Taiwanese IT Pioneers: Robert H. C. Tsao

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Ling-Fei Lin: I am Ling-Fei Lin. Today is February 17th, 2011. This project belongs to part of Taiwan's IT oral history project by the U.S. Computer History Museum, and the interviewees are pioneers in Taiwan's semiconductor and computer industry. Our guest today is Robert Tsao.

Ling-Fei Lin: First, please give us your Chinese and English names.

Robert Tsao: My Chinese name is Shin-Chen Tsao [曹興誠], and my English name is Robert Tsao.

Ling-Fei Lin: OK. Please tell us when and where you were born.

Robert Tsao: I was born in China in 1947.

Ling-Fei Lin: In which city?

Robert Tsao: I can't remember.

Ling-Fei Lin: Where did you grow up?

Robert Tsao: In Taiwan.

Ling-Fei Lin: In Taiwan. How old were you when you came to Taiwan?

Robert Tsao: One year old.

Ling-Fei Lin: One year old. Can you tell us about your parents' occupation and your childhood?

Robert Tsao: Wait, how does this have anything to do with the history of IT development?

Ling-Fei Lin: This is a history of IT development as seen through your own personal experiences. You can describe things in your own words and I won't push you to talk about anything that you don't want to talk about.

Robert Tsao: My family sought refuge from China in Taiwan in 1948 when I was one year old. My father taught Chinese and History in Tsing-Shui, Taichung, so I grew up in Tsing-Shui, Taichung. When I was

studying in high school, I transferred to Taipei Municipal Jianguo High School, Taipei; and afterwards, I entered the Department of Electrical Engineering of National Taiwan University (NTU). After joining the army, I entered the Graduate Institute of Management of National Chiao Tung University (NCTU).

I was then introduced to the Industrial Research committee of the Ministry of Economic Affairs after graduation. The function of this committee was mainly aimed at combining and reorganizing three foundations. They were the Chemistry Institute, the Metal Institute and Mining Institute into the Industrial Technology Research Institute (ITRI). This organization was implemented by Yun-Suan Sun, the Minister of Economic Affairs at that time. Two years later, the Industrial Technology Research Institute (ITRI) was founded and I was assigned to this organization. Later, ITRI established an Electrical Engineering Institute which was founded in order to transfer in IC design and manufacturing technology from abroad. The Electrical Engineering Institute then launched a famous project in 1976 to sign a contract with RCA from America to buy technology. How we carried out this project was to assign Taiwanese to [go to] America to learn this entire technology; and we established an integrated circuit (IC) demonstration plant in Taiwan simultaneously. The purpose of this project was not only to conduct pure research but also to transfer over an industrial technology. Here, the phrase “industrial technology” indicates not only a transfer of the technology itself but also the ability to carry out economically efficient mass production of goods. Therefore, the difference between this project and other research projects was that it was a challenge, one which imported a technology and utilized it to produce goods in a demonstration plant. The project had to prove the economic feasibility of mass production before the technology was finally transferred to private industry. Strictly speaking, it was a technology transfer project, rather than a research and development project. Everyone knows what happened next; the demonstration plant went quite well. United Microelectronics Corporation (UMC) was founded in 1980, which was four years later …

Ling-Fei Lin: Excuse me, President, may I ask some RCA-related questions? At that time RCA had technology that was quite advanced but people had argued both for and against how advanced their technology really was. Why, then, did you choose RCA? How advanced was their technology, and what was their attitude toward it?

Robert Tsao: We had 14 candidates, and RCA was the most advanced in its CMOS technology. CMOS was considered the best in bipolar process technology and one benefit of using CMOS was that it saved power. In terms of producing consumer electronic goods, take stereos for example; they were produced using bipolar process technology. Consumer electronic goods had just begun being produced at the time, and RCA had the advantage that their CMOS technology was the best among all the others. Among the entire industry, there were surely other technologies apart from CMOS. However, CMOS technology was

very suitable and the right option for Taiwan's industry.

Ling-Fei Lin: Can you share with us about the process when you joined the RCA project?

Robert Tsao: There were about 30 engineers sent to RCA to learn the whole set of industrial production technology including design, packaging and testing. As for me, I was assigned to learn the complete planning process, such as production planning, logistics planning, and etc. I only stayed there for two months, but I had learned the whole set of planning and management rules. I brought the complete set of regulations back to Taiwan that later served as pioneering production management technology for those who were engaged in semiconductor industry.

Ling-Fei Lin: So were these regulations followed by UMC and other companies?

Robert Tsao: Basically yes. I had intended to stay longer in the United States of America, but I was temporarily being assigned to transfer back to Taiwan to put out some fires. When we were receiving training in the States, the demonstration plant and equipment were also being built and prepared in Taiwan in the meanwhile. However, we had encountered a huge issue that we ought to purchase and operate the same equipment as what RCA was using in their factory when we signed the contract. If we purchased different equipment, then they would not be able to guarantee the production yields. Nevertheless, Taiwan's government had a distinctive procurement [process] that any procurement case over six million dollars should be put up for public bidding. Thus, we needed to call for public bids because the equipment used in the demonstration plant was covered by a governmental budget. We were not allowed to randomly buy any equipment, or else it would be a violation of the contract. So I was immediately recalled by the government to handle this emergency.

I tried to negotiate with the National Audit Office to ask for a favor to make this project an exception and that [I made the case] it would fail if an exception to the law was not made. The National Audit Office rejected my application at first, so I came to their office every week to persuade them. One interesting story was there was another applicant there all the time, Yao-Tung Chao, who was fighting for the establishment of China Steel Corporation. Both of us were considered troublemakers as we tried to break through audit process to successfully establish our companies.

Later, someone told me about a loophole whereby I could authorize Central Trust of China in New York to stipulate a product brand and negotiate a price. This was surely an illegal method and we ought to take responsibility ourselves if any negative outcome resulted. However, we were just glad that at least there

was a loophole that we could use, so at once we flew to Central Trust of China in New York for negotiation and solved this problem. We finally purchased the same equipment and the contract went well.

