce various devices. Ever since I learned that the invention of the transistor happened around 1948, which was the year of my birth, I felt a connection, a sense of commitment to it.

Ling-Fei Lin: Let's talk about your first work experience. Where did you work? And what's your job description?

D.Y. Yang: In 1974, when I finished my dissertation, I left Princeton to go to Florida to work for a semiconductor company, named Harris Semiconductor Company. Working in Harris was a turning point in my career. In Princeton, we didn't really have to handle practical work. But as soon as I got to Harris I had to solve some problems on the production line, which were really too difficult to solve.

However, looking back on history around 1974, the semiconductor industry in the U.S. went through a hard time. Layoffs of engineers occurred in a large number of firms. Harris Semiconductor only kept those with Ph.D. degrees. Subsequently, my supervisor asked me if I'd like to engage in designing. I said I had no clue about design. He said he would guide me through [the process]. Within a year, I designed a product called static random access memory. That's why, even with my background in semiconductor device physics, I ended up becoming a design engineer. Soon after I came up with the product. I had no idea if that was extraordinary or not. Afterwards, the Vice President of Harris, named Jim Dykes, who later became the general manager of TSMC---I went to talk to him, introducing myself. He said "Oh! You are that Dr. Yang!" My static semiconductor product was the first to be mass-produced then. Harris Corporation was a leading company in the arena of CMOS. This company manufactures products for national defense industry. Most of their products were more expensive than gold. The electronic watch ICs were all made by Harris too. I was asked to design a static memory with the same process as the IC. And my design was a 1024 bit memory. It was a memory with a 1k capacity.

Ling-Fei Lin: Were there any Ph.D.s designing the product with you, or were you the one and only person who was in charge of this?

D.Y. Yang: Just myself. I remember that I spent a lot of time learning how to draw and design circuits on computers, designing circuits and drawing them out myself. That was a lovely experience to me. I also learned about CAD, which is called EDA nowadays. It was so important---it could allow someone to learn to design from scratch in only a matter of months. Looking back, the training in Princeton helped me a lot. For example, in the very beginning, professors would give you a paper to read. After that, they hardly intervened in your working process. You had to work on experiments and come up with many topics. They did not discuss your work with you before that. From my point of view, a very vital part of training of being a Ph.D. is to find a problem and the feasible solution from scratch. No one will assign the topic to you. You need to find it out. And prove that you're doing something no one has ever done before.

Ling-Fei Lin: You majored in semiconductor devices physics and then switched over to IC design. In your opinion, is the gap between these two fields big?

D.Y. Yang: Actually, in order to catch up on this change, I read plenty of books. When I just got involved in the part of production line, I could barely recognize the locations of photo resist and the oxide. I had to ask people working on the production line where the photo resist ones and the oxide parts are respectively, and then put together the whole picture according to their answers. When I was in Harris after finalizing designs, making photo masks was a necessary step in the process. Prior to doing photo mask, piles of forms were to be filled out. During that time I asked tons of questions like “Why do we fill this in this way?” “When should I amplify photo mask here, and minimize it there?” They told me about everything once. From the answers, I gradually scraped a whole picture together. This is how engineering and technology were slowly integrated. And this technology became “know how” that I could duplicate in the future. Afterwards, when I led the technical transfer of RCA project, this experience helped me a lot.

Ling-Fei Lin: You served as an Associate Principal Engineer as soon as you joined Harris?

D.Y. Yang: Because I have a Ph D. degree. That’s why. Harris Semiconductor was in transition at that moment. The mother company of Harris was a firm making printing machinery. The company hired the president of an American university as the Chairman of the Board and transformed the company into a high-tech firm. After that, Harris did an excellent job in the fields of optical communication, radar and so forth. That led to final acquisition by other company.

Ling-Fei Lin: So they were in the transition phase when you joined them?

D.Y. Yang: Yes. The manager of my division was a Ph. D., and so was my section chief too. We were all newly employed.

Ling-Fei Lin: Would you please talk about the RCA project? You graduated from Princeton in 1975…

D.Y. Yang: Yes, I got my degree in 1975, but I left Princeton in 1974 to work. When I was in Princeton, C.C. (Ching-Chu) Chang and I shared the same lab. Chintay Shih was doing his experiments in an adjacent lab. All three of us had the same advisor who studied the oxide layer in MOS. My experiment went smoothly, so I had results earlier. And was thus, I able to leave a bit earlier.

So when we were at Princeton, it was an interesting incident, I joined the KMT (Kuo Min Tang) when I was in NTU. That brought me the benefit of receiving The Central Daily News from Taiwan. We read news about the Taiwan government asking the Telecommunication Lab to develop IC technology. So we sent a letter to say that we were eager for further details. And they replied. I often tell about this incident. P.H. Kong wrote back to us, which impressed me a lot, because he wrote in an informal language instead of an official one. It was like coincidence. In his reply, it was stated that the two major advisors of the project were both in Princeton. One of them was Dr. Arthur W. Lo, a professor at Princeton. But he was teaching other circuit designing at the undergraduate level. The other one was working at RCA Lab, as in the documents that I gave you, Dr. Wen-Yuan Pan.

In 1974, the Technical Advisory Committee (TAC) was founded, consisting of experts working for IBM and Bell Labs on the East Coast. It so happened that two of the advisors were in Princeton. Thus, we got the chance to discuss many things with them. They kept saying “OK, keep us posted of the progress”. At the time, I was about to leave Princeton. They suggested to me to wait for a while, so I went to Harris first.

In fact, it was not easy to find a job. Of course everyone hoped to find a job in places like the research center of IBM, or other research centers like that. Because of this IC project, the job I found was closer to being an engineer. It was the same with Chintay Shih. It was in preparation for this. When I was at Harris during the summer of 1975, I flew to New York for an interview at one of the TAC members' place. It took me several hours talking with dozens of TAC members. I was interviewed for several hours. Actually they told me that they were pleased to find someone like me because I was familiar with the entire process. I suppose that people who had both working experiences, and the desire to go back to Taiwan, were not numerous.

Ling-Fei Lin: You mentioned that all three of you were discussing participating in the RCA project. And your work experience as engineers was good preparation for this RCA project. Am I right?

D.Y. Yang: Yes. As for C.C. Chang, he was my junior, so he stayed in school, after graduation, he went directly to Industrial Technology Research Institute (ITRI).

Ling-Fei Lin: All three of you shared the same advisor. May we know the name of your advisor in Princeton University?

D.Y. Yang: Our advisor's name was Walter Johnson in the EE department. He was well-known in the study of transmission lines. In fact, RCA's lab was well-connected with Princeton. Many things were therefore connected together. RCA had a very famous lab in Princeton called David Sarnoff. David Sarnoff was one of the pioneers who were devoted to rolling out color televisions. If you can find a little dog logo on a gramophone, then it was made by RCA. RCA stands for Radio Corporation of America. Many Princeton professors were closely related not only to RCA Labs, but also to Bell-labs because these labs were all located at New Jersey. So, many problems or obstructions they encountered were solved with the help of professors from Princeton.

Ling-Fei Lin: Why did the committee choose to use CMOS, but not bipolar, which was more popular at that time?

D.Y. Yang: This is in fact a really good question. In many discussions back then many experts challenged this issue and questioned the selection of CMOS. Actually the decision was rather good. Taking the output value of semiconductor industry in 1975, 1976 was only 500 million US Dollars. We had a great minister, Yun-Suan Sun, who, based on the recommendation from his advisors, could make such a daring decision, to take on such an advanced emerging technology. I believe it was a very good, very right decision. I have always said that the semiconductor industry is one of the great pillars in the technological civilization in human history. "Thank the Heavens for having blessed Taiwan" that seized the chance to develop the technology of CMOS technology from such an early stage. As you mentioned, back then everyone chose to do NMOS, CMOS was generally regarded as a difficult technique to execute. The reason that these TAC members were so happy about having me was that I did CMOS technology in Harris. And the success of CMOS technology in electronic watches proved that this component technology had very low power consumption among consumer products.

Ling-Fei Lin: Taiwan did a technology transfer from RCA to Taiwan. What was the attitude and technology level they had toward this project?

D.Y. Yang: It is another issue we had to learn. The technology that had been transferred was not the high-end one. However, looking back, people from TAC and ITRI told me that the technology transfer was not welcomed in lots of U.S. companies. Or they would ask for an impossible price. As I mentioned earlier in 1974 and 1975, semiconductor firms on the East Coast, like RCA, encountered some financial difficulties so they were willing to do technology transfers. The technology transferred back then, I remember was the 7micron metal-gate technology. Yet, when I was at

Harris they were already using the 5micron silicon gate [technology], which was quite advanced. However, I think that the key point of technology transfer was not in the technology itself, but how much complete information you receive during the progress.

Ling-Fei Lin: So the whole package of training by RCA was fully-formed and detailed?

D.Y. Yang: Yes, it was.

Ling-Fei Lin: Would you please name some?

D.Y. Yang: I think I keep repeating this, but let me start from the beginning. I reported to the RCA project at the end of December,1975. The HR supervisor made a joke about me and said that I was cunning to start to work on the 30th of December, so that I could have one more year of experience on my CV. As soon as we got back, I became the manager of the engineering division, and the training of engineers at the electronic centre was launched. Chintay Shih and CC Chang joined in later on.

In March of 1976, we signed a contract with RCA. We had prepared a team to receive the training starting in April. Looking back I was only 28 years old at that time. If I were only 28 now I would not dare to do so. But probably due to the overall environment we were assigned to be the pioneers. I was the leader of the RCA training project. Chintay Shih was assigned to lead another group to learn manufacturing process in Ohio. As for C.C., he was in New Jersey with me and took charge of testing. Still another leader, Dr. Eugene Hsu was assigned to another place in Florida. So there were four leaders in the project taking charge of different tasks. Like I mentioned before, the training was not merely limited to engineering and manufacturing, but the four of us also learned about designing, testing, quality control, procurement accounting, and database management. It was a holistic and complete package of training. If we only transferred these techniques in a lab, we wouldn't have been able to attain industrial production.

Ling-Fei Lin: Who planned the whole training package? Dr. Ding-Hua Hu?

D.Y. Yang: Yes, I think the idea was originally provided by Dr. Ding-Hua Hu. It was to make a demonstration plant. In the transferring of technology it was indeed a more correct and effective way. You have to get into a factory, bring in some products and transfer some of them out to verify the effectiveness of the transfer of manufacturing technology. Only when you reach a certain yield rate can the transfer be considered valid. So the equipment in the factory was mostly suggested by RCA.

My job at New Jersey RCA was to have meetings with them everyday and to coordinate and monitor the whole transfer process. It also included procurement affairs and agreeing on the equipment they designed. I understood that many tasks were beyond my knowledge, but there was no one else who could shoulder this responsibility besides me at that time. So if we look at the correspondence between RCA and the ITRI during that time, they would all say: "Agreed upon by Dr. Yang" or "Approved by Dr. Yang". I had to take the responsibility so that things would go more smoothly. Naturally, I requested that RCA provide lots of practical training for our engineers. It was somewhat difficult in many US companies on the East Coast since there were labor unions. In order for our engineers to actually practice on the production line, they had to talk for one month or so, in order to get the permission of their labor union. They told us “you can move a desk, but if you want to move a table then, sorry, only union workers can do that”. We didn’t know how influential American labor unions were until then.

Ling-Fei Lin: So the desk you mentioned means work in the office and the table means tasks in the factory?

