Oral History of Chih-Yuan Lu

Interviewed by:
Craig Addison

Recorded May 13, 2023

CHM Reference number: 2023.0073

Addison: Today is May 13, 2023. I'm doing an interview with C.Y. Lu, President of Macronix International for the Computer History Museum Oral History Program. Thank you, C.Y., for taking the time.

Lu: Yeah. You are most welcome.

Addison: So let's start off with just talking about your childhood, you know, a little bit about where you grew up and your parents and so forth.

Lu: Okay, sure. I was born in China, Canton City**,** Guangzhou. And then after that, very soon, my family moved to Hong Kong. Our family moved to Taiwan when I was 4-years-old, so we moved to Taiwan, and I received my primary school education in Taipei City. It is pretty smooth for me in study. … reports are always good <laughs>. So I got to the best high school through the so-called United Entrance Examination, you know, a big examination. Everybody, high school students, need to participate and compete to get into a good university. At that time, maybe only 10, 15 percent of students in high school can get into university in that time in 1968 to '70s. I got into my first selection, National Taiwan University Physics Department. At that time, physics is the most fashionable department in Taiwan because physics is easy to get a scholarship and go to United States for further graduate education. At that time two Chinese young scientists got Nobel Prize, physics, that's T.D. Lee and C.N. Yang. Lee and Yang are the first two Chinese professors in United States won Physics Nobel Prize. So physics becomes very fashionable at that time, I'm fortunate and I got into the top university's top department. I think I received pretty good undergraduate education in physics. And later, after I got my Bachelor's degree in National Taiwan University, I applied for scholarship and I got a full-scale scholarship and went to Columbia University in New York City, Physics Department, to further study physics there. After 5 years, I got both my Master's degree and my Ph.D. degree and it is 1977, I got them almost finished my education at this stage, all physics major.

Addison: So were you interested in that or it was just the scholarship that attracted you?

Lu: I was certainly very interested in that; even today, I'm still a professor at National Taiwan University Physics Department. I'm very interested in Physics. You know, at that time, politics were pretty turbulent in Taiwan. Actually, talking about the situation then was not safe as compared with now. Now, people say Taiwan is one of the most dangerous place, right? <laughs>

Addison: Yes.

Lu: That's today. But at that time, Taiwan was being kicked out of United Nations and United States, caught in a diplomatic relationship with Taiwan, and they recognize mainland China as the only China, everything was turbulent in Taiwan. As a student, I see the opportunity of Taiwan at that time is huge because everything was preparing to take off. You know, in late '70s, Taiwan is doing well in light industry, like, although there's no IT yet, but started assembly industry, there's an energetic move in Taiwan. And the ROC government wants to establish high tech as the base of Taiwan's economy. So I feel there is a lot of room for me to do what I like to do. So when I get my Ph.D. degree, I just returned to

Taiwan, National Chiao Tung University, as Associate Professor. At that time, you know, there are very few students study in other foreign country and come back to Taiwan because, I told you about the political situation and everything, and then the salary compared with what I got in United States is a huge gap. You can imagine. I give you an example. When I was a research assistant in Columbia University, I can get a monthly salary of $500 dollars per month at that time. It's okay for one person living there in New York City. But when I returned to Taiwan at the National Chiao Tung University as a professorship, I can only get something like $200 dollars. <laughs> My salary got cut in half. So almost nobody will return to Taiwan. But I saw it in another way. I think as a professor and the high tech research workers in Taiwan, the social standards are very high. And actually, you can almost choose whatever topic you like to do because the government, they have some grant they want to give to faculties at a good university to do something. But no qualified people. So when I came back, I got the freedom to choose whatever I like to do. That is why I chose to return to Taiwan.

Addison: Okay. So, C.Y., you said that you went to Columbia University. So you had every intention of coming back to Taiwan? You didn't think that you might stay in the U.S.?

Lu: Yeah. As I told you, I think and there is more room for me if I stay in United States. Certainly I can survive. I can get a post-doctorate and then Assistant Professor and, you know, just as a good [career] track. As a good student from top universities in United States, I can find a nice job. But I need to work very hard in order to keep on the track and the track is almost fixed for me. I have less extra energy and much less flexibility and opportunity for me to transfer to another field. For example, I'm in Physics and when I came to Taiwan, I can look around while I taught in National Chiao Tung University. That is a major research institute in electronics discipline. I teach lasers, optics, and I also teach semiconductor devices, and electrodynamics and all those kind of things. And by doing that, I was starting to choose the area I want to focus more and I can get more resources and contribute more to Taiwan. So I have a lot of room. I am very happy. Although my salary <laughs> is very low, but as a professor in Taiwan, the living standard is low. The living cost is very low. So you will not starve. <laughs> You can raise your family pretty well. This is just like at 20 years later, in China. You teach in China and the salary is very low, but if you're a professor in Peking University or Tsinghua University, your social status is high. You have resources you can control.

Addison: So how did you make the transition from like an academic career to industry?