But unfortunately I was reported for violating the law and was investigated for almost a year. I finally got rid of this after a pile of reports was filed on my behalf. When we were founding the semiconductor industry, we not only encountered technical problems, but also a lot more systematic restrictions. For example, that was a foreign exchange control period, so we had to spend thousands of US dollars hiring a lawyer and we also needed to explain our intentions every time when Foreign Exchange Department came to us. Apart from this, we ran into some technical issues during the process of design to production, such as the fact that a specific reticle (mask) production machine was not available in Taiwan, so we had to design it, put it in magnetic tape, and send it abroad for production. Yet, Taiwan's Military Policy Headquarters was suspicious of the plan and forbade the export of the design tape. They commanded us to report the tape's content and it turned out to be gibberish and unidentifiable. Thus, we encountered another problem and were stuck again. What's funny was the solution that they finally decided was to place an inspector with us to supervise, even though the inspector was completely clueless. Luckily, everything was well taken care of, and thanks to everyone's efforts, the demonstration plant went very well.

Ling-Fei Lin: I heard that RCA initially guaranteed the yield rate would only be 17%, but the yield rate the demonstration plant carried out was 70 to 80 %. Can you explain why the demonstration plant had a better yield than RCA's plant?

Robert Tsao: This was probably owing to two reasons. On one hand, we used new equipment, and on the other hand, the initial target yield rate was set lower. After we learned the technology, the yield rate could increase easily. This was a natural phenomenon that the yield rate would be higher than originally predicted yield.

Ling-Fei Lin: But didn't this surprise RCA? Didn't they consider those Taiwanese engineers who were sent to America were elites? Or were there any other factors that made your project so successful?

Robert Tsao: Those who were hired by this project were all very outstanding, such as Ding-Yuan Yang, Chin-Tay Shih and Jian-Jun Chang, each of whom had doctoral degrees from Princeton University. Even in the semiconductor industry, it would almost be a waste of their great talents to use them on manufacturing alone. Therefore, it was natural that yield rate was high.

Ling-Fei Lin: We know that this demonstration plant and related people were later members of UMC, can you describe what was the biggest challenge you faced when UMC was first established?

Robert Tsao: UMC was founded in 1980 and launched its first production in April, 1982. I was assigned to be in charge of the entire operation by the Electrical Engineering Institute prior to launch. There was a general manager, Chuan-Yuan Du, who was working several jobs at the same time, and was unable to work full-time in UMC. I was his replacement. I joined UMC at the end of 1981 and became General Manager in March, 1982 to promote the company. UMC's main technical resources were derived from the Electrical Engineering Institute, but Electrical Engineering Institute was suspicious of UMC for its overwhelming production capacity. The Electrical Engineering Institute considered UMC's the production capacity of 40,000 *ping* [a unit of land measurement derived from the Japanese *tsubo*] as too large to be sustainable and believed we were unable to load it. Despite this, we firmly believed that the three major elements to be prosperous in semiconductor industry were: loading, loading, and loading. Like the occupancy rate of a hotel, if it reached 60%, a hotel probably could breakeven on its cost. If it reached over 60%, a hotel could make 80 cents net earnings on every dollar. However, if it couldn't reach a 60% occupancy rate, there could be a great loss, so it was in the semiconductor industry. Therefore, the Electrical Engineering Institute was at first very concerned that UMC would fail to meet the production capacity and its loading issues would lead to a severe losses.

Ling-Fei Lin: Why did you initially target a production capacity encompassing 40,000 *ping*?

Robert Tsao: Because the general manager at that time, Chuan-Yuan Du thought there could be more sources of product. The Electrical Engineering Institute, however, worried that their design department could not provide them with as many products as they needed, so they began with very limited product categories such as electronic watches and music cards at first. It was rather a tough beginning when we started in 1982. We set a goal of reaching a revenue of 190 million dollars with a net loss of 80 million dollars. In 1983, we came across a good opportunity that the amount of our exported product, telephones, rose six times from 4 million to 24 million pieces. Providentially, the integrated circuit used in the dialer for telephones was a main product of UMC, and we caught this opportunity to improve our business volume when American and Japanese suppliers were not able to pick up the slack on this product. Our revenue reached over one billion in 1983 and each stock made a profit of seven dollars. However, the volume of telephone exports declined rapidly in September, 1983 and we had nearly a half a year window where we were not manufacturing anything. After 1984, the amount of telephone exports dropped dramatically from 24 million to 6 million, which was the initial amount of exports prior to the boom. Thus, due to the instability of the earliest stage of running UMC, we strived to expand our product line to stabilize our

operation.

In 1984, Li-Teh Hsu, the Minister of Economic Affairs at the time, was enthusiastic about the developing semiconductor industry and arranged for me to expand the business scale of UMC up to 10 billion dollars. Afterwards, we embarked on some preliminary planning based on the situations we had encountered during the establishment of UMC. Situations such as a shortage of investment capital and the possibility we would fail if we were going to invest in our own product, design, manufacturing, testing and packaging, the so called vertical integration, IDM; it was very likely that the company's existence would be threatened tremendously by this.

Consequently, I made a proposal that we should expand in two different ways. We should encourage Chinese to be engaged in design so that less capital would be required to invested in design houses because the main expense in design is in personnel. This was the idea of original equipment manufacturing (OEM) that we invested in many design houses and brought design products to certain foundries for production. In this case, specializing in manufacturing (OEM) enabled a factory to minimize the loading problem; besides, the threat of a decline in exports of a particular product would be halted by virtue of diversified product lines. Therefore, our OEM foundry would not have to invest in product design or diversification, thus allowing our resources to be applied efficiently and effectively. Based on this concept, the Ministry of Economic Affairs was greatly in favor of it; however, Mr. Kwoh-Ting Li told me to ask Mr. Morris Chang for advice.

Ling-Fei Lin: Can you tell us when this happened?

Robert Tsao: In 1984.

Ling-Fei Lin: In 1984, what was Morris Chang in charge of at that time?

Robert Tsao: In 1984, Morris Chang left TI (Texas Instruments) to go to GI (General Instruments) and was positioned as COO in New York. To meet him, I flew to America with Ying-Da Liu. I sent a proposal in advance to him, we had dinner together and a discussion; but there was no result afterwards. What was intriguing was the Ministry of Economic Affairs urged us to complete this project at first, but stopped communicating with us about it thereafter. I was not sure of what was happening after the meeting until later I found out that Morris Chang had sent a letter to Mr. Kwoh-Ting Li expressing the sentiment that this project was unworkable. Chang explained that only DRAMs would be prosperous in Taiwan's market environment, while manufacturing and design would meet a dead-end.

Ling-Fei Lin: Did you read that letter?

Robert Tsao: Yes. He did not send a copy to me, but I was aware of it later when someone forwarded it to me. Consequently, the project was suspended; however, when Taiwan Semiconductor Manufacturing Company (TSMC) was founded in 1987, they were engaged in specializing in OEM according to my ideas and planning.