D.Y. Yang: Yes. The experiment table was not to be moved. For instance, to change a light bulb, they needed to get three people in accordance with their rules. One of them changes the bulb, another one holds the ladder, and still another one stands by and watches. So when Harris inducted me as their engineer, the first thing they told me was that they requested me to report to them about any labor union activity. So the company in Florida could still survive because the influence of labor unions was not yet that strong.

Ling-Fei Lin: Would you please talk about RCA's attitude toward everyone? Did they treat people in the factory and those on the management level with different attitudes?

D.Y. Yang: I don't think so. I think that on this project...RCA put a three-person team in an office to run the project. I was in the same office with a secretary and the team. There were a total of five people. They had a project chief. Another one was in charge of technical affairs, and still another one coordinated every operational detail of the project. The Americans were serious about the implementation of the contract. The problem was some particulars that were included in the contract. Yet people at RCA did not hold the same opinions. Some disputes occurred. The person in charge of RCA's semiconductor division, who later on became a famous person, Mr .Bernard Vonderschmitt---he worked in Xilinx on the West Coast afterwards---was in charge of the semiconductor sector. When we worked together, he was at the age of 50 or 60. He later on worked at Xilink until he was 80 years old. He was a legend in the American semiconductor industry.

Ling-Fei Lin: You learned about each and every segment from this training. Can you name some parts that were especially constructive and helpful to you, such as techniques or factory management?

D.Y. Yang: In fact there was one thing that I found out. We decided to use our own products to go through the whole production process. This is what I insisted on. Looking back on the history of it, CIC0001 was the one product we developed. We used four digits as product number. I negotiated the project to design this product for psychological warfare against Mainland China.

We got the design contract for controllers for high-altitude balloons. I brought it to RCA in the States and let one of my engineers carry it out. In the middle of the process, I realized that in our contract with RCA, photo mask technology was not included. So in the middle of the product development process, I brought the design to the West Coast to produce the photo mask and then brought it back to the RCA lab to produce the chip. This product didn't have a good performance result, because I was not well informed about the environment in which they were to be used.

But this whole procedure was how we did things then. So we understood every detail. In fact I asked my engineers to jot down everything they saw in the factory because some things might be unavailable in Taiwan, even things like cleaning tissue paper for mopping the floor or any paper tags, for example. All of it had to be jotted down because I did not want to miss the tiniest detail, which might be an indispensable part in the process. People in the factory sometimes did not know what was important or not. Hence, we needed to copy down every detail and then bring them back and digest them slowly.

Ling-Fei Lin: So our demonstration factory had the exactly same equipment as they did? Did they copy everything?

D.Y. Yang: It depends when it comes to certain equipment. We actually had quite some disputes with RCA. For example, we had a long argument about the ion implanter. Their factory was not absolutely the most advanced. Dr. Hsu, who now teaches classes at Asia University in Taiwan, he was in charge of the equipment back then and was skilled in vacuum systems because he studied physics and was experienced with vacuum systems. He found out that the design of the ion implanter RCA used was a bit old and thought we should buy something more advanced. So we tried to find some new equipment ourselves.

RCA then claimed that if we used the new equipment we bought, they would not be responsible for that. And we replied that we would be responsible for it if they were not. However, with one kind of equipment we still followed their recommendation. It was an Applicon CAD system for IC designing, since this equipment contained too much data, we still agreed to buy the same machine. Thus, during the training period, I visited numerous equipment suppliers in order to be sure of the effectiveness of all equipment.

Ling-Fei Lin: You mentioned that photo masking was not included in this project. Would this affect our…?

D.Y. Yang: As soon as we came back we signed another contract with IMR to redeem this shortcoming.

Ling-Fei Lin: How were the elites selected for the RCA project? Were there thirty or forty something experts at that time?

D.Y. Yang: Three of us did the interviewing of all the candidates together. And I think the decisions we made were quite good.

Ling-Fei Lin: You mean the three Ph. D.s from Princeton?

D.Y. Yang: Not exactly Dr. Hu was in it. Whenever Dr. Hu was in the interview the stress was much more prominent.

Ling-Fei Lin: What were the criteria you had at that time?

D.Y. Yang: Some people were experienced. Two of them worked at the Telecommunication Lab. The majority of them worked for TI or other companies. They all knew a bit about ICs but were not familiar with them.

Ling-Fei Lin: Was there a scramble for those positions then?

D.Y. Yang: It was okay I think. I am not sure if there was a scramble or not. The only thing I am sure is that we were satisfied that we had these partners in our team.

Ling-Fei Lin: Can you tell us how many people in total were sent to RCA for training?

D.Y. Yang: There were about 36 people. About 19 to 20 of them were sent for a longer period of time. For the design team, the length of story was for 12 months and for the process engineers it was nine months. Some were there for a short period like 1 to 2 weeks or half a month.

Ling-Fei Lin: It was the same 36 people who took turns being trained?

D.Y. Yang: Yes, later on there was a technology transfer for bipolar and we continuously visited to keep updated.

Ling-Fei Lin: Did you turn the bipolar into one of the techniques used at the plant?

D.Y. Yang: Yes, we did. But since it's more difficult to design, it didn't turn out to be as profitable as expected.

Ling-Fei Lin: Could you describe what could probably be on the participants' minds back then when they joined the project? Were there any patriotic emotions or thoughts like saving the country via technology? Or was it just simply a job they wanted to do?

D.Y. Yang: I think we can't say that it was patriotism that drove us or that we looked at it simply as some job to get done. Most people in the semiconductor industry know that, to be able to participate in an IC plant or in designing means that they have a promising future. To most of the people, this is very helpful to their career. Also, this was a technology transfer opportunity supported by the government. So everyone did their best.

Ling-Fei Lin: Can you explain to us why was the yield rate of the demonstration plant of ITRI so high after learning from RCA?

D.Y. Yang: I think it was because the quality of the people we sent was beyond their expectation compared to the US workers. For example, when I was in Harris Semiconductor, I used to see workers having lunch and drinking beer. So it was hard for me to imagine when they went back to the production line to work, the products they produce would have the expected quality. But people we sent were all university graduates, with their masters, or doctorates. Their understanding of the technology was therefore much more complete than the local workers. That's why the equipment we bought and the sanitation of our plants were both much better than theirs. I think this is why our yield rate was higher.

Ling-Fei Lin: So, manpower and facilities were the key points?

D.Y. Yang: Yes, these two were what semiconductor [production] depended upon.

Ling-Fei Lin: We know that UMC was like an extension of this team. Why didn't you join UMC?

D.Y. Yang: I think it was related to the start of the computer project. Since 1978, I devoted most of my time on the planning and executing of the computer project. I slowly left the product development of the semiconductor department and the transfer of UMC was the IC department's concern.

Ling-Fei Lin: Why were you willing to be the director of the computer project?

D.Y. Yang: It was not my initiative, but I was asked to do it. It can all be traced back to the technology committee, TAC. They told me that Minister Sun was very satisfied with the whole IC technology transfer. He wanted to continue pushing the development of other technologies. At that time, there was a Princeton professor, Professor Lo, in TAC. He had always thought that the computer industry would be an important direction for [the development of] Taiwan. I expressed my agreement and said that I thought it was good that people were working on this.

When I came back from RCA I was in charge of the product development department which included the design of ICs, and microprocessor applications. I was in charge of both [of those] aspects and Chintay Shih was in charge of the plant. Around 1978, Advisors Dr. Pan and Dr. Lo came to me and asked if I wanted to take charge of the computer project. I inquired about the reason that they chose me since I did not major in computer science. They said they thought I could do it. I asked if they had asked anyone else. They told me they had spoken with some other people, but they still thought I was the most suitable person. I told them if they couldn't find someone else, I'd do it. So I took the job, I was actually more interested in a new job. Therefore I separated the microprocessor part from the IC product development department and started to make an outline of the computer project.

Ling-Fei Lin: Was TAC past of the planning of this computer project?

D.Y. Yang: Yes, I think we could put it in this way. Back in that time, Minister Sun had slowly institutionalized the whole process of technology development. That's the reason he asked to have national conferences on the science and technology. Besides, the "Modern Engineer & Technology" seminar had been operated for many years. The "Modern Engineer & Technology" seminar was the most important occasion for TAC or overseas scholars to make suggestions to the government. After one or two years, many experts from overseas were invited back to provide some suggestions and opinions on the development of technology.

Taking advantage of these two occasions, many outlines and suggestions were slowly formed. I think one important skill was to state the conclusion first. After some further discussion we could produce a formal conference minutes. And then the plans would start. These suggestions were also given to ITRI to execute them. ITRI would propose and sign a project contract with the Ministry of Economic Affairs and then start to execute it. These kinds of national projects were all four-year contracts, which allowed it to have a certain continuity. So in 1979, ITRI signed the first national project contract for computer technology development with the Ministry of Economic Affairs (MOEA).

Ling-Fei Lin: Was the development direction or technology direction clear back at that time?

D.Y. Yang: In the technological aspect, the general direction was clear. We planned to make smaller computers instead of super computers. "Smaller computers" had a wide definition. In 1978, 1979, the definition of small computers was vague. Looking back at that time microprocessors weren't that popular. But, there were already many minicomputers made using microprocessors. The mainstream of minicomputers included Wang Laboratories and DEC and many other minicomputers. It was the era of minicomputers.

We planned in two directions. One was to see if we could develop a minicomputer system. The other was to use microprocessors to make computer systems. These are some experiences we gained from the IC project. That's why we also emphasized the developments of the engineering technology and production engineering. It was not a purely design task. In this process, for example, through some personal relations such as advisor Pan, he invited a very experienced senior Chinese engineer working at HP to teach us about engineering technology. Engineering technology is when you are designing a computer system…the analysis of heat conduction electro-magnetic waves and vibration needed in the system. What are these skills? These are engineering analysis techniques. Only in this way can you be sure your system is very reliable. This is not something we could figure out within a couple of days. This person was from HP and our advisor Pan graduated from Stanford. He was classmates with Mr. Hewlett. That's where he had the personal relationship.

Ling-Fei Lin: So this Chinese you invited from HP made a great contribution to the whole project?

D.Y. Yang: This is a part of the contribution he made. I think the computer project is different from the IC [project]. IC technology is highly focused. I said earlier that this is the most important pillar of human civilization and that is quite clear. Moore's Law tells you what the development would be like in the near future, so you have a clear direction. The biggest difficulty that computer technology faced was that it's something everyone does in his own way.

Back in 1978 or even earlier, every computer company had its own operating system, hardware and CPU design. Because of this situation, everyone had to develop or integrate its own peripheral equipment. This is the problem that all was faced with at that time. So what kind of computer technology should you learn? That was a big problem. In order to accelerate the training process of personnel, ITRI arranged for a training program at Wang Laboratories. We sent many people to Wang Laboratories for training in 1979. But Wang Laboratories was focused on word processors and they were growing rapidly. Our engineers were sent to different departments to help them to do certain things and to learn with them. But then I was not there in person and did not lead the team myself.

Ling-Fei Lin: How many people were sent?

D.Y. Yang: About 20 to 30 people were sent.

Ling-Fei Lin: Was it a technology transfer or was it just to learn?