Lu: I was still teaching in University, right, but I can study a lot of applied physics. I can devote time to, although maybe I was a beginner, I can devote to industry things, electronics and semiconductors at that time, lasers. I was still in university. I was a professor. But at that time, Taiwan is starting to try to do high tech. A lot of government positions are searching for professors to go to the government to help. Since I wrote some articles to explain my opinion about it, what Taiwan should do in education and R&D, whatever. And that article, those kinds of articles [were] published in newspapers, Taiwan newspapers, and ended up being seen by K.T. Li. At that time, he is the Shah <laughs> in Taiwan's high tech industry. He called me to his office. He said, "You have good ideas, a lot of good ideas. Would you come to my office to work for me as, you know, a research assistant? Try to find a lot of new ideas to help Taiwan's industry." So I did. I was a professor. I had a part-time job in K.T. Li's office (STAG). That is even more

exciting. While I was teaching in the University, I can also influence the policy and then watch how the government was running at that time. At that time, the [Hsinchu] Science Park was just established, in the 1980s. For the first Science Park involvement in the government, I also have an opportunity to participate. So very exciting. By doing this, I am still more like an academic advisor helping the industry. So I start to have an interest to really get into an industry. I read a lot of proposals from outside of Taiwan and inside Taiwan go to K.T. Li's office, and many proposals say, "We should do this and we do that." And K.T. Li showed these things to us and asked our opinion and comments. I read a lot and learn a lot. I think I'm also interested to do those things, but I have no experience in industry. So finally, I decide to quit Taiwan's job. I go to United States again in order to get some experience in real industry, at least in a real high tech manufacture in the worldwide top companies. I've been a Visiting Professor at North Carolina State University, but actually, during the visiting professorship, I'm looking for a job so I can stay in United States and have the opportunity to achieve my vision. Fortunately, I got a job from AT&T Bell Laboratories. They offered me a job due to my previous study expertise, and they think that it is valuable to them and then they have two choices for me. One is in their pure research site. Another is in their manufacturing side, also to do technology transfer. Certainly, to my purpose, I choose the later one. I want to see how things are being built, being researched and then transferred to manufacture. At that time, in the 1980s, the United States is still on the top of the world, even for semiconductor manufacture, although Japan is just emerging. In the '80s, Japan and United States are the biggest competitors, but United States still very good. So I took the chance, I took the job at AT&T Bell Labs, Reading and then Allentown, Pennsylvania. I work there in industry for more than 5 years.

Addison: So what particular type of manufacturing?-

Lu: The most advanced IC manufacturing in AT&T Bell Labs. AT&T at that time is still one of the top IC producers and also had the best factory in AT&T's system.

Addison: So you said you were there 5 years.

Lu: Yeah.

But after 5 years, I got a phone call from Taiwan. The phone was from Morris Chang. Morris Chang had already moved to Taiwan at that time, '85 or '87. He's the President of ITRI. Industrial Technology Research Institute. We met each other later on. He called me to say, "Hey, C.Y., K.T. Lee recommended you. We have a big project we want to launch." And Morris searched for leaders for this project. This is the Submicron project.

Addison: Okay. So before we get on to that, just at Bell Labs, I see in the bio here a couple of things you did. There was a paper that you wrote, "Variable Hold (Retention) Time Phenomenon in DRAM," that improved reliability of DRAMs-- I mean, at that time, you mentioned the Japanese and the problem was-- American DRAMs were not good quality.

Lu: Right.

Addison: So how did you see that--?

Lu: <laughs> I participated in the US team more against the Japanese. I was one of the technical leaders in AT&T that's doing AT&T's DRAM. At that time, very interesting. My brother, Nicky Lu, if you remember him, he was a leader in IBM. So Nicky and I, one works for AT&T as the leader in DRAM; one is in IBM. We all fighting the Japanese, <laughs> although we are also competitors. <laughs> If you call AT&T and IBM a competitor. At that time, they are the best ones in United States. One night, I got a phone call [from Morris Chang]. I say, "Okay, I need to know more." He says, "Well, will you come back for interview." So I do come back [to Taiwan] for an interview. And he told me what the project is doing, what they intend to do. Then we go back to, you know, Taiwan's situation. In late 1970s, Taiwan tried to get into the IC industry, how to do that? The government said, "We need to buy technology from United States or other places, Japan or Germany or whatever." So they're starting to work out where to buy technology. The end result, I think many people have been talking about that period of history, the result is that RCA has been chosen and RCA was willing to sell. This is the most important milestone for Taiwan, the RCA project. Like those guys, Bob Tsao<laughs> and Chintay Shih, they are also a member of the first team. Once we get an RCA project and build it, the pilot, in Taiwan, the organization under ITRI is called ERSO, E-R-S-O, Electronic Research and Service Organization. The leader [of the RCA project] is Dr. Ding-Hua Hu. He is also a professor of National Chiao Tung University. He is about 6 or 8 years older than me. He came back to Taiwan earlier than me. He became a leader of this RCA project. RCA project was very successful for the first 5 years. So they think, even we were successful in a research institute, but we're still in research in the pilot, we'll try and see if Taiwan [Industry] can survive in commercial IC industry. It's really about commercial competition. So ERSO formed UMC, United Microelectronic Corporation. It's the first spinoff team from ITRI ERSO to become a company. And the most investment was from government funds. But less than 50 percent, otherwise it becomes a government <laughs> company, so it collects some other money from civilian resources.

Addison: So were you in the U.S. when this was [happening]--?

Lu: Yeah. At that time, I was in United States.

