



Oral History of Stephen Su

Interviewed by:
Douglas Fairbairn

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Fairbairn: Okay. So let me give a brief introduction. It's April 19th--

Su: Mm, yes.

Fairbairn: --2017. We're at the Computer History Museum. I'm interviewing Stephen Su from ITRI in Taiwan, and we'll be talking about some of his background and specifically his work on the original iPhone camera system. So Stephen, welcome. Glad to have you here.

Su: Thank you.

Fairbairn: Just as an introduction to how we, how you got to that program, I'd like to actually go back to very beginning. Where were you born and tell me a little bit about your upbringing and how you found yourself into the world of technology. So just give me a brief introduction there.

Su: Okay. My name is Stephen Su, originally from Taiwan. Born and raised there until I was about 14 years old. Then I came to the United States for high school, college at Berkeley, a masters at Caltech, before going to work for Motorola Semiconductor factory in Phoenix.

Fairbairn: Oh, I see. So before you go, so you even came here for high school. Did your family move here or how did that come to be?

Su: My brothers and my mom. As usual, during that time, a lot of dads stay in Taiwan and sent their family to U.S. for education.

Fairbairn: I see.

Su: So my dad was in Taiwan during all those years. My mother went back to Taiwan after two of my younger brothers went into college.

Fairbairn: I see. So-- and you went to where for undergraduate?

Su: Cal Berkeley. Here.

Fairbairn: And what did you study there?

Su: I was studying Electrical Engineering and Computer Science, before going to Semiconductor with Caltech for my master [degree]. Then after working for Motorola Semiconductor factory as an Applications Engineer, I went back to get my MBA from Kellogg.

Fairbairn: Okay.

Su: At Northwestern, yeah.

Fairbairn: Who did you study with at Caltech? Who were the major professors that you worked with there?

Su: Nicolet, Professor Marc-Aurele Nicolet, yeah.

Fairbairn: Okay. Did you interact with Carver Mead at all?

Su: No. <laughs> No. It was a very short stint. Originally going for the Ph.D. program, but met with a couple people from Bayer Labs and we talked about studying our own stuff. <laughs>

Fairbairn: Oh, I see.

Su: Yeah. But then went to this Rotation Engineering Program at Motorola, and the manager at Motorola encouraged me to do things like he did by going for an MBA degree and returning to Motorola. But as, you know, [like] most MBA students did after graduation, [grabbing] the opportunities from China [which] came up [at the time]. So seven of us graduated in that year went to Hong Kong to work on China business. None of the seven people were originally from Hong Kong.

Fairbairn: I see. So--

Su: Yeah. So we stay there, you know, through the returning of Hong Kong to China, through 1997. But at that time, you know, we were everywhere, in China and also Southeast Asia, etc.

Fairbairn: Okay. Tell me a little bit. So when did you come to United States? What year?

Su: I remember very vividly, it was the Christmas of 1980. <laughs>

Fairbairn: 1980.

Su: Nobody was on the street.

<laughter>

Su: I thought, "This wasn't the America I was told."

<laughter>

Fairbairn: Must've been quite a shock. <laughs>

Su: Yeah, yeah. It was Visalia, California. Nothing like California.

<laughter>

Su: Just next to Fresno, you know.

Fairbairn: Oh, my.

Su: No store was open during Christmas. <laughs>

Fairbairn: Right. Yeah. So-- and then you went to high school and then when did you graduate from UC-Berkeley, what year?

Su: I graduated in 1988.

Fairbairn: Okay. And then you went to Caltech, and then you started working at Motorola. What year did you start there?

Su: Mm, 1989 to 1992.

Fairbairn: Okay. And what programs did you work on while at Motorola?

Su: The first year I was in the Rotational Engineering Program, and I rotated through IC design, sensors, applications of engineering, and also semiconductor modeling. I ended up staying with the marketing side of application engineering. So I was designing kits to demonstrate different sensor products, different ICs for motor control.