D.Y. Yang: It was for learning, nothing about product transfer was involved. It was very different from the RCA project. It was for sure not possible to transfer Wang Laboratories' products and then to produce them ourselves. Now looking back, setting up an IC demonstration plant in a research institution was something truly unique in the world. Normally a private plant is set up, and they transfer technologies by themselves. Using the power of the government to establish a demonstration plant in a research institution, to plant it as a seed to spread it out, was a very unique method. Maybe we were lucky that it turned out to be very successful. But I don't think it will happen again, because most people couldn't accept the idea of operating a plant in a research institution. The demonstration plant also had many commercial conflicts with UMC. Since the demonstration plant had to maintain its own operation, it had many fixed cost to share. Therefore it had to develop products to sell products. This was the reason it had many conflicts with UMC.

This was why the demonstration plant trained so many business people. It's a bit strange that you could train people for plant management, accounting, sales and marketing in a research institution. But it was also the most important reason, how the industry got to expand because of the completeness of the skill sets. In most research institutions, they offer you only the technology or products, and you have to figure out the rest on your own. But in this way, a break down occurs in the value-added chain, since the most expensive parts are the development, marketing, and the selling of a product.

I remember when the demonstration plant first produced ICs for electronic watches, no domestic company was interested in purchasing [them], because nobody thought products made by a research institution were reliable. It was a classmate of Chintay Shih's at NTU in the Mechanical Engineering Department---he was making electronic watches in HK---he came to us and said of course he'd like to buy them. So the first products were sold to Hong Kong. People from Hong Kong are faster at doing business.

Ling-Fei Lin: Did he buy them since he was a friend of Chintay Shih?

D.Y. Yang: No, it was just that as soon as he thought he could use something, he would buy it. HK later on became a main base of electronic watch production because they made very good shells but they lacked electronic components. When we just came back from RCA, we did lots of promotion for our design and promoted the importance of MOS ICs. We did lots of educational work.

There was another thing I was very impressed with. A teacher from one vocational high school came and said that he used to copy electronic clocks from Japan. Japan used to use transistors in the electronic clocks so they were easy to copy. But, one day he found that the transistor was gone. Instead of the transistor, there was this square-like thing, something he couldn't copy. I said that square was an IC, and we could try to figure out how to make it. It took quite a while for us to make it for him. Later, electronic clocks or the so-called motor-electronic clocks became Taiwan's biggest product. Winbond inherited the market and Taiwan became the biggest production base for the quartz clock module. This is something interesting we can talk about when we speak of electronic clock chips. The owner of a Tainan noodle stand in Hua-Hsi St. actually ran the largest quartz clock module company.

Ling-Fei Lin: You mean the owner of Tainan Tantsumien (a kind of special noodle) Seafood Restaurant there??

D.Y. Yang: Yes, the boss was making quartz clock modules. He was the biggest one in the world.

Ling-Fei Lin: Why didn't the computer project consider transferring a product or even establishing a model of the demonstration plant? It might lead to good results if we learn about them all over again.

D.Y. Yang: Personally I didn't think it was a correct strategy. Since back then we had Acer and MiTAC promoting the development of microprocessors. The whole industry in Taiwan was shifting from TV to CRT terminals. If you track the path of the development of Taiwan's electronic industry, you'll find it's highly related to the color TV and black and white TV. Therefore in my book I talked about how Taiwan shifted from making TV tuners in export processing zone to making CRTs, black and white TVs, and color TVs. And, then we used the CRT technology for CRT monitors.

Actually, the first computer product Taiwan made was CRTmonitors. With CRT monitors and the basics of printed circuit boards, our computer industry started as an assembling industry. Many technologies already existed in Taiwan. That made it unnecessary for us to transfer any technology. And, as I mentioned before, in the computer industry in the States, everyone had their own operating system. Many products only had a very short life cycle. This made selecting one specific product to transfer difficult. So, when I was making the decision, I thought I would establish something that's more fundamental. We started with the design of CPU, and the understanding of the operating systems, and also the network. Personally, I think that private companies should figure out product development and commercialization on their own.

Ling-Fei Lin: Were you satisfied with the whole outcome of the design of CPU, software, and operation system?

D.Y. Yang: I was very satisfied. Take the operating system for example, when we were developing this operating system, many experts from overseas kept challenging our strategy, saying that we couldn't compete with others. I said I was not just making a product but trying to break the black box. Therefore we assembled some professors and graduate students from four universities, including NCU, NTHU, NCTU and NCKU to analyze each line of source code of operating system from a US company. We assigned a portion for each student to do the analysis and write reports. And we also held two seminars at Sun Moon Lake and Shitou to give these professors and students a complete understanding of an actual operating system.

These professors later admitted they knew little about real OSes. They used to only teach according to the textbook, and had no idea what really went on in a real operating system. For example when you're making a keyboard, only 20 percent of the programming has to do with the correct typing of it, 80 percent of the programming was to make sure keyboard functions even if people hit the keys erroneously. Textbooks do not tell you such things, which is what engineering technology is about. Although when we talk about the development of PCs, we design a BIOS, I believe we in fact trained many (system) software engineers throughout this process. Many of them didn't stay in ITRI but went straight into industry. Thus, the development of BIOSes in Taiwan grew rapidly. When you can design a BIOS fast, you can develop the motherboard fast. This is the reason why Taiwan could keep up with the pace of product development in the States.

Another basic technology I mentioned was engineering technology. We developed a product development process manual that we would give out if someone asked. I made great efforts accumulating the development process of various products from many American companies and friends. We spent about a year on the archiving of the process. We coded the process of a product's production with CI, C2, C3, C4. If you see this code for production process nowadays, it's very likely they inherited it from us.

Ling-Fei Lin: You said you asked for this from a friend; didn't this come from HP?

D.Y. Yang: No, we asked for these through an informal channel.

Ling-Fei Lin: May I ask which company gave these to you?

D.Y. Yang: I got some from DEC, some from HP and some other documents from other companies. You can't get anything from IBM.

Ling-Fei Lin: I heard that you got them directly from HP…

D.Y. Yang: No.

Ling-Fei Lin: So, it was a combination of HP and other…

D.Y. Yang: Yes, since this was something that we needed to absorb. There was a great deal of information to digest. We put a lot of effort into learning design rules. The design rule is something very definite in the IC industry, but it's something we didn't know about before the training [that we received] from RCA. It's about the relationship between your design and production. When you're designing something, you must consider the precise details of lengths and distances of every part of which there are theoretical bases. Later on we set the design rule for PCBs, what the angle of a resistance should be and how much space we should leave and where. We asked the production engineering department to get this information down pat. I made a big board at ITRI and attached all the connectors and asked the engineers to confirm their specs one by one. We thought everything must be made according to standards, including screws and every detail… there should be a standard. That is what we called production and product technology. We did much basic work like this and slowly spread the techniques out. Later we did surface mount technology as it was just emerging. With the support of the government's special project, we sent some people to cooperate with Philips on all of these technologies and we learned the [related] technical information and designed a training program to spread the technology and techniques.

Ling-Fei Lin: You mentioned design rules, whom did you learn them from?

D.Y. Yang: It's something no one would teach you. You need to sort it out from all kind of information. Of course, many things are related to production, including the design spacing, and width of the PC board. Actually every engineering technology boils down to the same thing. You need to figure out how to make the design rules, which are the most important interface document between design and production technology [teams].

Ling-Fei Lin: You mentioned that you sent 20 to 30 people for training, there seemed to be other computer companies involved?

D.Y. Yang: We'd dispatch engineers to other companies once we had the chance. If some companies needed some engineers, I would offer them some engineers without pay. When the engineers returned with their job completed, some software engineers told me that the companies they had been sent to were only average. And I would tell them that it was the main reason that I dispatched them. Our training courses were in fact, better than others.

Some foreign experts suggested to me, that although our engineers were very good, we lacked "exposure". That is, not having horizons broad enough and an international perspective, we were unable to link our businesses with international industries. I totally agreed and replied that it was indeed one of the most fundamental issues. But we needed vast investments to improve this. We'd have the engineers go out of our institute to work at some other companies and they learned through cooperation.

At the time we visited Wang Laboratories, my engineers complained to me about how the company was chaotic. They could produce such products while in chaos. For it was the most hectic and rapidly growing period of Wang Laboratories. I told the engineers that how they manage to produce good products while in such chaos was exactly what we needed to learn.

Ling-Fei Lin: One of the trainees in Wang Laboratories told me that, instead of an integrated and overall learning as in the RCA Project, the trainees were sent to master specific areas of knowledge in Wang Laboratories. Do you agree with him?

D.Y. Yang: Exactly, it was just a training project. Wang Laboratories offered training, but we did not pay for this [directly]. However we did maybe, through other arrangements. Executive Yuan and ITRI purchased computers from Wang Laboratories, so they may have gotten paid indirectly somehow. Anyway, this project was not a technology transfer, so it did not necessarily include technology or product transfer. It served merely as a training project. Initially, people were not really involved in the project. In my opinion, managers tended to prefer a successful outcome with the training project. However, that was not necessarily the case.

A technology transfer should contain a clear, so-called target product, follow-up production plan and investments. This investment really mattered in the semiconductor project. After the technology transfer from RCA, the government continually invested billions to maintain and to advance our know-how. The know-how had to be maintained to forge ahead and gradually disseminate the technology. If you only keep producing products after the transfer of technology, the industry would just fade out as the technology grows outdated. We see a lot of such examples in China. They mistakenly believe that as soon as they bring back the technology, it would naturally grow roots and start growing, which is, in fact, not the case. Everybody should know that the life-cycle of know-how is very short. You need large investments to make it grow roots and branches. Only after it takes its roots and private enterprises develop, is the industry truly stable and able to grow.

Ling-Fei Lin: You've mentioned that the government spent billions to root and branch the industry after the technology transfer from RCA…?

D.Y. Yang: Among all the government high-tech projects, our government invested billions in the semiconductor industry. We've consumed a large part of the budget. However, as of now, the industry had sprung up and is big enough. The R&D budget in individual enterprises nowadays exceeds the entire budget of ITRI. That's the way it should be.

Ling-Fei Lin: Have you ever considered similar technology transfer for the computer projects? Have you ever sought cooperation with IBM?

D.Y. Yang: No.

Ling-Fei Lin: Why not?

D.Y. Yang: I believe that the OS of every company is their source of life. Of course, one of the biggest challenges I had to face when the computer project was launched was deciding on the target product. Initially, I could only pick some fundamental work to do. I remember very well that I had two choices for a 16-bit CPU. One was the microprocessor from Motorola. The other was the microprocessor from Intel. Motorola was a more "senior" company and their CPU was generally considered better in the industry. But I chose Intel because I talked to MiTAC sales personnel, and asked if they could provide us with technical support. MiTAC said "Okay", so I chose them. Now, it has been proven that I made the right choice. We learned later when Intel was promoting its CPU that they had developed many development systems and released large amounts of data to the outside. So when I heard the IBM PC was equipped with CPUs from Intel. I believed I had fulfilled half of my responsibility to history. Maybe it was luck, maybe it was a right decision, for we were familiar with Intel CPUs.

Ling-Fei Lin: So you chose Intel first, then it was used by IBM?

D.Y. Yang: Yes, Intel… I think in most cases, was a better choice.

Ling-Fei Lin: You just said you never talked with IBM because you knew that the OS (Operating System) is the heart for each company. And you felt it was not possible, therefore you did not attempt to approach them, is that right?

D.Y. Yang: I often traveled to the western part of the US, and I also visited many companies. At the beginning, before Apple and IBM PC emerged, there were only microcomputer companies in the US. Microcomputers were everywhere, including someone you might know, someone named Albert Yu. Albert Yu is a Chinese American who later became senior executive with Intel. I also visited his company back then. They were manufacturing a microcomputer called "Video-brain" with the 8-bit CPU from Fairchild. I had also discussed with Yu, and everyone in the field, each of their products were very different, therefore it was very difficult to make the choice.