Ling-Fei Lin: Can you tell us did you plan to do solely OEM wafer or both, I mean did you plan to be an OEM and design your own products?

Robert Tsao: No, we specialized solely in OEM. Apart from this, we also shifted our focus to encourage more Chinese designers to do IC design and gathered their products at our OEM foundry for production.

Ling-Fei Lin: So did you actually suggest that UMC be specialize solely in being an OEM foundry (as opposed to designing its own products)?

Robert Tsao: Yes, but UMC had some difficulties in the course of specializing in OEM. The reason was because we originally produced products and we wanted to transform to an OEM foundry and expected competitors to become our clients. This was unreasonable to our competitors, so we had to establish a new company to do OEM. Obstacles occurred when we tried to transform our company and we figured out a solution which was to establish a new company to specialize in OEM wafer if the Ministry of Economic Affairs supported us.

Ling-Fei Lin: To be an OEM foundry? What would happen to UMC if you suggested establishing a new company?

Robert Tsao: Yes. I thought that UMC was capable of repositioning itself by having the new OEM foundry take over the manufacturing part and UMC itself could specialize in design.

Ling-Fei Lin: So was it your idea to establish a new company of OEM wafer and transform UMC to be a design house?

Robert Tsao: Therefore, when TSMC was founded in 1987, they followed our concept to run their company. This concept of OEM foundries was proposed by us and the Ministry of Economic Affairs

approved of this concept. However, Mr. Kwoh-Ting Li respected Morris Chang's advice very much for he was his consultant, and after hearing his advice, Li halted this project immediately. Yet, the first stage of managing TSMC followed exactly what I proposed. What was intriguing was TSMC even claimed to the government that there was no need to build other manufacturing companies in Taiwan, and every company only needed to engage in design and there was no need to build other foundries. There were other design companies besides UMC, such as '*Guo-Shan Corporation*' (phonetic translation) [國善] and Mosel, Vitelic Inc., TSMC had the idea that all other companies could just do design and ask them to manufacture the products as an OEM foundry; therefore, we could all develop successfully. By following our concept of implementation, TSMC developed very smoothly at the beginning. Another factor contributing to their success was that ITRI's Electrical Engineering Institute had established a second demonstration plant after the first one, and the second one was given to TSMC as their own foundry. This demonstration plant cost 100 million US dollars and 5 years of construction, and was rented by TSMC as their first foundry, which meant TSMC got a free foundry at first.

Ling-Fei Lin: Wasn't it just a demonstration plant?

Robert Tsao: This demonstration plant had the same industrial production capabilities as the first demonstration plant. Let me go back to the topic of UMC's initial stage, demonstration plant of ITRI's Electrical Engineering Institute were keeping its production, operation, selling and it even held market competitiveness.

Ling-Fei Lin: What was the capacity at that time?

Robert Tsao: It was about 20, 000 pieces. So after spending 5 years and 100 million US dollars on construction, the second demonstration plant was built, and about 500 to 600 trainees were all sublet to TSMC. Therefore, TSMC had foundry at first and they only needed to spend 2 million US dollars on subletting the foundry. It cost 100 million US dollars and 5 years of construction, but there were only 2million US dollars in return. Apart from this, ITRI even gave TSMC 7 million US dollars to subsidize the cost of subletting the foundry. The 7 million US dollars were given under the name that UMC commissioned TSMC for research and transferred the 7 million to TSMC. In other words, the first 3 and half years of running TSMC was for free and it went very well under the protection of ministry of economic affairs.

Ling-Fei Lin: It seemed that government had given TSMC much more favor, but didn't UMC receive the same favor as TSMC?

Robert Tsao: When we started UMC, we only had piecemeal technology transfers and no subsidies from the government. Moreover, UMC even gave the government 15% of its tech stock as compensation for the technologies transferred in the beginning of UMC's establishment. Although UMC received governmental technology support , we had to repay the government for this subsidy.

Ling-Fei Lin: So was the demonstration plant given to UMC or not? Was this different from TSMC?

Robert Tsao: No. The demonstration plant was kept as competition for UMC. UMC was having a hard time striving for existence; whereas TSMC was able to take over the whole demonstration plant.

Ling-Fei Lin: You mentioned [that the] demonstration plant was still a competitor with UMC because they still manufactured their own products by taking orders, were they?

Robert Tsao: Yes. ITRI's Electrical Engineering Institute was founded prior to UMC's founding, UMC hadn't appeared in the market nor had market share, and they still needed to compete with the Electrical Engineering Institute.

Ling-Fei Lin: Can you talk about what was the original idea of OEMing wafers? How did you think of this production model?

Robert Tsao: The story was that after brainstorming and some discussions, I was thinking about why foreign experts considered we would fail when they came to visited us, because our capital was too few and technology too outdated. Now when I recalled this, it was true that our capital and technology were few and far from maturity. What we had at that time was only 5 micrometer, and the whole industry was advanced to 2.5 micrometers. No one had confidence in us. Thereupon, I had an idea that we had to concentrate our resources. Design, manufacturing, testing and packaging all required great sums of investment capital, and technology had indeed progressed rapidly. If we invested in everything equally, we would probably lose everything. The first idea that came to my mind was concentration of resources and vertical segmentation. The second idea was the issue of stability. If a factory merely produced its own product and this product happened to be problematic whether in the production period or in the market, this factory was doomed to shut down. This is very dangerous for a factory. Consequently, a factory should have as many different product lines as many as possible rather than confining itself in its product to stabilize its own operation. So basically these two vital concepts were what we had proposed as running UMC which we considered separating design and manufacturing as two different parts.

Ling-Fei Lin: Was it because, initially, you saw IDM companies splitting their resources to do both design and OEM? Was it then that you had identified this trend and come up with your concept of specialization?

Robert Tsao: There were no other companies specializing in OEM, and surely it would be better to have more OEM opportunities when production capacity was off. However, it was somehow difficult such as Samsung tried to do OEM with some part of its production capacity, but they had never succeeded.

Ling-Fei Lin: You decided to transform UMC into an OEM foundry despite the fact that Morris Chang did not approve of it, can you talk about this timing and why you made this decision?