Fairbairn: Okay.

Su: Yeah. And that was before I went on to Northwestern's Kellogg program for a dual degree between MBA and Manufacturing Management.

Fairbairn: Okay. So what years were you at Kellogg?

Su: 1993 to 1994.

Fairbairn: Okay.

Su: Yeah.

Fairbairn: And so then some people from China had contacted you and-- or how did that--

Su: No. It was all--

Fairbairn: Tell me how that happened.

Su: --mostly-- in 1993 summer between two years of MBA program. Many of us went to China for the first time. It was a learning trip, and from that group, most of the seven of us were from that group ended up going with different companies to Hong Kong. I was with the Boston Consulting Group Hong Kong office back then, so we were all recruited from U.S., then went there for different fields, etc.

Fairbairn: So as part of BCG were you then-- you were consulting with Chinese companies to help?

Su: Chinese companies and also Western companies.

Fairbairn: Oh.

Su: Look into get into China.

Fairbairn: Getting in to China.

Su: Yeah.

Fairbairn: And were these companies in a wide variety of areas? Are they semiconductor-related or what was the--

Su: Well, the business of BCG tended to spread widely between different industries, so I was working with ID companies, semiconductor companies, consumer product companies and also some local Chinese companies,.

Fairbairn: So very broad--

Su: Very broad range.

Fairbairn: Very broad range.

Su: My first assignment was with the oil industry in Malaysia.

<laughter>

Fairbairn: You had to do a very fast study and... <laughs>

Su: Yeah, yeah.

Fairbairn: Help them. So then tell me, that was in '93, '94? How--

Su: '94. Between '94 and '98. The returning of Hong King to China was in 1997. <laughs> So I saw the fireworks in person.

<laughter>

Su: In 1997 [Hong Kong was returned to China]. Then after 1998, my grandpa passed away, so I had an opportunity to go back to Taiwan and decide to go back to Taiwan and work for the first time in my life and I chose this company called Primax. The person who recruited me there was from McKinsey Taiwan, and he sort of attracted my attention with a consulting background but working for a, pretty much a small-to medium-sized manufacturing company back at that time. The Chairman, Raymond, and also later on my direct supervisor, Brian Yang, were very good in looking out for the future. So when I decided to go back to Taiwan I did not look elsewhere, but went into this company serving two years as the Head of the Corporate Development, sort of like a Strategy Office for the Chairman. Then after two years in--

Fairbairn: What was their product? What were they manufacturing?

Su: They were in mostly OEM, ODM manufacturing business for computers, a little bit for mobile phones before I joined them, and office products such as shredder, projectors, etc.

Fairbairn: So they were purely manufacturing, no design?

Su: For-- well, we design on the engineering part, but no own brands. So most of the customers were from U.S., Japan and Europe.

Fairbairn: So you did some design work as well as-- or the company did some design work as well as manufacturing?

Su: Yes. I would say mostly all the product and engineering design, but because we did not own the brands, so we had to go mostly with what the customers prefer.

Fairbairn: Right.

Su: Yeah.

Fairbairn: Right. And this was a big business in Taiwan at the time, especially PC-oriented, you know, design and manufacturing, right?

Su: Yes, yes. So this was in OEM/ODM business. I joined the company in 1998, soon after my four-year stay with BCG in Hong Kong. At that time, TSMC was a little bit beyond 10 years in history. Starting, showing some promise, and at that time Hon Hai, or sometimes known as Foxconn, was just starting to establish itself.

Fairbairn: Mm-hm.

Su: But most of the Taiwanese IT, ICT industry are in OEM, ODM manufacturing at that time. Very little brands coming from Taiwan. At that time Acer Asus was still having OEM, ODM manufacturing and brands all in the same company because their customers did not view their brands as a threat.

Fairbairn: Right. <laughs>

Su: So allowed them to stay with one entity, but later on as their brands businesses became larger, they were forced to separate into different companies.