After that, we used CPUs from Intel and decided on using the CP/M operating system from Digital Research. From then on, operating systems gradually became a standard product. If you look at the history of IBM PCs, they too went to Digital Research for the CP/M operating system. However, the story went on and Digital Research rejected IBM's request. This was why IBM came back to Microsoft. Microsoft then bought a DOS system elsewhere for IBM. This is what happened. The whole computer industry was at a stage when a lot of so-called microcomputers were being developed. And in this booming age, Motorola and Intel emerged [as leaders of] the microcomputer industry. It was a phase of the industry when many things were blooming all at once. Then in 1977, the Apple II computer incorporated the 6502 chip. It was only then that the milestone of the microcomputer industry was set.

Ling-Fei Lin: So we could say that it was in 1979 and t IBM PC had not been released yet. It was not clear as to which path you would later take. Let's assume if it were the minicomputer--- would it have been possible to go down that path?

D.Y. Yang: We were learning using Digital DEC as the model since Digital Equipment products were made specifically for engineers. The founder, Mr.[Ken] Olson just passed away last month. I think because they produce things for engineers to use, a lot of their technical information was provided. You could even print out the source code of its OS. The bus information was very accessible. Hence a lot of its information was very clear and therefore, engineers had a better understanding of the Digital Equipment [products]. At that time, we used the bit slice technology, with different ICs to design CPUs and succeeded in this way. And this helped a lot with the understanding of the microcode. We also tried to make our own OS and hoped that one day, we would cultivate our own group of engineers. I felt much more confident after the second or third year [of doing this] because by then there was a good technology basis. We basically got all the fundamental technologies. The rest was just to wait for the product to bloom and pay off.

Ling-Fei Lin: You meant we had taken after DEC in terms of making minicomputers. How are they related to the production of microcomputers, later on?

D.Y. Yang: Then there was the emergence of IBM PC. I think on this matter… of course many people have different views. This is a key issue in history. The situation in Taiwan at that time was that Apple computers were being copied everywhere. And judging from different angles, the government and people in the industry were all very concerned about the issue. Taiwan had already shown basic skills in this area. Therefore, everyone, including the US, was very concerned.

The impression I have of Apple II was from Minister Sun or Director Sun of the Ministry of Economic Affairs. MOEA asked us whether or not the government should impose a ban on copying Apple II. I told them our answer was "yes". Of course we needed to ban this. We cannot copy other people's work. We need to develop our own and I told some of my colleagues that. They also told me how the Industrial Development Bureau was under a lot of pressure to find a way out.

In 1981, when the IBM PC came out, we thought this might be just another microcomputer because the microcomputer market was always going through ups and downs. We were not even sure what would become the mainstream market until one day, Stan Shih told me that they had decided to follow suit. He believed that the IBM PC would become a mainstream product. I had mixed feelings about this. First of all, Acer actually came to us to work on this together. Secondly, I was embarrassed to ask why couldn't Acer do this on its own? My understanding was that Acer should be able to do this on its own. He came to me and of course I agreed, saying “let’s work on this together”. And the dispute later on was that the project started as a commissioned project, but then turned into an open project.

This had to do with the MOEA and Industrial Development Bureau. There was great pressure and they needed many people to join this project. So this project went from a commissioned one of a single company to a joint-development project of 5 companies. I have heard Mr. Shih expressing his dissatisfaction about this on several different occasions.

However, if you look at the whole… how the whole PC Industry became an asset to Taiwan, there were actually many factors. Before the PC or IBM PC came out, we had already been working as a laboratory for the FCC compliance test. The FCC laboratory measured electromagnetic interference and was built for testing CRT monitors, not for PCs. Before the lab was set up, new monitors had to be shipped to the US, be tested and certified, then shipped back. All of this took too much time.

During that time, we had regular meetings with the private sector. TECO and Tatung brought this up and said “we are experiencing great problems on this issue”. Then I thought I had the flexibility in managing the budget of national project at the Industrial Technology Research Institute. I told them I could spend NTD 10M to set up this laboratory. I immediately handed the task to another department of the ERSO, the Quality Management Department, to oversee this set-up process.

The first thing after its establishment was to obtain an authorization from the U.S. Federal Communications Commission.. Then, we could start to give out certifications. I heard there was a queue 24 hours a day, everyday. This way we assisted them in solving a serious problem. That is how it can be said that we did a lot of work in infrastructure, which facilitated the development of the industry. Apart from this and the story about PCs, there are of course numerous other stories to be told. The first was this story of the national project. The second was being held up at U.S. Customs.

Ling-Fei Lin: Held up at Customs?

D.Y. Yang: It was the first shipment… The PCs Acer shipped to the U.S. were held up at the U.S. Custom. They were shipped to NCR. To the computer industry in Taiwan, this was of course and actually a turning point. I thought this was a great opportunity. After IBM discovered this incident… I should put it this way. After the IBM PC was released in 1981, the entire PC industry around the world was a bit… Well, I cannot use the word "crazy" but everyone was very, very excited. During that time, 100-200 PC companies sprouted in the U.S. and wanted to become the next IBM compatible supplier. There were also a large number of firms waiting to be chosen by IBM as suppliers. So, this whole industry especially in the U.S. was in a frenzy for IBM PCs.

And of course, we were waiting. We were waiting for the time for us to step up and take part. So when Acer came to us for such a job, it did not take us a long time. But I was not satisfied. I remember, from signing the contract to the shipment of product, it took us less than a year.

Ling-Fei Lin: When did they come to you for developing such products?

D.Y. Yang: It was around 1982 or 1983. I remember we had signed contracts with 5 companies in '83. The contract stated we had to deliver by the end of '83. We managed to develop [a product] in those few months. It was around 84’ that we encountered some problems when the first shipment arrived at U.S. Customs. As a result, IBM sent many engineers to interview our engineers. After a series of interviews, everyone, including the [Taiwanese] government, was nervous about the outcome.

I had also handed in my resignation. At that time Chin-Tay Shih was the acting Director. Ding-Hua Hu was studying in the US. But we said we should, of course, focus on solving the problem first. Later, representatives from IBM told me that our engineers were all very good and that the technology did not seem to be an issue. But our engineers knew nothing about copyrights. IBM people said that our engineers thought that with such simple programs there was no need to write it themselves. So they just took what others had already done. Therefore, they said it was okay. It was only because we lacked the concept of copyrighting so they did not see it as software piracy. Afterwards, Minister Chao said we were ignorant. I agreed and said yes, we were ignorant. We knew nothing about copyrights.

Ling-Fei Lin: Was it really like this?

D.Y. Yang: Yes.

Ling-Fei Lin: You mentioned earlier that, IBM is a very “gentlemanly” company. How was this incident of “blocking” resolved? Was the clean room established before or after the incident?

D.Y. Yang: As I mentioned before, IBM sent their engineers and legal personnel to interview our engineers one after the other. They concluded that our engineers’ ability was beyond doubt and we did not copy the BIOS. Therefore, they suggested that we rewrite the whole program. And that we consult an American consultancy firm, called Arthur D. Little. If Arthur D. Little approved, they wouldn’t have further objections. However, they could not give us the consent if our BIOS was OK or not, because they were a competitor.

We took that advice and sent our engineers to Kuangming New Village. That is ITRI’s dormitory area with rooms for single persons. Our engineers thus were asked to work around the clock, rewriting the program, so as to minimize possible similarities with IBM’s BIOS. They rewrote every part that was even close to theirs. Then we asked Arthur D. Little to verify the program, which took three months according to the firm. When I was in the US, I got a call saying that there was no problem, and therefore the entire pressure was relieved. Based on this incident, I believed IBM that was a real gentleman of a company.

Many developments followed this incident. IBM had a stronger impact on Taiwanese engineers. Later on, IBM asked our research lab to establish a firm, called “Cheng-Chian” for them. co-invested by us [ITRI] and China Development Company. “Cheng-Chian” was a company in Hsinchu Science Park with capital of only one million NTD, which was the lowest in the entire Science Park. Nevertheless, the company had a very unique background. That is, its expenses were all paid by IBM, while both ITRI and China Development received a certain percentage of profits.

We then transferred some engineers to “Prospect” for product development. The initial manager of this project was Mr. Wang, Bo-Yuan Wang, who once worked with IBM’s Bob Evans [System 360]. He is at this moment [2011], the president of Taiwan Venture Capital Association, as well as the chairman of several other companies.

The legal problem with IBM was gradually resolved. IBM provided us with many training opportunities. Our engineers were invited to IBM PC headquarters in Boca Raton, Florida for some legal and BIOS training. They also received training in Hong Kong. They hoped that the concept of intellectual property right could be developed in

Taiwan through these channels. I learned a lot about the concept of intellectual property rights.

I also gave lectures later on about intellectual property rights, patents, and trademarks. These resulted in the design of semiconductors, the mask protection law. That was when the education of intellectual property started in Taiwan. IBM then invited us to organize a team of managers, which was led by me and included current executives of many companies, like Bai-Li Lin, Kun-Yiao Li, Bo-Bo Wang. Many of them were at the top of the [PC] industry. We were invited to visit IBM. We spent about two weeks visiting 9 places such as a quality control center of theirs in the East and their local factories and [had many discussions] with their managers. This really broadened the horizons of our company executives then.

Ling-Fei Lin: When did this happen?

D.Y. Yang: Around 1984 and 1985…I can't really remember. I did not have the habit of bringing a camera with me at that time and I am not sure if other team member had taken photos.

Ling-Fei Lin: What was the main concept discussed? Why did you feel that it broadened your horizons?

D.Y. Yang: We saw how a big company functioned. Each so-called site in IBM was composed of thousands of people. How they perceived automation and production management could also be discussed openly between us.

Ling-Fei Lin: Why did they invite your executives?

D.Y. Yang: I believed that IBM was hoping to initiate further cooperation with Taiwan through this opportunity. We also understood that they sent some managers to Taiwan. They discovered that Taiwan actually had very capable technical abilities. Costs and capacity of engineers in Taiwan exceeded the imagination of many of their middle-level managers. Many of them had worked in IBM for their entire career, and had no idea what was happening in the outside world. However, after the IBM PC was launched, they also realized that the development of the computer industry represented a different phase. Their old approaches might not be able to adjust to future developments [in the PC industry] . Super computers or so-called mainframes could be sold in person by salesmen; however, PCs could not be sold by a single individual, but through channels, sales channels had been changed.

Ling-Fei Lin: Were the engineers kept in Kuangming New Village to re-write the program the same group of people as before?

D.Y. Yang: Yes.

Ling-Fei Lin: I've heard that it was a different group of people that was recruited, who did not understand the original BIOS at all.

D.Y. Yang: No. It was the same group. Actually we could reflect on many different aspects. Our development in fact involved many of our own technologies. For example, the first generation of IBM's product had a floppy disk. Later, we had to develop with hard disks. One needs to fully understand a hard disk to design its drivers---for example, how long it takes for the hard disk to read data when the head moves. One cannot achieve this without thorough knowledge of hard disks. Accordingly, our engineers informed me that our hard disks had significantly better performance than theirs. This proved that we had knowledge about many of the hard drive's technical aspects. We were happy to have a clear target that we could continue to work on.