Robert Tsao: Because we believed it would be better if we separated OEM and design. While IDM was much tougher and the idea of specializing on OEM was stolen by TSMC. Later, we thought we could authorize manufacturing part to TSMC while we would specialize in design. However, this plan was impeded due to the fact that TSMC never delivered the OEM goods to us. Their reasoning was as follows: if they performed the OEM manufacturing for us, then our production capability would be greater than theirs. This is because, after design, testing and packaging are taken into account, our production capability would be three times what it would be if we only manufactured the silicon wafers. Thus, if TSMC did the OEM manufacturing for us, our production capability would always be better than theirs, so they decided that they would do OEM manufacturing for anyone except for UMC.

Ling-Fei Lin: Why didn't TSMC do business with UMC?

Robert Tsao: Because TSMC wanted to be the leader and they thought if UMC became an OEM wafer foundry, then they would lose the battle to be the top electronics company leader and instead become the understudy

Ling-Fei Lin: So was TSMC willing to do OEM with overseas companies rather than domestic ones?

Robert Tsao: They did not want to do business with UMC.

Ling-Fei Lin: Weren't there other domestic design houses doing business with TSMC? Wasn't TSMC worried about that?

The first general manager of TSMC was a foreigner and he disfavored our domestic design houses but

preferred more mature, large overseas design companies with great growth potential. It's ironic that the government's purpose in establishing TSMC and giving them subsidies was that the government anticipated that they could resolve domestic manufacturing issues. Instead, it turned out that TSMC was doing a high volume of OEM business with overseas companies to the detriment of our domestic design houses.

Ling-Fei Lin: So do you mean TSMC did not accept UMC's orders or those of other domestic companies?

Robert Tsao: They accepted orders from other domestic companies but not from UMC.

Ling-Fei Lin: TSMC accepted orders from other domestic companies except UMC's was because they feared that UMC would take the lead among others. Thus, TSMC did business with overseas companies rather than domestic ones.

Robert Tsao: Yes, so we had to figure out a solution ourselves. It was almost impossible to transform into a foundry from an IDM, so we just awaited opportunity. After many years until 1995, we noticed that an American design house comprised of Chinese had vigorous growth, so we went to California and talked to 12 design houses for joint capital partnership. Later, we established 3 companies specializing in ODM.

Ling-Fei Lin: Were the 12 design houses founded by Chinese?

Robert Tsao: No, some of them were founded by foreigners. We became partners with these overseas design houses and established 3 foundries specializing in ODM—"*Lian Cheng, Lian Rei, Lian Jia"* (phonetic translation) [聯誠、聯瑞、聯嘉]. The idea we conceived in 1984 was ultimately carried out 11 years later in 1995. After establishing these foundries, we combined them as part of UMC; UMC was then officially became a semiconductor foundry. We transferred and separated design to other companies, so did Mediatek, Novatek and other design houses that were established under UMC.

Ling-Fei Lin: Did you transfer design in 1995 or 2000?

Robert Tsao: The time ranged from 1995 to 2000. We started the transformation since we established the three ODM foundries in 1995; in 2000, UMC combined —"*Lian Cheng, Lian Rei, Lian Jia"* (phonetic translation) [聯誠、聯瑞、聯嘉] to become semiconductor foundries and let design houses to develop independently. Since 2000, however, TSMC was founded in 1987 and the entire UMC group was

reorganized in 1995, the eight-year difference contributed to huge lag of market share. Another reason was that the industry of semiconductor foundry was quite service-oriented and customer loyalty was higher than other industries. Who led the trend, who took the utmost advantage and was uneasy to be replaced. In Taiwan, there were TSMC and UMC that took the lead and gave little chance for other start-up companies. In China, there were limitations to develop semiconductor industry due to formidable entry barriers, and also because service orientation which led to high customer loyalty. Let's say choosing a hotel, people usually choose a hotel in which they are familiar with, so is semiconductor industry. This is the industrial characteristic.

Ling-Fei Lin: Let me go back to the question that why did you find more than 10 design houses? Were any of them TSMC's clients?

Robert Tsao: They were all doing business with TSMC.

Ling-Fei Lin: They were all doing business with TSMC?

Robert Tsao: We thought that if we drew their clients as partners, we would be able to draw all of their clients. However, TSMC offered their trump that they forced their clients either to sign a long-term contract or stop offering them services immediately. Therefore, our investors were all forced to sign long-term contracts with TSMC, creating another huge obstacle for us. For TSMC, this strategy acted as both a defense against our encroachment and an attack on our strategy.

Ling-Fei Lin: They already signed long-term contract with TSMC, but did they still partner joint-capital with UMC? What made them still wanted to be partners with UMC?

Robert Tsao: This was why Taiwan's semiconductor industry was so prosperous that people all realized the significance of having different options. If there was only one option, others would build more foundries to compete with. TSMC tried every possible way to take the lead and edged out UMC, while they did not understand the importance of having two options in a market was exactly the way of existence.

Ling-Fei Lin: Was Chartered established yet?

Robert Tsao: Chartered was founded later around 1990s.

Ling-Fei Lin: Earlier than UMC's foundation?

Robert Tsao: Earlier than when UMC shifted its focus to OEM.

Ling-Fei Lin: So were there two foundries?

Robert Tsao: Yes, but they were far from mature.

Ling-Fei Lin: How did you persuade them to be UMC's partners? Comparing to TSMC, they did not need partners' investment capital, but you needed it to build factories and the capital was quite…

Robert Tsao: It was their business relationship that I needed most, not capital.

Ling-Fei Lin: So was UMC the main investor?

Robert Tsao: Yes, more than half of the investment was from UMC.

Ling-Fei Lin: More than half? Did UMC get technology stock or other equity?

Robert Tsao: No, they were simply investors.

Ling-Fei Lin: In this case, the investment capital was quite a huge investment for them.

Robert Tsao: Yes, because their design companies had already IPO'd, they had a bunch of money and no idea what to do with it. This was a good opportunity for us to partner with these people in 1995 and this somehow prevented others from building semiconductor foundries in other places.

Ling-Fei Lin: We knew that gradually you combined the five foundries and they gradually sold stock, why did you think this mode of operation unable to last? I mean the joint capital partnership with design houses.

Robert Tsao: Because design houses had some financial demand and continuously sold stock. The second reason was that there would be conflict of interest if your clients were also your investors. If your investors were stockholders, they were aware of every detail of cost and this caused conflicts when we underwent price negotiation. Therefore, we gradually encouraged them to sell stock and we bought the

stock back.

Ling-Fei Lin: Around 2000…

Ling-Fei Lin: You just mentioned the joint capital design houses, did they sign a long-term contract with TSMC?

Robert Tsao: No, they were forced to sign long-term contracts with TSMC after we partnered joint capital with them.