Addison: Right. But you were following the news--

Lu: Yeah. I followed that. Although I quit my National Chiao Tung University job, I [also] quit the K.T. Li's office (STAG) assistant job. But I kept a close connection with them to understand what was developing there. And another interesting thing is: When I was teaching in National Chiao Tung University, I had many undergraduate students, master's students, even Ph.D. students working for me. Later, they become the employee of these companies. <laughs> So in addition to the top level connection, networking, I have a lot of these employees' network, you know, communication and chat results in more understanding. So I pretty much understand what's going on in Taiwan. UMC is okay. It's surviving and making money, but, it's low end. You know, IC community has a wide spectrum. <laughs> Like today, there's 2 nanometers, 3 nanometers that TSMC is doing well, and if you only have 200 nanometers, you still can make money doing that. And at that time, UMC's technology level was in the very low end. But they can do IC anyway. The technology is low and if they can survive long-term, business is coming. At

that time, Taiwan becomes very energetic in electronics. Electronics needs ICs. And most of the IC is consumer grade, so their business is good. The government sees the situation is still good enough. And there are many companies coming out, but they don't have that kind of capital that can build a [fab]. They come to government to apply, say, for either the financing or whatever try to build that. So this is the kind of environment to cook the idea of TSMC.

Addison: So when Morris Chang called you about his project, did you agree straightaway?

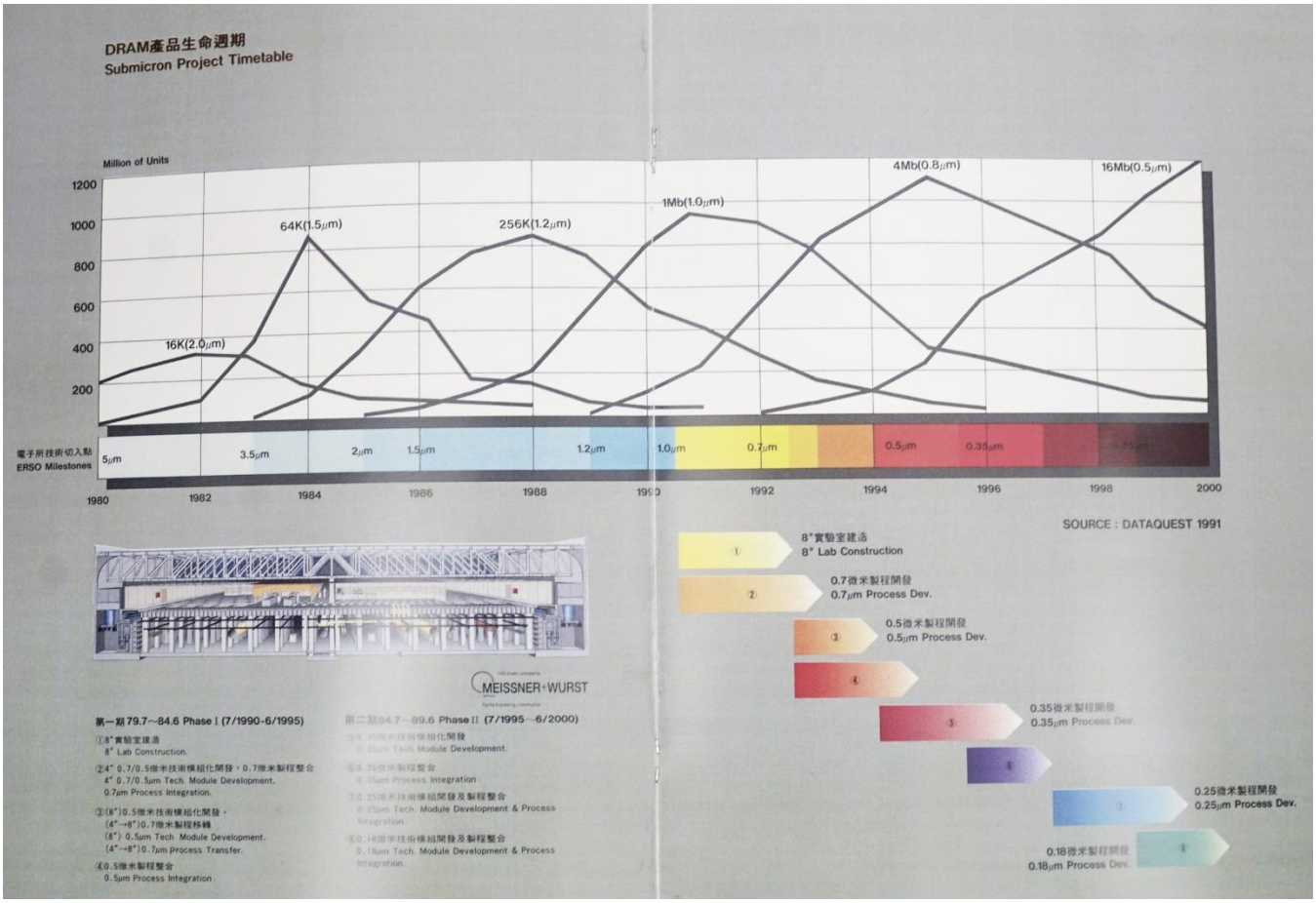
Lu: I say I will interview to see <laughs> what you are doing.

Addison: So this was the submicron project?

Lu: Yeah, submicron.