We started the IBM compatible PC project in 1983, we launched the new product in 1984, In the follow on projects we hardly had gaps between IBM's AT and ours. Moreover, I felt we had been waiting for them when it reached 386, because as soon as the IBM's PC using Intel's new CPU was developed, we were able to predict the trajectory of its development. Indeed, there was a trajectory of development to follow. If its [IBM] own CPU was used, we couldn't predict the trajectory. However, Intel is an IC company whose development could be predicted. Also, Intel's CPU was open to others so you could design it in [easily]. The 186 was followed by the 286 and the 286 by 386. In addition to selling to IBM, the 386 was also sold to the public and therefore we were able to catch up with them.

With regards to development during this timeframe, many factors contributed to the computer industry in Taiwan. I especially attribute it to the great participation of the industry. As we are all aware, the development of semiconductors was really rapid as demonstrated by "Moore's Law", which led to the rapid development of Intel's CPUs. But if an entire computer needs to be shipped to the US, one faces the question of choosing transportation by sea or by air…there are different costs [involved]. The most expensive items are the CPU and hard disk drives. As a result, many small Taiwanese companies, and American Chinese developed a business model. That is, motherboards produced in Taiwan were transported by air, while power supplies and casings were shipped because they are heavier and it is cheaper to ship them. On the other hand, CPUs and hard disk drives were purchased in the U.S., so that a final product could be rapidly assembled in U.S.

I have been emphasizing that Taiwan invented the concept of [building] motherboards instead of taking apart an entire PC and working on parts separately. I later learned that it was in 1986, when even the positions of screw holes were standardized, the production of casings was divided into different tasks. That is, mechanical interfaces became standardized so that everyone could cooperate. Thus, later on, when the XT and other versions of motherboards were introduced, cooperation accelerated. I refer to it as "the ability of innovation", which allowed Taiwan to break up the PC into parts, and to involve everyone's participation. I remember very clearly how I was impressed with a scene on television, in which an old worker sitting in front of a dark machine was stamping sheet metal manually. The sheet metal was the metal plate for the back of a PC casing, turning high technology product production into a low technology method. That is the strength of Taiwan. When many people are involved, it reduces the cost of the products and makes them reliable. At that time, old industries in Taiwan, including CRT, PCB, as well as others, were all able to participate.

Our contribution was the development of at least one legal BIOS. I called it the "ERSO BIOS" then. Another thing our lab did is less well known. Microsoft was at that time still a very small company. We thought that maybe we could talk to them about business. Many of our colleagues, including myself, visited Microsoft. I assumed that many small Taiwanese companies were unable to afford the upfront licensing fee of tens of thousands of N.T. dollars. We offered to pay the fee and to re-license it at $2 U.S. dollars for each copy. Microsoft, which then was a small company, agreed, so I believed it was also looking desperately for other revenue [sources]. This contract was established through a Japanese firm, ASKI, which was close to representing Microsoft.

We flew to Seattle to discuss details of the deal, which would solve the [market] entry barrier problem for small companies. As long as they could afford two dollars for a copy, we collected it and paid Microsoft. In other words, we centralized all resources with support from the government, and then spread them to each company to lower the [market] entry barrier. This thinking pattern can be slightly expanded today. Namely, how can we make up those missing links? Once those missing links were gone, the industry started developing naturally. That is what I often called the added value chain.

We must keep reviewing the bottlenecks faced by the industry. In the process of developing, these bottlenecks change. Back to IC design, for instance, photo mask making was a missing link, so indeed, mask technology was very important. When IC design improved, the legacy photo mask technology was a bottleneck, because the mask was "the mold" for IC design. I remember an interesting incident. When we bought the advanced mask manufacturing equipment, as the power of government was so much stronger at that time, we even asked China Airlines to change its schedule to pick up the equipment in U.S. We also asked police cars to secure the road for us, transporting the equipment from the airport at the speed of few kilometers per hour, because the equipment was extremely vulnerable to vibration. The entire infrastructure at that time was not that great.
Another interesting incident worth mentioning is that, when the equipment arrived, we moved it using only manpower. We hired many local people who were very strong and were able to carry the equipment without any machines. Many interesting incidents happened.

So let's return to my point. If you can constantly observe the development of the industry, see the opportunities and further fill in the missing links, it can develop on its own. But they have to begin with knowing what can be done.

Ling-Fei Lin: Before we continue with the questions, I would like to go into more details about previous topic. You mentioned sublicensing from Microsoft. Was that a sublicensing of its DOS?

D.Y. Yang: Yes, DOS.

Ling-Fei Lin: Was it ITRI who received the license?

D.Y. Yang: I paid a higher amount of money, which we called "upfront" for the right of re-licensing. They agreed that we could re-license it…

Ling-Fei Lin: How did ITRI come up with the project of IBM compatible PC? Do you mean that it was actually an idea of Mr. Stan Shih from Acer?

D.Y. Yang: Yes, as far as I remember it was suggested by him at first. From the viewpoint of our other colleagues, it was also from the Industrial Development Bureau of the Ministry of Economic Affairs (MOEA). I am not sure who exactly came up with the idea first. In the end, the development contract became a joint development, with five companies and the expenses were shared by all. The project was called MCP-1, which stands for Multi Client Project No. 1. This was the first multi-client commissioned development project of ERSO.

Ling-Fei Lin: In other words, Acer first sought cooperation with you, which later turned into cooperation with five companies?

D.Y. Yang: Yes.

Ling-Fei Lin: Did he [Shih] also know that the five companies agreed to share the costs?

D.Y. Yang: Yes.

Ling-Fei Lin: But complained that they originally proposed the project to you?

D.Y. Yang: Yes.

Ling-Fei Lin: Which later turned into five companies?

D.Y. Yang: Yes.

Ling-Fei Lin: You mentioned that [ERSO] had cooperated with four universities on the OS, and also that many people ended up working on the BIOS, making it really strong. Can you describe the relationship between the OS and the BIOS? Also, why did the software industry in Taiwan not develop?

D.Y. Yang: The BIOS is very important software connecting the CPU to the operating system. The BIOS on Apple 2 and IBM PC were completely open to the public. Its purpose was to allow some further applications to be developed, like for example, adding additional disks and other applications, which sometimes requires additional programming of the BIOS. Although the BIOS program was open to the public, it was still protected by intellectual property rights. Therefore, what we did was a process to legitimize the use of the BIOS with our own codes.

Once you control the BIOS, when your CPU and chip set changes, you will be able to change the BIOS. I believe that many graduate students from universities take this kind of job in companies after the training of system software, as they have full knowledge about how to integrate hard disks, display cards and keyboards, this is why Taiwanese PC motherboard could rapidly adapt to CPU changes. Without this ability, that could not have been done. In fact, among hardware companies in Taiwan, the ability to develop better products is highly related to the firmware or BIOS. Without this ability, product development cannot be successful. Consequently, a software engineer in a hardware company has to be more than a hardware engineer, because hardware design has mostly been replaced by IC companies. The major task of a system company is to develop software, or “firmware”. In fact the BIOS is a type of firmware. Later some new companies such as Award and Phoenix were established to focus on providing the BIOS.

Ling-Fei Lin: I would like to add another question about the idea of IBM-compatible PCs. Because Mr. Fu-Ching Wang (Peter F.C. Wang) mentioned that he had proposed this idea on a certain occasion. So do you think it was him or Acer who first proposed the idea?

D.Y. Yang: I can’t remember…I think I highly delegated responsibilities to my staff at that time, so I was…well, I had a great number of external tasks to deal with. The government was promoting the project of automation. I also spent much time taking part in the automation project in ITRI, as well as many other tasks related to the management system. Therefore, many tasks were taken care of by my managers. The information I received was that Prime Minister Sun asked if we should ban Apple hard and we agreed. In fact, as we worked in ITRI, we had plenty of opportunities from the beginning to provide advice to the government concerning technological development.

For example, earlier we discussed about how Taiwan should develop the electronic industry, and in which direction it should go. We proposed at the time that it should be digital, not analog. The second issue [raised] during development was whether we should protect the domestic industry with high tariffs. We suggested a free competition without protection. That was the right course of development. No matter whether our opinions were important or not, I am sure we provided ample experience [and opinions] regarding technological developments. I will tell a story as an example.

Not long after I returned to Taiwan, I had to write an article because there were two groups in Taiwan, with one supporting IC development, and one the computer development. We had an IC project, of course the IC [project] was considered more important. However, many people in Taiwan did not believe that the IC project could be successful, because it was too difficult. There had been also many failures in the US.

Ling-Fei Lin: Which part do you mean, applied the IC or the system?

D.Y. Yang: I meant the priorities in developing the electronic industry.

Ling-Fei Lin: And the conclusion was to apply both in parallel?

D.Y. Yang: No, the IC [project] in the end was still the priority.

Ling-Fei Lin: By making the IC [project] as the priority, are you referring to government budgets or other aspects?

D.Y. Yang: Correct.

Ling-Fei Lin: So, the system approach received less national support?

D.Y. Yang: The computer project had started later. At that time, the entire technological project focused on semiconductors, which I believe was right decision Today ICs have become a major source of system design. Indeed, now IC design has become system design.

Ling-Fei Lin: Then why was development based on ICs? What was the major argument?

D.Y. Yang: Because this is the most important component. If you really spend time to understand the development of the semiconductor, you would realize that it is a very critical factor. It is a very generic technology, very generic, and that is also the reason why many countries have pursued every possibility to develop it.

This also brings us back to the question of why many [of the global] IC industries faced the problem of excessive capacity. In 1986 Intel in the US gave up DRAMs, so as to focus on CPU, because it was impacted by the development of DRAM industry in Japan. Japan’s development of DRAMs was also a national strategy, and so was Taiwan’s. Nations believe that if they hope to develop a self-sustaining, autonomous industry, they have to control the technologies of semiconductors. This is also the reason why China has devoted itself to semiconductors. Sure, many countries intend to develop semiconductors, but products that can be selected have become more limited. There are two choices, if the pockets are deep, wafer foundries or DRAMs. However, this may have migrated nowadays to flash memory.

Ling-Fei Lin: You mentioned that we considered whether to set ICs or [PC] systems as the priority, when was it?

D.Y. Yang: It was 1976 when I just came back.

Ling-Fei Lin: Is there any comparatively big technical barrier with the IBM compatible PC?

D.Y. Yang: Actually, there's no such technical barrier. It's simply the use of many existing technologies. But without the human power we invested within the previous three years, it's impossible that we could make it within months.

Ling-Fei Lin: You mean the involvement of the three-year computer project at the ITRI?

D.Y. Yang: Yes, by the second or third year we were already able to control most of the technologies, but how to commercialize the remaining? It was good that the IBM PC emerged. It was like lighting wild fire, then, also, a private company endorsed the business.

Ling-Fei Lin: Since you participated in the whole project for semiconductor and computer technology at ITRI, could you compare the differences between these two projects?

D.Y. Yang: I think IC technology is a technology of continuous, visible breakthroughs. It is a fundamental technology, a capital-intensive technology. That is why its development is so visible. Capital, human resource, equipment and product, with all of these, it could develop according to Moore's Law.

Computer technology blossomed everywhere. You never knew who started what from where. But when the IBM PC appeared, it offered a great opportunity for Taiwan. I often say to people that we have experienced a "golden age". We have enjoyed it for 30 years. The IBM PC came out and we grabbed this chance, making Taiwan an important IT PC base [in the world]. I really think it's something very important for Taiwan. Thinking of the past, what did Japan do at the same time? Japan was doing a PC called NEC98. It was NEC's PC and it controlled the whole Japanese market. But since the NEC98 was never in the [global] mainstream [market], the entire Japanese computer industry has been very negatively affected ever since.