Ling-Fei Lin: In which year?

Robert Tsao: Around 1995.

Ling-Fei Lin: Was the long-term contract a five-year long-term contract?

Robert Tsao: I did not know, I knew it was at least a two-year contract. As a matter of fact, we did not investigate if this was violating the Fair Trade Act; there was very high percentage that it could be illegal.

Ling-Fei Lin: What proportion was given to TSMC? Did those design houses still give UMC some proportions?

Robert Tsao: They held so many limitations against the orders from UMC.

Ling-Fei Lin: So did TSMC receive the major proportion?

Robert Tsao: Yes, I still wondered if it was legal or not about TSMC's trump.

Ling-Fei Lin: Let's talk about employee stock bonuses. You separated and transferred the IC design department to other design houses subordinated to UMC, can you talk about this impact and unique significance on Taiwan's IC design industry?

Robert Tsao: There were some small and independent design houses in Taiwan with some space to grow, to mature. Later when UMC transferred most of the design to design houses, they developed very vigorously and prosperously after gaining independence from an IDM. Successful examples such as

Mediatek and Novatek, they were well- developed and were far better than other design houses by virtue of a coming out of a well-organized foundation. Moreover, the composition of this group and techniques of IC design were full-fledged that facilitated and flourished Taiwan's IC design industry.

Ling-Fei Lin: So in UMC, was it possible that due to the fact that they were familiar with manufacturing that it became an advantage even after they were separated independently?

Robert Tsao: Basically, in a foundry, designers knew the common knowledge of design and manufacturing; while in semiconductor industry, designers knew the common knowledge of manufacturing; likewise, people engaged in manufacturing process knew some basic knowledge of design.

Ling-Fei Lin: So what was your interpretation that foundries such as Mediatek and Novatek were so powerful? Was there any other reason?

Robert Tsao: My interpretation was that they were quite sizable at first which permitted a more functional management system after independence.

Ling-Fei Lin: Okay. Would you like to talk about the origin of your grand idea of the employee stock bonus system you invented first in Taiwan?

Robert Tsao: This idea was conceived of a critical moment that we realized it was a hardship if hi-tech industry in Taiwan was going to flourish only by the efforts of these trainees, we must introduce more elites from abroad. But how? In fact, the purpose of combining and reorganizing those governmental institutes as a non-governmental foundation, ITRI, was to remove the restrictive lockstep civil servant wage system and attract talent. However, I discovered this measure was insufficient when I was employed by ITRI's Electrical Engineering Institute due to the fat that there were few people of talent to be discovered either domestically or abroad. Also, it was difficult to attract or train people in this industry. Though this solution to innovate the wage system had its limitations, I finally sought a solution to this problem by studying the Company Act when I was in charge of UMC. The Company Act stipulated that a certain proportion of revenue should be distributed to employees. Some stingy people would argue that only 1 percent of revenue should be distributed to employees, while others would argue that 15 percent of revenue should be distributed to employees.

Ling-Fei Lin: Was the proportion applied domestically or abroad?

Robert Tsao: Domestically. This regulation was in our Company Act that company should distribute certain proportion of bonus to employees. You can find it out by studying Company Act. In fact, when I was assigned to UMC, general manager Tu regulated the bonus proportion as 25 percent; yet, if there was no revenue, there was no bonus. We did not make money in the first year; but our stock earned 7 dollar profit per unit one year later in 1983. The capital stock of UMC was only 500 million dollars and the revenue was 350 million dollars. I thought it was a good time to distribute bonuses, but the attempt was stymied by the board of directors. They declared that the reward could only be around 1 to 2 months' wage, which was against my will and the Company Act. Stockholders expressed that they wished they would be paid out before the employees. They demanded that the reward to employees be set at 1 month at base, while they would keep the rest of the profit, which was namely a scam. Therefore, I suggested not distributing cash to employees, but stock; by the way, UMC IPO'd in 1985, afterwards, we offered stock shares to employees instead of cash. I am not sure if it were the same situation now. If we chose stock, those stockholders could get stock according to par value like 10 dollars, no one took cash. You would need to pay tax if you took cash.

Ling-Fei Lin: So do you mean even prior to the issue of stock shares by UMC, people all chose stock?

Robert Tsao: Yes, so…

Ling-Fei Lin: So did this system already exist?

Robert Tsao: Yes. Everyone chose to hold stock. The stockholders were playing some tricks at that time. For instance, if the stockholders made a hundred dollars, they kept 90 dollars as profit and only distribute 10 dollars out of 100 dollars. Thus, even the bonus was 10 percent of the profit, employees could only get 10 percent of the distribution, i.e. 1 dollar. The rest of the profit, 90 dollars, was kept until next year and distributed again to stockholders. This seriously violated Company Act; likewise, I condemned that stockholders should not play tricks with the Company Act. Employees should gain the same as what stockholders gained.

Ling-Fei Lin: The profits weren't just for the stockholders?

Robert Tsao: According to the regulations of Company Act, I suggested that everyone should be equal and received the same kind of reward as stockholders did. Cash should be kept in company, while stock shares could be distributed to everyone. If employees received stock value of 10 dollars, but the stock market value was lower, they would rather choose cash. However, if company's stock market value was a

hundred dollars, employees received a hundred dollar stock. The market was paying our employees but not company; besides, this did not require taxpaying. We were pondering why there were all the small companies before UMC's establishment, and the reason was that the wage was too low whether you worked in a foreign company, domestic one, or private corporation.

People at that time considered making money was the business of boss, and employees only made very little money even if they worked hard. In fact, the basic salary was very low, no matter how earnest employees were; they only made both ends meet. What's worse was a company could never grow under this condition. Sometimes, outstanding employees often thought they were better than the boss and wondered why they only made very little money and they could rule the company as well. That was why there were all small companies and no bigger firms.

I was inspired by this and tried to improve this condition that earnest employees made both ends meet, while outstanding employees got rich like boss. The system of bonus and stock shares basically followed the spirit of treating employees as stockholders. If a company ran well and its stock value would also rise, this was due to the hard work of employees. Thus, it was right and proper that employees shared the revenue with the company and it was the essence of Company Act. The system of bonus and stock distribution solved the inequitable profit-sharing situation and restored the essence of Company Act. By virtue of this, the thin line between labor and capital was smashed and employees had chances to be rich and no need to risk of everything to start a business, the risk of starting a business was very high.