Addison: So, did it seem like an impossible challenge to you?

Lu: Sure. It's because you see the target that they set. As I see it, UMC's successful, many design fabless companies come out and the government comes up with an idea of a central kitchen. This is TSMC. And they do foundry for you guys, you can have a product to sell. So TSMC was founded in 1987. I am still in AT&T at that time. So Morris, the founder of TSMC, he had two hats. He's TSMC Chairman. He is also the Chairman of ITRI. When he called me, he was already the Chairman of ITRI, promoted from President. He came to Taiwan as the President of ITRI and later he was promoted as Chairman of ITRI. Even when Taiwan has TSMC at that time, their technology is still lagging pretty much. I think that you'll remember when you visited Taiwan, even in the '90s, our technologies were still lagging. So they think about what they should do next. That comes out in the submicron project. And they say, "We must have better technology, independent, built by Taiwanese, not just buying from or license from people. Okay, we need to do that." So this is the whole reason for the submicron project and the target. And also I have a very interesting diagram to illustrate this.



If, take this. You see all these curves? Any technology and the product they have in their lifetime, and they're starting from there and it goes up and down right? This is the volume of business, so your business becomes more and more and they mature and then the next generations come, right. So one bell shape life curve after another bell shape, each bell shape curve is represented by a technology node and its associated products. So here (horizontal axis) is the calendar year. Taiwan products appeared in the market always in this bell shape tail part, [so] where was Taiwanese products cut in point? In the past, UMC, TSMC, their cut in point was in the later part of the bell shape tail. That means that you cut in when the technology is lagging behind and already coming down. The peak is here. So then submicron projects say, "We need to bring technology much earlier. When submicron project technologies will cut in the earlier part of the bell shape curve, and need to cut in somewhere here." So today, we already achieve this target or even better. TSMC, they cut in here, <laughs> right? So UMC has proven Taiwan's IC commercial situation, can UMC made their IC products survive? UMC got a good answer: Yes, it can survive. But it’s of consumer grade. And the second project was TSMC, to providing a common central kitchen for many, many fables companies therefore can survive. That's the second successful one. But the technology was still in a pretty late stage. So here's the goal of submicron project that will bring technology up. This is a big thing. A big thing to make advanced technology here. So, if I come back to take a leadership job, I need to achieve this mission. If I can do that, it is very-- <laughs> very exciting for me. I don't know if I can or not. I have strong confidence, but I don't know how big the percentage we can

accomplish this goal within the target budget and time frame. The final results are [that] we did it completely ahead of time with less budget granted!.

Addison: So, C.Y., you're invited back to Taiwan by Morris Chang to head up the Submicron project. What sort of resources did they give you and did you think you had enough to succeed?

Lu: I came back to Taiwan for an interview and to understand more about the project they intend to do. And the ROC government promised a big grant to ITRI and they ask ITRI to carry this project. And then Morris Chang is the Chairman of ITRI, so certainly he needs to build the team to complete this job. I felt the commitments from ROC government and ITRI, so I decided to come back. And at that time, the international environment was like this, in very late '80s. The United States' memory is almost totally crushed by the Japanese. At that time, '80s, early '90s, Japan becomes the king in semiconductors <laughs> right? But people except Korean also encourage us, how can Japan do this? If Taiwan can do the same, we are very excited to see this happen. And although at that time, I'm still in the United States, so I see the United States is doing the SEMATECH project. You remember?

Addison: I remember.

Lu: In order to come fighting back, right. So there are also a lot of things US put on Japanese, you know, more political things against Japan, asking Japan to import more US ICs, tariff, etc…those kind of things. It was very hot at that time. Everybody, just like today, everybody was trying to do IC [projects]. European Megaproject. Japan was successful, one of the reasons was they have a big consortium project called the VLSI project. And their government, MITI [Ministry of International Trade and Industry] is leading the project and asked those big Japanese companies to work together. Taiwan is facing this kind of international environment. Talking about resources, your question, what resources I can have in order to achieve this? I think it's reasonable resources, but compare it with international competitors in an absolute dollar amount, it's very small. We had very low numbers at that time, compared with Japan's giant consortium project, the European Megaproject and US SEMATECH, these kinds of consortium projects. Because Submicron project is also a consortium project, government through ITRI is doing this, and of course, UMC, TSMC, you please come and join as a member. So I become the consortium leader. I have my team. In total they give us $7 billion NT dollars for 5 years. It includes all our capital construction like the clean room, the fab and then buying all those machines and all the expenses. Almost half of it, 60 percent of [the money] is spending on capital, building the clean room, buying the lithography machine, etching machine and those things. Forty percent is the expenses for salary, materials and those kind of things. This number is a big number. For Taiwan, this is the largest project ever taken, even today, for a single project, $7 billion dollars for 5 years to achieve this job. This amount gives me the resources to do that, just like in the very first RCA project, [which was] about $0.4 billion NT dollars to buy the technology from RCA in 1975. But compare the economic situation in the world, and 7 to 8 generations of technology node for 15 years apart, that RCA may had even more <laughs> than what I got in 1990. Still I think then the government has a big commitment. Morris Chang is a strong supporter. And the environment in Taiwan, people are very excited. My previous students are all excited saying, "If you come back, we will work for you." So, I was excited. I took the job and the mission impossible challenges.