So, if we see PC from the view of the entire information industry, it was a crucial industry. We can all see now clearly that PC industry has penetrated into consumer electronics. That's why I said back in that time, that we will make great use of it, and we will make lots of applications and software and make PCs a channel of entering other industries. It is now very clear if you do not have the PC industry, that the other industries will not have that support to support your developing other products and markets. The PC industry is the driver of the [overall] market and ICs are the technology provider. As often mentioned by many, the reason that so many things took place in 1987, 1988 was that these two industries began to integrate in Taiwan in 1987-1988. The other element was the emergence of DRAMs in Taiwan. Why did TSMC emerge? Because some companies or Chinese engineers abroad, developed DRAMs in our [ITRI] lab, but had no place to produce it. They went to Korea to do production. It did not make sense to us. People were wondering why it could not be produced in Taiwan. This led to the idea of joint production lines and joint labs.

That's why so many arguments about foundry have occurred. People argued about who brought up the concept of foundry. Anyway, I am glad that TSMC has become the foundry of the world. Taiwan invented [both] motherboards and [a] dedicated foundry industry, This is Taiwan's greatest contribution to the entire information industry.

Taiwan's PC industry developed rapidly in 1987, 1988, since many people and companies jumped in, including overseas Chinese and numerous companies, and they all hoped to develop this industry with the PC industry as a focus segment. It allowed

Taiwan's PC industry to keep up with the trends of Intel and Microsoft. Compared with the [rest of the] world, Taiwan is the only one who can provide PC products in this way.

Also, Taiwan standardized keyboards and power supplies, etc, and thus made Taiwan an irreplaceable supplier [to the industry]. People started to think about which IC can be is replaced like when Winbond chose to develop I/O controller for PC. Some developed DRAMs and companies that developed chipsets also emerged.

There's another interesting story…it could be a good or a bad story. When the first fabless company established in the US, a company called Chips & Technology, their founder came to IRI [Design Services] for cooperation. And, IRI said no, because our people thought that we could do it. In the end, they became the first successful fabless semiconductor company.

Ling-Fei Lin: Was it a DRAM company?

D.Y. Yang: No, it was a chipset company. They were the first fabless company in the world. They produced chip sets for the IBM PC. Many companies then thought about how they could replace them. Many of the ICs on the motherboard were provided by Intel, but they were able to integrate them so that they made the motherboard cheaper. And many companies put all [of their] efforts to get in [to that market]. Many Taiwanese IC companies also spotted these opportunities, and began to put resources into it and to make it happen, like Silicon Integrated Systems (SIS) or VIA. Actually, I'm often asked "when did the Taiwanese information industry really take off?" I say it's when PC and IC [industries] were starting to integrate. They become both very powerful industries once they were integrated. I dare to say Taiwan can never be replaced.

Ling-Fei Lin: You just mentioned that Taiwan invented the motherboard industry. But, weren't there companies like Micronix in the US?

D.Y. Yang: I believe that this is, of course, relatively speaking. Taiwanese companies may not coordinate well enough, but each company clearly defines its own focus. And [they] break down the PC industry into parts. Each company does what it does best. Some do the keyboards, some do the monitors, some do the motherboards and some do the casing. This is what I call the ability to innovate. In addition, when all other technology elements are in place, it will develop naturally. We can actually see the same circumstances in many other industries.

Ling-Fei Lin: But you thought the motherboard was unique. Did [Taiwanese companies] make it an industry?

D.Y. Yang: Yes. Motherboards became an industry, the most crucial industry with BIOS and CPU provided by Intel. Many motherboard logic circuits were what we called TTL standard components. Many companies started to integrate groups of TTL components into ICs and connected them with Intel's ICs, which became the so-called chipset - motherboard components. SIS and ViA were both leaders in this field. If we go back to talk about what role ITRI or others played, we can talk about why people in SIS came back to Taiwan. Back in 1979 or 1989, my classmates and I had a class reunion in Silicon Valley…people like me,Bob Tsao, and Bobo Wang, who was the founder of Microtek. We held a few seminars on the development of high-tech in Taiwan. People who came were excited and hoped to use our experience in Taiwan. The current chairman of ViA and some of his main staff came to me. Winbond first invested in them and established a company called Symphony. Maybe it wasn't very successful in developing our relationship. Hsueh-Hong Wang later invested in VIA by recruiting these people. They quickly produced chip sets and set up operation in Taiwan. Shing-Chien Dwan and Shiao-Ming (Samuel) Liu were all my classmates. Mr. Dwan came back to join UMC. He established a LCD company named Unipac Optoelectronics Corporation, which later merged with Acer Display Technology, Inc. and became AUO. Mr. Hsiao-Ming (Samuel) Liu was also in our class. He joined SIS and focused on chip set development.

In the past 10 to 20 years, many friends or classmates from abroad came back to Taiwan because of fast development in Taiwan. We suggested that some come back to ITRI first for a few years and then to go into industry. The projects that ITRI supported provided a beacon, or a rallying cry; it was if they raised a flag for people to rally to. So many people kept coming back to Taiwan. For they had a specific target to go for, when they come back from overseas, lots of people who studied abroad come back to Taiwan for the same reason.

Ling-Fei Lin: Why weren't ITRI's computer projects given lots of credit in Taiwan like their IC projects [were given]? Why weren't the computer ones given as much credit?

D.Y. Yang: I think I might have to blame myself more regarding this. I don't talk about this often. Some colleagues in our computer development center also had misgivings about this, because I left ITRI to set up Winbond later, to develop semiconductors instead of computers. This didn't meet their expectation of spinning off [from ITRI] a computer company. My thoughts were that computer business is something private enterprises had to develop and we had a different role (compared to IC project).

In the early years, one of our managers asked me, "We have 300 engineers and staff just like Acer, but Acer grew so rapidly, what do we do?" I told him "You should leave ERSO if you envy their rapid growth. Because when Acer reaches 10,000 employees, there is no way we could [have done that]. We are a government supported research institute, Our role is to support the development of an industry. We can't think of our own development only"

There is an important concept here. When I was the director of Planning Division at ITRI, ITRI focused on external benefits instead of internal ones. External benefits mean that when you're using government's funding, the benefits should be external instead of internal. You need to keep thinking about what the industry needs. Today, both the Taiwanese semiconductor industry and the computer project have good developments and I think the credit belongs to private enterprises.

I conducted some market surveys during my last year as Director of ITRI's Planning Division. Even if a company has technology from ITRI, the company still thinks its success is due to its own effort. This is natural. After all, ITRI could only offer them technology, they had to deal with their own business issues and solve their own problems regarding the running of business. If you go and ask UMC whether they consider their success to have come from ITRI's ERSO, I don't think they would give you yes for an answer. We heard some similar conclusions after many interviews. This is why I often say we shouldn't expect for credits in this aspect.

But the IC project was different. It was a highly concentrated project; all of the technology used by the spin-off companies that emerged from the project was developed by the government, with the exception of Winbond, although Winbond did draw many of its personnel from ITRI. When I emerged, we didn't use any of the government's power (or its money), so you could say I was helping ITRI solve a problem.

Ling-Fei Lin: You mean the problem of demonstration plants?

D.Y. Yang: Yes.

Ling-Fei Lin: Why did you establish Winbond? Was it because some people would become unemployed since the [ITRI] demonstration plants were closing? Was this the most important driver, or...?

D.Y. Yang: I don't think we can say. There are some stories [involved]. We spoke about how Ding-Hua Hu went to Stanford Business School. He was first to go. Chin-Tay Shih went the second year. I went there in 1985-1986. It was the equivalent of today's "EMBA" (Executive MBA) programs. We took classes fulltime there. When I came back, I was Director of the Planning Division, Morris Chang was already the President of ITRI. In 1986, 87, the external capital markets and the success of UMC and the growth of PC [business] were all obvious. Investors were very confident about the Taiwanese information electronics industry and were hoping to find a chance to participate.

The first example was that with the support of the government, TSMC was established. The second and also more threatening one (to ITRI's people stability) was that Hualong established Huawei Electronic. And there was also SIS established by Mr. Chung-Yan Do. They were all recruiting people from ERSO/ITRI, so the demonstration plant was facing a huge loss of engineers. Because most of the R&D people were transferred to TSMC, those who stayed with the plant faced lots of competition and challenges from UMC and were therefore under great pressure. They wanted to spin off. Of course, I explained to them… that it was unlikely because Morris wanted them to join UMC. As the Director of Planning, I would participate in all these meetings. Being the key staff, I had to participate these meetings, at that time, I was planning to leave ITRI, but I didn't know what I would do yet.

Ling-Fei Lin: Why did you leave ITRI?

D.Y. Yang: Because after one year in Stanford and with the influence of MBA training, I said I must leave ITRI before I was 40. I did not want to retire from ITRI. So I had already started to think that I might leave. I participated in their meetings concerning spinning off the demonstration plant, and later I analyzed to them that Morris Chang, who was already the chairman of UMC, he wouldn't let them leave to establish a company competing against UMC.

Ling-Fei Lin: How about joining UMC?

D.Y. Yang: This was Morris Chang's intention. But for so many years, these people had been competing against UMC, it was impossible that they would agree to this. I analyzed it for them---of course it was my personal opinion. Later, one day I told them on a whim, "How about I take you guys out?" They had been expecting this. So I thought I could help to put an ending to the demonstration plant. Thus I went out seeking funding everywhere, also a place for me to begin with.

In 1987, I was lucky to have Walsin Lihwa to invest in the new company. Like with many other companies, the government "twisted the arm" of Walsin Lihwa, and made them invest in UMC. Many people weren't optimistic about the future of UMC by that time, but since the government had been taking care of them, everyone eventually invested. It was later proven that they all made money out of the investment. They learned from this that this industry does have a future. That's why, within a month I had their agreement and established Winbond. And then I started to slowly move people from the demonstration plant to Winbond.

Ling-Fei Lin: How many were there?

D.Y. Yang: About 200 in total.

Ling-Fei Lin: 200, and they were not from R&D?

D.Y. Yang: Yes, they were all from the demonstration plant, and [there also were] some design engineers. But, Winbond paid a lot of money to ERSO to license the technology and products. I think, though we know all these of technologies, still I should give ERSO the license fee. And, ERSO could slowly transfer products to me; this was the beginning of Winbond.

Ling-Fei Lin: Winbond and TSMC were established in the same year, 1987, and you also mentioned before that Morris hoped people from the demonstration plant could join UMC. Wasn't he aware of the founding of TSMC?

D.Y. Yang: Yes, he knew.

Ling-Fei Lin: Why not just ask these people at the demonstration plant to join TSMC directly?

D.Y. Yang: When it comes to the transfer of technical personnel, I often say that there is an emotional element to the process. When some people joined up, that meant that others wouldn't. Besides, TSMC personnel were all in the R&D project and VLSI project. The technology of the demonstration plant was more "conventional". Back then, people joining TSMC were all development and technology-oriented. Or I should say the people [who were] more "process-oriented" all went to TSMC. The electronics industry is about two things. One is more business-oriented [managing] operations, the other is R&D. People doing R&D, went to TSMC. Therefore, people who stayed at the demonstration plant felt uneasy about it. That's why I took them out to Winbond.

Ling-Fei Lin: But aside from R&D personnel, TSMC still needed lots of factory workers. I still do not see why TSMC did not turn to them?

D.Y. Yang: Because they also had lots of factory workers from the VLSI Lab. And, somehow some people were just not willing to go, and some were not able to.