One time I was visiting California and found out that it was quite popular to start a business in California. However, statistics showed that there were less than 5 percent of those start-up companies survived over 3 years. So with this bonus and stock distribution system, people could grow within a big company instead of starting businesses on their own. This was my interpretation of this system; without it, those who worked in TSMC would not come back from abroad and Morris Chang would not work in TSMC, either. This was a crucial point.

Ling-Fei Lin: In which year did you issue bonuses and stock?

Robert Tsao: It was in 1985 when UMC issued the bonuses and stock to employees.

Ling-Fei Lin: In what year did UMC IPO?

Robert Tsao: Because since we made profit in 1983, the stockholders were fraudulently not sharing

profits with employees. They thought 25 percent of profits was too much for employees, so I suggested lowering the percentage to 12.5 percent and employees would gain exactly the same as what the stockholders gain, whether it was cash or stock. My point was we must insist on obeying Company Act to execute bonus sharing and living up to the spirit of the Company Act. It had an enormous impact and the employees were highly-motivated that their wage was actually allowance, while the stock shares became the main income. This system substantially opened a new chapter for Taiwan's electronics industry over the past 20 years. Later, when we developed LCD industry and founded Unipac Optoelectronics Corporation in 1990, we invited Hsing-Chien Tuan as general manager, who was working in Xerox from abroad. I asked how much did Xerox paid you and he replied 500,000 dollars; and I offered him at least 1 million dollars per year.

Ling-Fei Lin: 500,000 US dollars?

Robert Tsao: Yes, 500,000 US dollars. Our bonus and stock shares system served as an efficient way to attract elites from abroad.

Ling-Fei Lin: It seemed that it was quite a unique system worldwide. Wasn't it?

Robert Tsao: Yes, and every company stole my idea later on.

Ling-Fei Lin: Did Acer use this system later than UMC?

Robert Tsao: Yes, Acer was late.

Ling-Fei Lin: During that period, stock option was quite popular in America, so why didn't you utilize stock options for your bonus system?

Robert Tsao: No, we did not have this stock option law in Taiwan. Though some people praised about stock option later on, there was no company applying it when it the law was implemented. A drawback of stock options was that employees bought stock at a low value when company was just founded; on the other hand, if company went well and stock value rose, employees bought stock at a high value, but when they got the stock, the value declined and they instead faced loss. Accordingly, stock option was not a sound economic system; it encouraged companies that were at the beginning stage but not companies that strived for success. If a company went well, their stock value soared high and stock option instead lost its attraction to employees because stock option was bought according to its market value. However,

if a start-up company using stock option, it could be attractive to the employees. As a matter of fact, stock option encouraged people to start business instead of company growth.

Ling-Fei Lin: Do you want to talk about the reform of the systems whereby stock distributions to employees are now taxed at market value and employee bonuses are included as company expenses? You mentioned both systems were very significant over the past three decades, and what are the greater impacts for our future?

Robert Tsao: Yes. The impact is that Taiwan's electronics industry will become very boring in the future and employees become wage earners. There is a great concern that no more shortcuts to be rich and electrical industry is losing its lure. As for the reason of abolition of bonus and stock shares systems, there are several reasons. First, Mr. Morris Chang is the one to be blamed and be responsible for that. Chang once criticized this system as a loophole figured out by smart people; nevertheless, he was one of those who benefited from it. Chang also claimed that stock option from America was a sound system, while bonus and stock shares system was an inferior local invention. Notwithstanding, he did not realize the advantage of the bonus and stock shares system.

Second, several companies took advantage of these systems. According to the essence of Company Act, employee bonuses were distributed based on proportion. In stock distribution, there was a process called excluded rights (ex rights); after excluded rights, stockholders distributed stock to employees without fill rights, this was called dilution of rights toward stockholders. Therefore, bonus and stock shares should be distributed after stock was able to fill right to tally with the original ratio. However, many companies ignored this rule and abused this system and distributed stock before the process of fill rights. This was unfair to stockholders and caused many criticisms. Furthermore, taxation was another weak point that brought about criticism that people would not pay tax for the difference between 10 to 90 dollars stock value. People criticized this system from every angle, especially taxation. Nevertheless, the biggest beneficiary, TSMC, did not support the system and treated it with sarcasm. Additionally, other companies abused this system thst contributed to its abolition. In fact, this system served as a very important innovation toward our local systems; without this, industries such as TSMC, UMC and other LCD industry would fail to prosper.

Ling-Fei Lin: So you extremely [supportive] of this system?

Robert Tsao: This system was definitely a positive.

Ling-Fei Lin: Do you have any avant-garde ideas to encourage people to join this electronics industry in the future?

Robert Tsao: It is pretty tough. Many sizable electrical companies with flourishing prospects could distribute stock and bonuses to their employees; however, that was not [possible] anymore. According to my knowledge, senior management was not as easy as before.

Ling-Fei Lin: Do you mean hiring senior level talented people? Can you talk about the UMC's technology in the start-up stage of UMC, was it comparatively outdated than others? Was it until about 10 years ago that UMC's technologies started catching up with those first tier companies? Can you talk about how did UMC catch up with the technology?

Robert Tsao: A technology requires talented people and capital to sustain it. If there was money, then it would be easier to buy new equipment and do research to advance the technology. This industry requires open and extensive exchange of knowledge rather than a secretive, closed environment. Within IC manufacturing, there are techniques for design, manufacturing, reticle and equipment; everyone is working toward a better future. As I've said before, a truly international company is made up of international production capability and globe-wide sales. An international company will, instead of just establishing branch offices worldwide, procure its equipment, materials and talent from around the world—moreover it must sell its products worldwide; this is called internationalism. Furthermore, you must have specialization so that you can be established. Business only appears when you have specialization; otherwise, no business would be done even if you claim that you are an 'international company.' Specialization and internationalism are two sides of the same coin. The idea to separate design and manufacturing is in the pursuit of specialization. With specialization, many international cooperation opportunities will appear naturally and you will advance rapidly. This is why I said advancing technology was closely relevant to this idea.

Ling-Fei Lin: You mentioned this technology was an open system, what if we were going to advance technology from 0.18 micrometer to 0.13 micrometer, do you think we can discover this relevant technology from the market?

Robert Tsao: It's not about 'discovery,' but about achieving a breakthrough via everyone's efforts. When you ask whether there is progress in technologies such as monitor resolution, photo resist technology, and photography technology as a whole, this is not someone one can do by one's self. It is like when we tried to start business in China on our own; we had to create all of our equipment from scratch, which

ended up in disaster. When you are isolated progress stops.