Addison: So a project like that, obviously, relies on talent. So where did you find the engineers and the people? Locally? Or you had to bring them in?

Lu: Then let me tell you that. <laughs> The salaries still a big gap, you know. I come from Bell Labs to Taiwan, ITRI, as a project leader. I'm almost the top guy. My salary was cut in half. <laughs> Terrible. You can only find a few people willing to sacrifice on the salary to join from US or even Japan. So I need to use local people. That's my advantage. I have been, as I told you, a professor, I have so many young people work for me and study [under] me. And at that time they are mature, semi-mature. Because I went to Bell Labs for 5 years and they are working [in Taiwan] for 5 years. They are younger than me by almost 10, 15 years. So they are really a strong force for me. Although they have no experience. <laughs> No experience at all. I am one of the few that has experience from Bell Labs and AT&T. So we form the project from scratch. In this human resources respect, there is another thing interesting and worthy to discuss while we review about the history. At that time, although Taiwan technology is lagging with a huge gap, but commercial business is pretty much booming, you know. The stock market was becoming crazy at that time. So that the people in ITRI being recruited by [companies in] the Science Park like crazy, the turnover rate is more than 30 to 40 percent. So that means that your people are coming and going [all the time]. That made it very tough to do a project like Submicron Project. Which demands a very sophisticated working force. Although there are some people coming, they very soon are being attracted by Science Park's commercial jobs, engineering jobs. That brings up another thing. When I worked with K.T. Li, almost 10 years before, when the U.S. breaks diplomatic relations and they restrict the weapons sold to Taiwan because of their [new] relationship with Communist China… they almost stopped the upgrade of Taiwan's military weapons. So in Taiwan, it is decided that we need to build our own weapons, but who can do that? <laughs> Actually, the United States had the willing to help by teaching.. United States cannot sell you the advanced weapons, but they and others can teach you how to do that and you do it yourself. But if you want to learn how to do weapons, you need the good, young people to learn, go to the United States to learn. But in the military [in Taiwan], there were no high tech people. Finding high tech people is difficult for the military. So at that time, I was in K.T. Li's office, I propose we shall have a new system. If young people, Masters degree graduates, join this team, the military weapons building team, they cannot [be conscripted] as a soldier, fighting as a soldier. They just work in government research, weapons research institute, as a researcher.

Addison: Yeah, so the conscription they had to do.

Lu: Yeah, pretty much like Israel. Israel has those teams, right, and they do weapons. But this is political, very difficult, even in Taiwan. K.T. Li promotes this. They take my advice to promote this. For National Chiao Tung University, Tsinghua University or Taiwan University, Cheng Kung University, these top universities, we ask you to join, because at that time still 80 to 90 percent of those are undergraduate, top undergraduate students. Where do they go? They will go to United States for graduate school. So this project I proposed saves about 10 percent the people who stay here, to join this program. Because [otherwise] you become fighting soldiers in Taiwan. That's an obligation. You almost have no pay. <laughs> Very, very small pay. But if you take this, you have regular industrial high pay. Just like ITRI salary level.

Addison: If you had to be a soldier, the conscription, how many years was that?

Lu: Two years. Your training as a fighting soldier is two years. If you go [into the military weapons building team] it takes six years, because you need R&D training. People at that time criticized my proposal. Said nobody will take this. But I think there is somebody who will take this. I do not think hundred percent of people will be hot for this. But, If only 10 percent, 5 percent [take it], that population is already big enough, because about 10,000 undergraduates each year go to the United States. If I take 10 percent, that is about 1,000 people. It is good enough. <laughs> So actually we got several hundred each year. They are very good, because they received a solid STEM undergraduate education. When I came back to do the Submicron Project, the program can be extended, made larger. If you do high tech in a research institute like ITRI, you can also take these kind of people. So, in my team, maybe half of them are these kind of people.

<laughter>

Very stable; good quality. So the people issue is partially solved.

Addison: Right. So this idea was your like secret weapon.

Lu: Yeah, <laughs> yeah. If military forces have all the [conscripted] soldiers, but you have no weapons, what you can do? So the Legislative passed this law.

Addison: These people obviously didn't know anything about semiconductors, so was there a stigma?

Lu: Yeah, not necessarily semiconductor. They're doing radar. They're doing microwave device. They're doing semiconductor. These kind of related things, and at that time a commercial company cannot hire you. Only a research institute. So ITRI can hire. The weapons research institute called Chung-Shan, the Chung-Shan Research Institute can hire them. It's doing jet fighters, tanks, those kind of things. You ask key questions. How much money I can have? How many people, good people I can get? I think in my first 10 years I was in Taiwan, it's nothing to do with this, but I build a lot of STEM the background human resources later on to support me. So in 1990 we start the Submicron Project. The project is supposed all the way to be completed in 1995.

Addison: So you built the first eight-inch fab in Taiwan for this project?

Lu: Yeah.

Addison: What were the challenges with that? Was that at the beginning or the end of the five years?