Ling-Fei Lin: So, some people from the plant still joined TSMC, and the rest, who were not willing to, joined Winbond?

D.Y. Yang: Some chose to stay at ERSO. But, the scale of ERSO's demonstration plant became very small.

Ling-Fei Lin: In 1987, the IC and PC markets were very lively in Taiwan. UMC was also very successful. You also mentioned the bull market…

D.Y. Yang: Yes, it was a very bull market especially in 1988, 1989. The stock market index was over ten thousand points at that time. It was so prosperous in the Science Park that we often joked about how those flower shops were doing better business than companies in the Science Park, since new companies were opening everyday, furniture stores, flower shops and stationery stores were all doing especially well. There were companies starting everyday. Fundraising was also very fast, it's like the money was ready before the company was established. People called this an unlisted stock market. There were many interesting things going on in the Science Park.

Ling-Fei Lin: When we talk about Taiwan's semiconductor industry, the histories of DRAMs and wafer foundries are very different. Why did Winbond choose DRAMs while TSMC chose to be a wafer foundry?

D.Y. Yang: We at Winbond positioned ourselves as an Integrated Device Manufacturer (IDM)…I suppose maybe that was because of my design background. I think a semiconductor company must have its own products. So when we added the second wafer fab, our capacity could still support our product growth. But, we can't say that Winbond didn't make memory. We started making SRAMs, cooperating with others, in our first fab. SRAMs were a good subject for technology cooperation. We worked with some Chinese companies from the US. We provided production capacity, while they provided process and design [capability]. We worked together, which is why Winbond made lots of money when we were listed in 1996. The motherboards at that time used a lot of cache memory. So Winbond was a big supplier of cache memory. But, after cache memory was integrated into the CPU, the market started diminishing. We were also making flash memory [in cooperation] with some overseas Chinese. We also exchanged our [fab] capacity for their processes and products. This product lasted longer. Even now Winbond still uses this strategy for flash memory. Our main strategy change was going into DRAMs. There are some things [about which I have reservations here.

Earlier in time, I was always kind of hesitant about the development of DRAMs, since the DRAM industry is very capital-intensive, and the technology moves at a very fast pace. But, I think it's hard for Winbond to compete with companies like Samsung---it's an issue of economies of scale when you step into a DRAM foundry…DRAM foundry has also a pattern of development.

I left Winbond in 1999, actually, I left the position of President after introducing technology from Toshiba. I worked as the Vice Chairman for three years. In those three years, I started to detach from Winbond, since it's scale had become too big for me. For many companies, once they enter a certain scale of operation, it's hard for anyone to make major improvements within…no, I mean to make changes. Winbond was also facing this situation like many other companies.

The logic products and the memory products were of two different operational modes. Of course, many people told me to separate them or to spin off one of them. Of course, Winbond did that later on, Winbond spun-off a new company called Cheertek. And now Nuvoton is separated from Winbond also. This is something many companies have to do after they grow big, since the two business models are different. UMC also faced the same choice.

When a semiconductor company grows bigger and bigger, you need to fill your capacity with products. According to the thinking of that time, there are only two choices, one is to become a wafer foundry, and the other is to manufacture DRAMs. There were already many big successful companies in these two segments. So what do you do? This is the problem many companies are encountering [today].

Ling-Fei Lin: Do you mean that you didn't approve of it when you were going to become a DRAM Foundry?

D.Y. Yang: I don't think that I can say I opposed it. Companies need to grow. I was there to execute the strategy. But, I think when it reaches a certain point I should hand it to someone else to operate because I believe that the scale of the capital necessary to a company like Winbond is huge. For Winbond… I was not in charge of the finances from the very beginning…I believe that a company like Winbond, the scale of the capital it needs, is more than I can handle. I can't handle the pressure of capital-raising.

Ling-Fei Lin: Did you ever consider wafer foundry when TSMC turned to it in 1987?

D.Y. Yang: No, I think since TSMC was a foundry company, that's its position. We had to go for other position. We saw every company was seeking for a [unique] position. From an objective point of view, UMC was facing a choice during a certain period of time. It was a so-called product company. And where would it go from there? For some time it wanted to do CPUs, and for some time it wanted to go for flash. But, when other companies emerged one after the other, it had to have a breakthrough in a new direction. When they announced they were going to become a wafer foundry, it was a relief for Winbond, UMC can go compete with TSMC, and leave the rest to Winbond. If they had chosen to go back to doing products, then the pressure of competition would have been greater.

Ling-Fei Lin: So, you think one wafer foundry company would be enough at that tim, and you didn't want to join them?

D.Y. Yang: Yes, since wafer foundries need considerable economies of scale. I think we can't compare our relations in the US with Morris Chang. He was well-known in US and has certain relationships in the US. With one phone call he can make appointment with someone, but we couldn't. However, we also did some foundry work only for selective customers.

Ling-Fei Lin: So you started out by making SRAMs?

D.Y. Yang: Yes, but the SRAM market disappeared after some time. I was hoping we could do flash memory, especially the 8-bit MCU with flash memory. Winbond is still doing a rather good job at it.

Ling-Fei Lin: Does this have something to do with your Harris experience?

D.Y. Yang: More or less I think. You'll be able to last long doing embedded flash memory on microprocessors, but you still face a choice regarding how fast you want to grow. So, if you think you don't want to grow fast, you can stick to a niche [product], slowly developing, but still being competitive. But, if you want to grow fast, then there are only two options, one is DRAMs and the other is foundry.

Suppose that the Indian government wants to invest in a big factory, it probably won't choose DRAMs, it would choose foundry, right? If Samsung has some factories capacity to spare, what would it do? It would do foundry. The business models of foundries and of DRAMs are very different. Their factories are very different, too. When you look at all the semiconductor companies, once its products have been positioned, its business model is also set, and the design of the factory would also be different. So, if you tell TSMC to make products, it wouldn't be able to. If you tell a DRAM company to do foundry, it wouldn't be able to either. Everyone is fixed by it by the product.

Ling-Fei Lin: You mentioned there is a difference between a DRAM foundry and wafer foundry. Could you be more specific? They are both foundries, one is for RAMs and the other is probably for various kinds of semiconductors…

D.Y. Yang: When you don't have sufficiently big scale [production] in a wafer foundry, you have to make your facilities multi-functional. If you make DRAMs, then you have to pursue its economies of scale. Products are produced generation after generation, your facilities wouldn't have to be multi-functional, your production management would also be relatively simple because every time you produce the same things. But, when you are in the wafer foundry [business] you make various types of products. How do you manage your production? Right? If I do DRAMs, I can produce a hundred batches and sell them together. But, if you do a hundred batches in a wafer foundry, every batch is a different product, it's a big issue in production management.

TSMC probably already had some breakthrough on this matter. In terms of scale and technology, you can't learn TSMC's production technology elsewhere. Therefore, Semiconductor Manufacturing Corporation International (SMIC) might be able to learn the process and the facilities, but they are not able to learn management [of those processes and facilities] within a short time.

The production capacity of Taiwan has been proven from several different aspects. The management and technology are also gradually exceeding those of Japan. It [Taiwan] has flexibility and management skills. And it constantly improves on itself. Taiwan therefore has a world-class position in production. But, it also means we are continuously moving towards an OEM business. It's a double-edged situation. It depends from which perspective you choose to look at it.

Ling-Fei Lin: You mean that being a DRAM OEM is simple? Because it was of a larger scale and had the same products, so it was simpler?

D.Y. Yang: Yes, personally I think so. Maybe there are some other DRAM companies that think differently, but I believe it is so.

Ling-Fei Lin: You mentioned that Winbond made DRAMs. Did you make DRAMs for your own products at the beginning?

D.Y. Yang: We cooperated with Toshiba technologically. Therefore, we sold some to them and sold the rest on our own. After all, there was such a market for DRAM in Taiwan

Ling-Fei Lin: Can you give us your analysis of the special characteristics of the DRAM industry? Why does everyone want to enter the industry despite seeing the great volatility of the industry in Taiwan, Korea, Japan, America and Germany? Why is it so volatile? Is it because DRAM has been commoditized? Or is there some other reason?

D.Y. Yang: I think the volatility in the DRAM industry has something to do with the "step function" in the whole semiconductor production capacity. I always say that building a semiconductor fab is just like building a house. In the early years, you can simply build up a house on your own. But then the builder says you can only build a house for ten families. Even if you just simply need a house of your own, the builder would say that it is too expensive to live alone. If ten people lived together... it's all about the economies of scale. So you will have to make the most use of the other nine places in the house.

And now the constructors tell you that, if you want to build a house, then you have to build one for one thousand people to be economically feasible, even if you say that you do not have such a big family. So you have to figure out a way to use up the rooms. And there are only two ways to use up the space. One is to produce the actual finished product, the DRAM, by yourself. The other is to go the foundry way and break it down for everyone to use. There are only these two basic strategies. For example every time you try to build a new production capacity of a fab, you need to increase your market share by certain percentage in order to use the capacity.

In order to increase your market share you just have to lower your price. In the semiconductor industry, if we see the concept of market share in the cost accounting way, it could be a frightening thing. It has low variable costs and high fixed costs. That probably is very rare in the world. The so-called variable costs are, when you have low material costs with a high depreciation rate, you'll certainly produce the goods with prices higher than variable costs. That means the business strategy is quite flexible when it comes to the products with high fixed costs.
In other words, I build a house for one thousand people, and rent the 999 rooms to others for free. If you pay me one dollar then I would earn one additional dollar. The volatility of price would always be like that because a single product in the DRAM market is a highly replaceable [by one from another company]. So there would be problems like that.

But the situation would be different if you choose the foundry model. When you're running a foundry model, it is already linked to your fab in many ways, and you wouldn't change partners easily…unless they are small-scale companies. Big companies usually need several providers and have a close partnership with the [multiple] fabs. TSMC has good quality service in this aspect. So in DRAM case we can call it a commodity.

The foundry model of TSMC used to be a bit like commodity. They all say that "TSMC foundry compatible". Or take SMIC…for instance, they claim they're "TSMC compatible", but apparently TSMC doesn't agree with that notion. With the integration of the whole production processes, I think that the more IC design is integrated with the production process, the less it should be called a commodity beause they are already integrated. I think the companies with commodity products are in more difficulty and DRAM isn't the only one of this type of products.

There are three kinds of products that we talked about. It is most difficult for information products. The hard drive is one of them. But there aren't many HDD manufactures now, so it is not that bad. Optical fiber is another example…all the products without design features, would end up like this easily. We often talk about the price reductions of DRAMs. But it is worse with the HDD and with flash memory devices too. It is said that if optical fiber is sold by the kilo, then the HDD and flash memory are sold by the megabyte and gigabyte. That is how they are sold.

I have a suspicious attitude towards products lacking in design features. You must have something special in your design features. Otherwise, you'll have to work harder on your management, or try to enlarge your capital-scale or compete with others by comparing the economies of scale and how deep your pockets are.

Ling-Fei Lin: So you don't think it's because certain companies, for example, Korean companies, especially like to strike a bargain?

D.Y. Yang: No. So that's why there was a time when rumors had it that Samsung was turning to automobile industry. We were so glad and thought if they went and made cars, instead of DRAMs with their money, we would all be relieved. I have to claim that I have nothing to do with the "Two Trillion & Twin Star program" in Taiwan, because I think both products, DRAMs and TFT-LCDs display devices lack designing features, and rely too much on the economy of scale. They both lack distinguishing features, and depend too much on the capital stocks. So when the stock market is sluggish, you can't issue your share price to be 10 dollars, to raise $100 billion to build a factory. So back to our former issue when the stock market is good, it bred many Taiwanese high-tech companies. The stock is good, so people buy it. This is why the stock market is extremely important to high technology. So I always say to others including China, that high tech companies cannot survive without the support of the stock market. The whole high-tech industry is closely related to the stock market.