Ling-Fei Lin: Can you share with us about OEM? Usually, people think of it low-tech when people mention OEM or manufacturing, which is different from semiconductor foundry, can you compare it because Taiwan is an OEM island …

Robert Tsao: People have misunderstanding about the term of "OEM island" for a very long time. The term OEM means your clients pay money to you to do manufacturing for them. It is similar that you hire servants to do house chores; you know how to sweep the floor but you are simply unavailable. Therefore, the definition of OEM is that the customer knows the technology but they use the cheapest way to hire OEM foundry. This is called OEM.

I later felt that the term "OEM" was not the best descriptor, so I called it "semiconductor foundry." The relationship between a semiconductor foundry and a design company is like that of a architect and a construction company. The architect is a professional who specializes in design, and not construction. You wouldn't say that a construction company is performing OEM tasks for an architect; In terms of construction, the architect designs and construction company should provide their professional assistance and let architect know the limits of his design. In construction, bridging large distances is a complicated problem that requires the architect and the construction company to work together. So as a semiconductor foundry, our technology never stops progressing and we are able to tell our clients about design rules based on our professional specialty. This professional expertise leads to design rules for designers as a reference.

Regarding professional manufacturing, the technology of semiconductor foundry advances continuously; likewise, we provide our clients with new manufacturing process constantly so that our clients have design rules to follow. It is different that as a foundry, we provide design rules to our clients; but construction industry does not necessarily own advanced manufacturing method and provide it to architects. So to speak, semiconductor foundry is different from architecture industry. An OEM is like a servant, who does not own technology and makes little profit. Semiconductor foundries make a lot more profit. This is the misunderstanding of terms.

Ling-Fei Lin: So can we say that semiconductor foundry is upstream rather than design is upstream and manufacturing is downstream, does semiconductor foundry launch first and provide design houses with design rules?

Robert Tsao: Well, it is called cooperation. Generally speaking, we call it upstream or downstream based on working procedure. Design is surely the first procedure and followings are manufacturing, packaging and testing. There is a procedure of process according to time priority. However, in the scope of technology, design and manufacturing develop independently and design houses also encounter their own challenges and breakthrough concerning designing profession.

Ling-Fei Lin: Can you share your viewpoint that Taiwan has been specializing in OEM over the past three decades, what is your opinion of this positioning and how do you think about our future?

Robert Tsao: You mean we have been doing OEM…

Ling-Fei Lin: Not just silicon wafers, but a whole industry.

Robert Tsao: We should not consider the silicon wafer business from only the standpoint of an OEM, although the current DRAM industry is very much like an OEM business. This industry provides services for their clients for which their clients also have the technology; they simply help divide the labor. In certain consumer electronics segments, such as manufacturing iPads and the packaging industry, many other have the ability to do what we can do and place competitive bids on the internet. Whoever offers the cheapest price wins the bid. The price is terrible because many people can do it. My point is do not judge merely by the term used, instead we have to know the content of an industry. Real foundries do not have sufficient content nor research or development; we must distinguish OEMs from specialized foundries if we want to elevate the industry content from OEMs to specialized foundries. We need to focus on specialization so that we will be able to dig into this industry.

Ling-Fei Lin: Is there any other industry in Taiwan can be considered “specialized?”

Robert Tsao: Our semiconductor foundry is a good example of this. Others, such as the building industry, Mr. Samuel Yin has been creating a new method as a reference for designers. He has been moving forward to specialization.

Ling-Fei Lin: How about designing sports shoes? For example, sports shoes manufacturer Pouchen thinks that very few competitors can reach their profession, or Foxconn helps Apple manufacturing iPad at a cheap price but with good quality, aren’t they unique and professional?

Robert Tsao: Yes, it is similar that servants can sweep better than their employers after practice.

However, we should focus on technological content, which is determined by gross profit and net profit. If gross profit is very low, it means everyone knows the technology and know-how. The price is terrible because of competition. You only make profit from management rather than technology, such as logistics and human resources. Foxconn, for example, foreigners cannot accept this kind of management that accommodating 80 people in a room or incidents like [employees] jumping from the roof. It is unacceptable to foreigners. In terms of management, Foxconn should self-criticize its own technical level. However, over these years, Foxconn surely has its own specialized technologies. Therefore, if Taiwan is going to develop from OEM to specialized industries, we need to sharpen our professional skills. We will not prosper if we stay at where we are.

Ling-Fei Lin: What if, thirty years ago, you had worked only on specialized foundry work instead doing OEM work? What if you could go back in time to thirty years ago? What would you have encouraged everyone to do then?

Robert Tsao: You have no choice sometimes. Thinking about this is useless speculation. It's as if I said I had to take a part-time job to support myself when I was in college and I was wondering "What if I had been able to study 100% of the time instead of working?" At the time, there was no choice, so there's real question now, of what should I have done at the time.

Ling-Fei Lin: So, you think the development path of past is acceptable; but for the future, you anticipate it to be developed as specialization.

Robert Tsao: It is not a hope, it is about creating more profit for this industry. Without profit, we simply waste time.

Ling-Fei Lin: Would you like to talk about why it is Taiwan which is so successful in semiconductor foundry [business] instead of Singapore or South Korea?

Robert Tsao: Because in the aspect of semiconductor foundry, it was quite unique that we imported IC technology into Taiwan from abroad. It was rare; I could not think of any other examples. We imported a whole set of technology rather than merely a product for production. We set an example and laid a foundation for conducting an insightful industrial segmentation of semiconductor foundry and design. With this concept and practice we secured our position plus the unprecedented bonus and stock sharing system that we won the battle and retained people of talents and demands from around the world. We prospered because of these reasons.

Ling-Fei Lin: Is there no way for other companies to catch up?

Robert Tsao: It is very difficult. Those who once worked in Chartered, they chose to work for us once we offered them opportunities. However, things are different now.

Ling-Fei Lin: Is it because bonus and stock shares system changed?

Robert Tsao: Yes, the industry will have a tough future.

Ling-Fei Lin: South Korea has its own industrial mode. Yesterday in an interview, principal Chang Jung-Yen mentioned South Korean companies established factories in America and attracted local elites including Chinese and finally transplanted everything back to South Korea. Why is this model unsuccessful? What do you think?

Robert Tsao: I don't know if they are successful or not. Aren't they successful? Samsung operates quite successfully so far.

Ling-Fei Lin: So what about semiconductor foundry?