Lu: Okay, let me see. They have a six-year obligation, right? After this five-year project they almost finished their obligation. So they became the hottest <laughs> people in a career job market. People want them. There is another important thing for the Submicron Project. What technology we should do. You do this, you are doing something real. You are not doing academic published papers where you only

have to show some prototype. No, no, no, not good enough. The project is very manufacturing specific, it says, “This is manufacturing, manufacturing technology”. We have to finish with manufacturing worthy technology and products… There’s no time for you to transfer and take two years to make it [work in] manufacturing. It needs to be done on the spot. The technology transfer to TSMC and UMC is immediate, totally manufacture to a high level of yield, reliability. So at that time, I invent a lot of system in order to achieve this.

Two important decisions. One important decision was in 1990. The most popular way to manufacture the technology is what? Six-inch wafers. Not eight inch yet. This is the first eight-inch wafer we produced <laughs>. For the Submicron Project we need to do breakthrough technology. Bring the technology to the front end, front line. This job is already very challenging. So people say, “Okay. Maybe use six inch to realize this, because on equipment, on cleanroom things, it is pretty much mature at that time. Like, for example, Intel is all six-inch fab, and AT&T, six-inch fab. Only IBM is starting to do the first eight inch, and the eight inch is just starting. So there is a big debate. Should we just use six inch, where we can have a much better chance to make the technology successful? But I think about a lot of things and later on I decide to Morris Chang. I say, “No, we should do eight inch straight [away],” because when we complete the project, eight-inch manufacturing will have started already. If I do six inch, you [have to do eight inch] again. Maybe easier, but will at least take you another one or two years. And that will not fulfill what we said in the goal, right? So I say, “I will take eight.” Morris Chang says, “If you take eight-inch approach, your risk is much higher.” I told him, “I think that’s worse.” Even if we fail due to this eight-inch process, a failed experience may be more valuable than success for six-inch, because other people who follow me will take the advantage. We are making the country successful. It’s not [whether] my project is successful. So Morris says, “Good, okay. You have determination and the commitment. Let’s go to the government. Tell them this is a major change, very major change. Go to the Minister of Economic Affairs. Even go to prime minister to say, ‘We want to change.’” We applied for the change. The project had not started yet. We’re fighting for the change. But if things change, we need more money. <laughs> More budget, right? Because, there is the pretty successful briefing for the minister and the prime minister. They grant us the money on the spot. <laughs> We got the money. We changed to eight inch. Another thing… if I do eight inch, my team members, those young men, are very excited, they become the front line. If they do six inches, it’s just like a common job, you know. So in Taiwan they are the first ones [to do eight inch wafers]. I told them, “Follow me. Work well. Five years later you are the hottest people <laughs> in the job market. Don’t rush out,” okay “Five years later, when the project succeeds, you can do whatever you want. I guarantee you will get the best offer on the market.”” <laughs> So they work around the clock <laughs> every day. This approach boosted the morale of my people, and I believe at that time you came to Taiwan. You visited. So maybe you [sensed this]. You see our team’s morale is very high at that time.

Addison: So eventually Vanguard (which spun out from the Submicron project) was merged with TSMC--

Lu: No, not merged.

Addison: Oh.

Lu: So Vanguard faced a big decision, will it continue or not, right? At that time I was already president of Vanguard. Bob Evans had returned to the United [States] -- and [Morris Chang] asked Rick Tsai, at that time the COO of TSMC, to come to Vanguard and make a serious evaluation what we should do. So Rick Tsai becomes president; I step down. That's why later on I created the Ardentec testing company and I joined Macronix. So Rick tried doing about a year as president. He gave the final proposal to Morris Chang. Maybe quit [the business] is what Morris wants. If quit, where will Vanguard go? As you said, people are thinking that TSMC just merged into it. It's a complete story, right? But no, Morris is the chairman of Vanguard. Morris is also the chairman of TSMC. Maybe conflict of interest, so he will not merge Vanguard, because this is a political and an economic dilemma, and also conflict of interest. I think. Morris is a very careful guy. So you see Morris merged the Acer DRAM company into TSMC without hesitation. There was no problem to M/A ASMI (Acer Semiconductor Manufacturing Inc.), because he can deal, and bargain with Stan Shih [chairman of Acer], right, <laughs> and people cannot argue with that. But if M/A Vanguard, he bargains/argues with himself, some shareholders of TSMC or Vanguard may say, "Who is your favorite?" I think he's very, very sensitive about this. So if Vanguard gives up DRAM, where to go? Only way to go is to foundry. Do the low-end foundry, only limited to 8-inch fab, because at that time 12-inch is just starting. So I think that is the under table decision as TSMC is doing 12-inch as a high-end goal. Vanguard license eight-inch foundry technology… like the second brand. Second brand is to do the eight-inch foundry, so that's what they do right now. And they are doing well. Vanguard's stock price is good and they become a really good and mature technology foundry provider.

Addison: But like you said, it was done before, so do you personally think that Vanguard could've continued?

Lu: Yeah, it could have. You know, this is a kind of commitment… because Vanguard is the only independent DRAM company in Taiwan. If Morris likes to do that, to use his reputation with the government, to inject more resources. This just like SK Hynix and Samsung, <laughs>. Although everybody say, "Ah, Now you have met turbulence. You need to inject [resources]. You need this kind of special support," and then later on if you can survive, big return will come, right. Even Hynix… Hyundai, invited the World Bank to come in. Government can negotiate with the World Bank, finance them with Hyundai to keep them going. They're tough, but they can survive there. But semiconductor fab, especially doing memory, needs a lot of wealth, you know, and commitment, <laughs> and I think this was what Japan, Korea has shown before and I feel today China is also a very formidable competitor, they usually have strong commitment and very firm national financial support Thus price war will be very bloody.