Ling-Fei Lin: So in your opinion, the display devices are also commodity products, lacking in [unique] design features, so that the [market] volatility was also apparent in the display industry?

D.Y. Yang: Yes.

Ling-Fei Lin: Would you like to talk about how Winbond caught up with other companies technology-wise?

D.Y. Yang: As I said before… We exchanged our production capacity with other companies for the technology. But we did do our own R&D in the meantime. When we established the second Winbond factory, which was more advanced than the old Fab 1… we were able to attract people back from overseas to combine their technical experience with our new equipment. So the main method we used was that, other than doing the R&D ourselves, we worked with people from overseas. They had their own production process experiences from the past. They wanted to trade their experience for some production capacity to develop some new products. We have always been using this strategy, including the collaboration with Toshiba later on.

Ling-Fei Lin: TSMC claims that their technology is almost the same as what Intel has in the recent years. As for Winbond, do you think there is any gap in terms of technology between Winbond and the other “first-tier” companies? Or do you think there isn’t such a gap?

D.Y. Yang: It has been more than ten years since I left Winbond. So I cannot tell how it is running today. For the time when I was still working in Winbond, I think that their technology was as good as the first tier because when we worked with Toshiba we learned a great deal. There no way you can use obsolete technology to work on DRAM. DRAM production requires true ability. The production cost is really important in the whole production process. And, the whole economies of scale in the semiconductor R&D has become larger and larger. The whole cost of a generation of production process nowadays has even reached one hundred million, or even one billion, dollars sometimes, you can roughly estimate the capability of R&D by the business turnover. You can even calculate the speed at which you hope your business to grow. After you’re done with all the estimation, you’ll know which strategy you should choose.

Ling-Fei Lin: You’ve mentioned the relationship between the IC and PC industries in Taiwan. Do you think they have anything to do with each other during the whole development process? Is there anything like mutual benefit between these two industries in Taiwan?

D.Y. Yang: I think they are closer than people think. Take the ICs on a motherboard for instance, the companies in Taiwan cannot make the CPU, and maybe not the NAND flash either. But they produce almost everything else by themselves. It is the same with many other products. I just mentioned that IC design in Taiwan has been pushed forward by the PC industry here. And it is penetrating other industries. And there are many other consumer products that take PC as their basis. In my opinion, as successful as it is, Intel would still want to promote their CPUs for other consumer products. But it will take more efforts to achieve their goal. Microsoft has the same thoughts. After gaining a large market share in PCs and notebooks, they also want to occupy a certain percentage in smartphones or other markets. This is what the “post-PC era” is like. Apple leads another trend in this post-PC era.

Ling-Fei Lin: You’ve mentioned that companies in Taiwan have the ability to produce almost all motherboard items by themselves, besides the CPU and NAND flash. Do you think the status of the Taiwan motherboard industry makes it easy to develop an IC design business?

D.Y. Yang: Yes. In the early times in Taiwan when developing certain technologies, there had to be demand pull. You can imagine many of the IC companies were thinking everyday what kind of IC, what machines can I make? You can imagine down to the very details. Afterwards this industry in Taiwan went from digital ICs to power analog and linear ICs. It all had to do with the development of the market.

This also leads to another point. That is, how ERSO had always focused on working closely with universities from the beginning. So ERSO and the National Science Council in Taiwan both had a hand in deciding on the research area for IC designs in the universities. So we started emphasizing the design of linear or power ICs in universities. In the past years, the efforts that universities put into this has provided a profound and solid foundation. And that’s why the Taiwanese linear IC industry has become stronger. It i also true in the power and converter areas.

Ling-Fei Lin: You have mentioned that in Taiwan, the PC industry is good for the development of IC designs in certain ways. Would you say that the semiconductor industry in Taiwan is also beneficial to the PC industry here?

D.Y. Yang: I think the benefits of IC to the PC industry was first shown in computer accessories. Looking back, another strong suite of Taiwan is the small network products. Companies like D-Link and Accton were also established around 1987 or 1988. Because of the nature of LAN technology, the companies emerged and now Taiwan is able to provide the ICs for many LANs. And as the network evolves into wireless network, so can Taiwan progress into Wi-Fi technology and that will make a huge demand pull for the RFIC products. The dropping of LAN prices contributed a lot to the growth of the PC [market]. There are other examples like graphics cards and other accessories. That’s why I said the benefits are mostly shown in the accessory market.

As for motherboards, except for chip sets and some memory items, Intel is still in control so they occasionally would lower the prices. And their penetration into the motherboard market is already at its peak. Of course there are some companies trying to replace Intel. But most of the efforts are made in the relatively low-end CPUs. So I think the most important part of the industry integration between PCs and ICs is that the very long technology and supply chains can work closely, which strengthens the competitiveness of the entire industry.

Looking back on the history of Taiwan computer industry, or before the IC industry emerged, we can observe that the electronics industry comes and then disappears. Taiwanese companies once produced electronic pens, which were electronic watches on pens. But those companies had to rely on the supply of ICs from Japan. Japanese companies made the items and ICs first, and sold them to Taiwanese companies. When there’s no IC supply from Japan, the companies here were unable to manufacture the pens. That is why there used to be one wave after another of manufacturing trends. We then thought if we developed an IC industry of our own, at the end, these products will take root on Taiwan. And today we are proven to have been right. Because we have developed the roots here through the demands of the market you keep watering the roots. So with sufficient water and nutrients, the roots would naturally repay you with plentiful fruits.

Ling-Fei Lin: You've mentioned about how the people who came back from overseas to join in the industry development seemed to advance more smoothly than others. Could you be more specific? Why is that?

D.Y. Yang: No, actually, I remember what I meant was, I hope those people could come back to Taiwan as soon as possible. Because we found that people networking played an important part when it comes to business development. So I said when you are back in Taiwan, your own place, the older you are, the more valuable you become. Because your colleagues and former classmates gradually take on important positions, so there is more space for you to expand. If you stay in the US, there will not be such a benefit. For Americans have social networks of their own with classmates, their children's parents. And it is hard to fit in when they are enjoying their own social network.

If they work there as engineers from Taiwan, they would hardly have any opportunity to go further. So it's better for them to come back to Taiwan. Here in Taiwan you might have a chance to be promoted as a manager, a business manager. So that was one of the reasons for their coming back from overseas. In the 1990s, many of the overseas students and experts came back. But we can see that people who are at the top in the industry are those who did not leave the country. Such as Stan Shih and Bob Tsao. They both got involved in the industry very early and started to build up their own social networks. So the later you join the industry, the more likely you are to only participate in technical aspects unless you try to start a business of your own.

Ling-Fei Lin: As for the rise of China in the recent years, do you think there's any change of the relationship between local and overseas Chinese? And you've mentioned that the integration of IC and PC industries is hard to shake. Do you think it will be any different now that lots of companies have moved their factories to China?

D.Y. Yang: Yes, in regards to the relationship with overseas Chinese…in the past, we used to have a close relationship with the Silicon Valley, lots of local companies had R&D or sales branches there in the Silicon Valley, which led to many technical transfers or market expansion. We used to joke about how a lot of business gossip was first leaked out from Silicon Valley. People working there might phone us about some rumors, they would call back and say we heard about this and that here. Did you know about this over there? So rumors in this business were first heard from in the Silicon Valley. That means we had a close relationship with each other.

But due to the decrease of students studying in the U.S., I think such a connection will be impacted in the next ten years. And as for the Pan-Chinese relationship nowadays, I think the focus is now on the people who went to the US from China, and the relationship between Chinese companies and their partners. Nowadays, China has a large number of IT industry exports. They believe that about 30% to 40% products are from Taiwan-based companies. Sometimes it's even more than 40%. So Taiwanese companies contribute a lot to the Chinese high-tech industry.

I think the natural specialization between China and Taiwan in the industry is running pretty well. China has a strong base in telecommunications, because they have a huge domestic market. As for Taiwan the domestic market is small, and the telecom produced by Taiwan companies haven't found the way to reach beyond Taiwan. But this is another topic to discuss. And the second thing is, in terms of consumer products, they have a strong base in that market because they have local brands. But I think some components for the consumer products may need to come from Taiwanese companies. Talking about the PC industry, it is extremely hard for China to shake Taiwan's present position. So I hope the companies on both sides can find a way to cooperate. In that case, one of the benefits is we can share China's market as well.

Taiwanese companies have never had problems with innovation. But innovation still needs the demand pull from the market. The lack of market demand pull used to be the biggest pain for Taiwan. Without the support of a huge market and without the demand pull, how do you innovate? No one knew and no one understood your innovation. There was no feedback from the market. In US, many companies are always looking for innovative products to solve their problem. When you talk about some new technology in Taiwan, people may not know about it. Let alone finding the market.

In China, 1% market share may bring 1 or 2 billion NTD. But in Taiwan it may just bring about 10 million NTD, and that can't do too much good for a company. This is something Taiwan has always found to be extremely difficult. I used to say to many foreign experts that it is not that we do not have the know-how, the problem is that we don't know what to develop. Whatever you tell us to make we will sure be able to make it. So Taiwanese companies are most happy when some standardization appears, like Ethernet, which are some good products of Taiwan. These products and their functions do not change too quickly, and there is a standard so the speed is either 100 or 1000. And as long as you achieve it you can sell them. In that case we can lower our cost, and the market would not be a problem.

But this will be a bit harder when it comes to DRAMs, since its technology innovation is endless. We've always wanted to see standardization. We've been discussing with China about standardization. They have always known their own market scale, and tried to make a standard of their own. But they found that they had problems when actually implementing it. Maybe it is different nowadays, but according to their past experiences, after setting the standards, they could not achieve them by themselves. They realized that in order to execute these standards. ICs were required. Without an IC to make up for the market demand, there is no point to do standardization. So the standard and technology are correlated. And it takes efforts to combine the two of them.

Ling-Fei Lin: Do you think this is a chance for Taiwanese companies?

D.Y. Yang: Yes. But for Chinese companies, of course the Chinese officials also know the importance of R&D. The research grant that the Chinese government can spend on any company is far greater than any number we could imagine. Every company there probably has more than $100 million in R&D every year. The grant is plenty for R&D. That era is over for Taiwan. Now it's time for the people here to think about developing a new industry.

Ling-Fei Lin: Let's move on to more personal and future-related topics. Up to now, what is the period of time you find to be the most exciting, that you are most satisfied with, or most proud of? Or, is there any special event to talk about?

D.Y. Yang: I never think too much about it about being proud. I don't think that at this age a person should have anything as the pride of their lives. It would mean that they will not have greater achievements in the future. The best thing that I have enjoyed from the past decades is working with colleagues. I keep learning new things. I always say that I have learned a lot from them. I can integrate everyone's knowledge and turn it into my own knowledge. Not just that, I can also share what I know with them as a feedback. This interaction is what I have enjoyed the most. I like to learn new things so much that it seems to be my problem. But to keep on learning is very important, especially in IT-related industries. There are way too many things to learn. But I realize that you can't learn them all. So now I'm trying to focus my interests on a certain thing. The semiconductor I can tell you, is not one of the things I want to go on pursuing.

END OF INTERVIEW