Robert Tsao: I used to say that an IDM being a OEM foundry was too unrealistic and risky, unless you focus purely on OEM. If Samsung wants to establish an OEM foundry, they have to establish an independent company to operate this part.

Ling-Fei Lin: Would you like to talk about China's semiconductor foundry? What do you think about the impact on Taiwan or whole world?

Robert Tsao: Until now, they still have room for improvement and there is no threat to Taiwan. However, companies such as SMIC and WSMC from China are becoming state-owned enterprises as government owns increasing stock proportion. In my opinion, this is detrimental either to talent attraction or strategy flexibility.

Ling-Fei Lin: If TSMC or UMC moved to China, would it be correct to say that they would take over the market? What do you think?

Robert Tsao: You mean if we develop in China?

Ling-Fei Lin: Yes, in China?

Robert Tsao: If there was no restriction from government, semiconductor foundry in mainland China would still be covered by TSMC and UMC. If there was restriction from the government, the industry would grow in its own way. Terry Guo of Focxonn once said that he expressed his gratitude to government that they restricted many Taiwanese businessmen to expand territory in China so that he had the chance to prosper his business.

Ling-Fei Lin: So basically if there was no restriction from government, do you think Taiwan would still prevail over China regarding this semiconductor foundry industry? OK. Would you like to summarize this interview and give an overall observation and comparison of earlier and contemporary Taiwan? What are the contribution and impact on global semiconductor industry that Taiwan has contributed?

Robert Tsao: In terms of our electrical manufacturing OEM and semiconductor foundry, they have become the indispensable part of electrical industry over the past two to three decades. Unfortunately, however, we make little profit out of OEM industry but with high risk; such a small profit requires high revenue. For example, you want to make 10 dollars profit with 1 dollar cost and the gross profit is three percent, you need to make twenty dollars profit to cover the cost. This is extremely risky and requires high revenue and inventory management. Sometimes, I think Taiwan's businessmen have sacrificed very much but the reward is comparatively low.

Ling-Fei Lin: Do you mean semiconductor industry only?

Robert Tsao: No, I mean the whole electronics industry. Industries like manufacturing telephones, computers or semiconductor foundries are quite robust.

Ling-Fei Lin: Do you mean the profit is acceptable?

Robert Tsao: Yes, the profit is acceptable and rather high concerning semiconductor foundry.

Ling-Fei Lin: So do you agree that Taiwan's semiconductor foundry has great impact on global semiconductor industry? What about other industry like IC design or else?

Robert Tsao: IC design definitely has [made] enormous contributions toward Taiwan's economy. Many imported products can be replaced by domestic products through the IC design industry, so it has been beneficial to the value-added nature of Taiwan's whole industrial situation.

Ling-Fei Lin: But doesn't Mainland China only succeed in IC design, especially new categories like consumer electronics and telecom; while Taiwan only specializes in computer? How do we overcome this situation?

Robert Tsao: In fact, China's progress is much more sluggish than we had expected, so we build semiconductor foundry in China. Moreover, they receive orders mainly from Taiwan instead of overseas companies. This is why I say China's IC design does not evolve flourishingly as expected.

Ling-Fei Lin: Not as expected?

Robert Tsao: What will be my confession and observation of serving over decades in Taiwan's hi-tech industry? My opinion is confidence really matters. When we were receiving training at RCA in 1970, people all considered IC's width range of manufacturing was 1 micrometer and [thought that there was] no room for improvement; however, this range made a gigantic breakthrough long time ago. Therefore, I often shared with our colleagues of UMC that those technologies we have today are far from developed and still are rather primitive. Why? It can be traced back to the beginning of the Earth. The Earth is not designed to take such population and now the population is over seven billion; what's worse, it will pass 9 billion in 2050. This is harmful and burdensome to human being's future survival and civilization. How to sustain the development of civilization is to utilize technology to cope with such a hugely intricate mission and continuously advance it. Technologies at the current stage are still too obsolete and we have to remind ourselves this from time to time so that we won't be satisfied with the current technology and bemoan the difficulty of advancing it. Some have said that the Earth was initially designed for only 20 million people. Once the population exceeds 20 million, the environment will be damaged exponentially. Thus, the existence of our civilization is at the expense of nature and is a luxury which depends on technology for its survival.

Ling-Fei Lin: How do you come out with the number 20 million?

Robert Tsao: Since you ask, I will answer—if you didn't bring it up I would not have. It was in 1950 that Harvard University scholars conducted a field investigation of Australian aboriginals. These aboriginals lived a life without agriculture or animal husbandry but merely with hunting, fishing and eating wild fruits.

With this type of lifestyle, one person required five square kilometers to sustain one's life. Under this rule, there could be only two thousand people's population on Taiwan's ten thousand square kilometers; and twenty million people could be sustained worldwide.

Why did people migrate from time to time? Because each human being required a five-square-kilometer area to survive; once it was insufficient, they started to kill each other for survival. Agriculture began ten thousand years ago, by the way, it was a grand invention and technical breakthrough, a human being was able to survive in a 0.5-square-kilometer territory after agriculture was invented. Furthermore, human beings began to evolve. Two thousand years after agriculture's invention, around eight thousand years ago, civilization began because of the evolution of agriculture. Five thousand years ago, human beings discovered irrigation and multiplied the accommodation of the Earth to one billion. However, 1,500 years ago, population on the Earth never exceeded over five hundred million.

The breakthrough of technology brought us development of civilization even though we understood agriculture and animal husbandry brought tremendous damage to nature. Bronze wares from the Zhou Dynasty were engraved with images of rhinoceroses and elephants which suggested there were jungles and swamps and they were extinguished due to the damage of developing agriculture. Currently, food supply significantly increased because of technology advanced. When there was no technology, food was not being able to transported or distributed properly. Most of the time, food rotted immediately if there was no consumption. Whereas, at present, a flower can be transported globally to other places utilizing technology. It is by virtue of technology that populations grow this number and exceeds the ecological loading.

Our water supply, for instance, it is ironic that the Earth is the only one filled with water among the entire planet, but we have problem of water shortage. It is really ironic that we are indeed lacking energy but not water. In the future, we can do water recycling, purification and reuse water from the sea and use desalinization. Everything depends upon technology. Our technology is still outdated in terms of energy reuse. Therefore, human development is infinite and beyond limits, but the technology is way too outdated; we have to advance in technology so that it will be able to sustain human beings' life and further to maintain the development of civilization, but also to protect the earth from our destruction. And one last thing to those who want to dedicate themselves to science and technology: work hard. Thank you.

END OF INTERVIEW