Lu: This is not like a common IC business, because memory market is severely up and down, big swings. Korea, they have a good thing [in DRAM]. At that time I see Taiwan's DRAM, most of them is buying technology from other existing foreign players , but I said only two companies may be finally successful. One I say is our Vanguard. <laughs> We have our own self developed technology, -- this is good. And the other one I say is Nan Ya. Formosa Plastics Group. Pretty much like Samsung and Hyundai. They belong to a conglomerate, that can support them, and that's true. Nan Ya's survival is due to support from Formosa Plastics. In the most difficult time [it can] inject capital into Nan Ya. So Nan Ya [at that

time] is Taiwan's largest-- although still very small in global scale-- the largest Taiwan DRAM provider, but technology was not good then. So there was another thing at that time which was proposed. How about Vanguard merged with Nan Ya? Vanguard had good technology. Nan Ya has a rich father. <laughs> These two become one company, but TSMC at that time was not large enough. Even in the '90s, TSMC cannot support another DRAM [company], so I sympathize. I agree with Morris's decision. That may throw TSMC down the drain.

Addison: Hm. Right.

Lu: But a conglomerate, Like Samsung**,** like Formosa Plastic, like China Steel group, have the capability to do that.

Addison: Okay. So before we move on to Ardentec, I just want to ask, there's somebody else who is called the father of the DRAM [in Taiwan], but sounds like you're the guy who brought DRAM to life in Taiwan.

<laughter>

Lu: Right, right. <laughs> Maybe I am the guy for DRAM in Taiwan. I was involved the most. Now, other people may be doing big DRAM business, but he doesn't have all this history and experience, all this tough and sweet time and exciting things. I agree with you. So there's a little bit of pity, actually we wonder if Nan Ya and Vanguard can work together, but sometimes it's difficult. It is not my position to do it. I'm not a board member. I'm not a chairman. Only a chairman can do that <laughs> for shareholders, right?

Addison: Okay. So you just wanted to do something completely different. Is that why you chose the wafer testing with Ardentec? What's the story behind that?

Lu: Okay, let's go to this part. If Vanguard is not continuing to do DRAM, okay, my mission was complete in that phase. So what should I do, and I am a semiconductor guy. So at that time I think a lot of people said, "Hey, why don't you start a company where you can get investors," but that kind of investment at that time is not enough for a fab company. Already a fab company needs a big chunk of money. That's one thing, I also think I should not do something against my boss, my previous employer, Vanguard or TSMC group, Morris [Chang]. So I tried to do something to support it. I think about, "Hey, testing, wafer testing." At that time it's not really a business. Interesting thing is, you know, several years later Harvard Business School came to me. They wrote a Harvard Business case study of Ardentec, talking about a new business model in Taiwan, because they are discussing a series of topics, as Taiwan is not vertically integrated like Japan or Korea. We are chopped into pieces. Mask company, design company, wafer foundry company, assembly and testing company and etc. I will say I will do this wafer testing to support it because I see the foundry business has become very prosperous, it will be okay. So a lot of IDM become fab-lite, you see, like a TI. They have a fab, but they also are using wafer foundry. Eventually like AMD, they will even give up their own factory and let it becomes Global Foundries. So in the United States, very few build a fab anymore. All the successful companies are like Qualcomm, Broadcom and

they are fabless, or fab-lite. So they come to Taiwan, ask UMC, TSMC, to do the wafers, but how do they check their result? The common practice at that time was TSMC test for them. UMC test for them. But they do need another independent third party. So I think to become an independent third party. Ardentec received the wafers from TSMC or UMC. I test it for you and I provide all the detailed data to you and tell you if there's anything wrong there. Where is the defect? This is pretty much like a physical examination department in hospital.

<laughter>

Although always in a hospital the physical examination team or those kind of therapy is not the leading group. The leading group is always the surgery, right? <laughs> But this is a very necessary evil. You have to do that in order to keep your quality, and Taiwan need to be really on a stage, become a really good quality guy, important guy. We need quality. Not only just manufacture. So testing is the quality guarder, so I think, "Maybe I can create this kind of business." Another good thing is, since Vanguard has become a foundry… before Vanguard is a full-fledged company. They have designers. They have marketing people, they have sales people, they have testing people. They must have every talent there, right, doing DRAM. But when it becomes a foundry -- it's a wafer manufacturer. All these guys except wafer manufacturing lost their job. Morris did give a pretty good layoff payment, so nobody <laughs> protest, <laughs> so layoffs went smoothly. I know my testing group is very good in Vanguard. I took them, and so they left Vanguard and join us at the beginning. Then I started this Ardentec.

But at that time, because I'm free, I say, "I quit." Morris wanted me to go to TSMC as their chief scientist, CTO. He offers me the job. But I think I want to do something different, so I went to Morris. I said, "I want to do this start up." He said, "Why you would go there? You join me as CTO and chief scientist. Your part is big enough." "You have enough resources here. Why you go there?" I say I think I will try the real taste of the industry. <laughs> Then he asked me, "What will you do? You will be chairman or president?" I say, "Supposedly they want to elect me as chairman. I will be chair." Morris say, "Oh, chairman. Then maybe you should go." <laughs> He told me, "Chairman and president are a totally different life." "If you want to try something new, even if they give you president, don't go. I give you vice president as the CTO. It's the same as the president." <laughs> So I later come back to him.. "I'm sure they will let me be the chairman and I take all the responsibility." Morris says, "That's different. If you go as chairman, I bless you, okay, and you will have a tough life."

Addison: <laughs>

Lu: And then later on I agree with him. You cannot sleep well [as chairman]. The bank needs your signature. <laughs> All those kinds things. So this Ardentec is being created. Now we are doing well. I have a pretty good team and right now we may be the [second] largest testing company in Taiwan. However the route and process to grow was very tough indeed.

Addison: Okay, C. Y. So let's just finish up with talking about how you came to Macronix and some of the highlights there.

Lu: Sure. Since I left Vanguard, that was also big news <laughs> in Taiwan circles. —even before I left Vanguard, people were already coming to me asking for opportunity to invest in Ardentec. So very soon after I left, I have Ardentec being in preparation for starting. When this happens, about the same time, Miin Wu, the president of Macronix, and then the chairman of Macronix, Dr. Ding-Hua Hu… Ding-Hua Hu is my old friend since National Chiao Tung University, ITRI, and he also become a very famous venture capitalist. He invested in Macronix. Hu was Macronix chairman up 2007. But actually a founder and then the CEO is Miin Wu, he returned from Silicon Valley to establish this company. He started this company in 1989, almost the same year I returned to ITRI. He started here as Macronix. So when I left Vanguard, that's the year of 1999 I remember the summer of 1999, when we almost have the company started… the big earthquake hit Taiwan, 9/21. Miin Wu and Ding-Hua came to me to ask me to join Macronix, but I told them, "I can't. I already got the money from the investors. The company Ardentec just formed. I'm the chairman. <laughs> How can I join you?" But they don't give up. They still come <laughs> to ask me to join. So I say, "I can help, okay, maybe as a consultant." As an executive advisor, each week I spend one day at Macronix. I get a promise from Ardentec's board, I tell them I have a part-time job <laughs> [at Macronix], because they say they need me so badly. They want me to lead in the technology of Macronix. Okay. So I become a part-time executive advisor of Macronix, and this is 1999. Macronix seems to be going smoothly, but we are fighting every day at the start of Ardentec. I spent a lot of energy to make Ardentec get going. But in 2001, there is another disaster, <laughs> okay. <laughs> Disaster happens again. Macronix has a big loss, historical loss. The company almost bankrupt. It's a loss of about 10 billion NT dollars. So Macronix comes to me even more [desperate]. <laughs> I say, <laughs> "I really have two ends burning," but I promised them I will do my best even if I come one day per week. But I will spend my moonlight time, working hard with your technical team, okay. So they say, "When can you spend more time?" I say, "I will let Ardentec go IPO. I have a responsibility to my investors. They trust me, they give me 60 million US dollars to start this company. Ardentec is doing well, okay, up to 2004. We succeed to IPO, and Macronix is even worse, because of the big loss and it is almost down the drain. Cannot get back up. So in 2004, I become the COO of Macronix. So I have half of my time there… at the very beginning of Ardentec I was chairman and president, so now I'm the chairman. Another person is there [to help] to be Ardentec president. Very capable and nice guy. So I spend more time to save Macronix. Until 2007, Macronix finally started to turn around. In technology, the ROM memory technology, we totally hog the market. For NOR flash, we are gaining market share. But there was a big shareholder fighting with Powerchip. That's 2006. Big fight. Powerchip intends to take over Macronix, drive the old team like Miin away. So I fight with Miin against Powerchip. We finally have success in 2007 shareholders meeting, although Powerchip gets two seats in the board, but we have the dominate number, and our business turns around, starting to turn around, and Chairman Ding-Hua Hu quit. So Miin was promoted as chairman, and he also asks me to be president. So in 2007 I became president. Then my time spent is reversed. I am chairman [at Ardentec], responsible for strategy and big stuff. As to day-to-day operations, the [Ardentec] president is doing great job there. I am doing a lot of day-to-day job [at Macronix] especially for the technology and manufacturing side, and Miin Wu takes over on strategy and the sales and the marketing, and legal thing. This is what has happened for almost 15 years, <laughs> up to now.

Addison: Right. Okay. So when are you going to retire? <laughs>

Lu: I don't know. <laughs>

Addison: You work so hard for so long.

Lu: Yeah. I work hard, but I kind of enjoy that work and life, and I almost work 14 hours a day. When I return to home, off duty from the office, I still continue working, such as an Editor of IEEE Transactions… especially nowadays with all the computers around. <laughs>

Addison: Okay. Well, I think we've covered everything. If there's anything else that you wanted to mention, please do, but otherwise...

Lu: I think there is a lot also in the development of how to make Ardentec become a top testing company; and the technology and then the product strategy to make Macronix as the number one NOR Flash and ROM provider in the world. There are some stories about that, but we can break and chat more later.

Addison: Sure. We can do that. The next time.

Lu: Yeah, yeah. I think today our story's starting from Taiwan, coupled closely with Taiwan's history.

Addison: Yes, yes. It's been fascinating and thank you very much for your insight.

END OF THE INTERVIEW