Fairbairn: Right. Okay. So how long did you stay with this Primax, is it?

Su: Primax, yes.

Fairbairn: How long did you stay with that and what caused you to leave?

Su: I stayed with Primax from 1998 until 2008, so a bit over 10 years.

Fairbairn: Okay. So it was your involvement with that company which led you to the Apple program that we're talking about, right?

Su: Yes. So after two years as the Chief Corporate Development Head for the Chairman, as agreed before, I went into the product line business. So I was the Senior Director for Mobile Accessory product. At that time we were working for the previously market leaders like Motorola, Ericsson, Siemens, Alcatel. So after I joined the business unit as the Head of Mobile Accessory product line, there had been some change in the market leader, so at that time it was Nokia overtaking Motorola, Ericsson, and Siemens. So for the first few years, we made a big progress in becoming Nokia's first manufacturing outsourcing partner in mobile accessories. So I was a winner of two leading Taiwan companies with that, that job, working for Nokia on the Mobile Accessories.

Fairbairn: So what specific accessories were you making for them or-- and were you designing as well as manufacturing?

Su: Yes. We co-designed but [were also] responsible for all the manufacturing and logistic outsourcing management. We made various products for Nokia at the time from Bluetooth headsets, phone stands, but--

Fairbairn: Sorry, what was it?

Su: The stands that--

Fairbairn: Yeah.

Su: -- we called charger stands.

Fairbairn: Okay.

Su: Or a display stand that you don't see nowadays, but at that time it was pretty relevant. But what was special was within Primax, we had a product line of digital still camera. So at that time there was no camera in the mobile phones. But people recognized that, besides talking over the phone we could send texts and also send images. So at that time no video sent from the mobile phone yet. I remember very vividly, we competed very hard for mobile accessory business from Nokia. A few years, a couple years down the road, they had this need of putting camera accessory for mobile phones, so we used what we knew from making digital camera and provided some product knowledge and also manufacturing capabilities for Nokia to introduce to the world the first add-on camera to the mobile phone. It was a combination of a camera and earphones in one — we called camera headset.

Fairbairn: <laughs>

Su: It was a very long-wire product, let's put it that way, but--

Fairbairn: So it was not integrated into the phone.

Su: No, no, it was not integrated.

Fairbairn: It was on a headset?

Su: Yes. It was connected through their pop-port connector to the Nokia phone, and with that connector there is also a headset. So you could pull out that camera, take one photo each time, <laughs> and it

would go right into the phone that you could do something with it, but you could not have preview, [and] you could not store multiple photos without connecting to the phones. However, the product was a big revenue for us because it went into every phone box that they had and at that time Nokia was already the market leader, so we sold at least millions of that particular accessory. But just about the same time that Nokia introduced the camera headset, even in the development stage, we were contacted by Motorola. At that time, my customer as well, but again, that, they tried to do the same thing. So we quickly designed with them. It was a different concept, a much smaller product connected to the mobile phone of Moto[rola] and almost at the same time we help two of the world's biggest competitors with the first of the kind products.

Fairbairn: But in either case, was it part of the phone? It was an accessory--

Su: They were all add-on accessories.

Fairbairn: --that plugged into the phone.

Su: They were all add-on accessory. They did not go into in-box, so as profitable as mobile accessory is, usually it's a higher margin but fewer products because you bought it off the shelf, not with the phone. However, at that time, having the ability to take picture and send it over the phone was a very big marketing scheme for both companies, so we sold millions.

Fairbairn: And Nokia-- right. And Nokia shipped this integrated headset and phone with every phone; is that--

Su: With certain models of phones.

Fairbairn: Certain models of the phones.

Su: Yeah. High-end phones. Mm-hm.

Fairbairn: High-end phones. Okay.

Su: Yeah. Yeah. Today we know Apple has this iOS OS.

Fairbairn: Mm-hm.

Su: At that time it was Symbian for Nokia.

Fairbairn: Mm-hm. Right. Symbian was a big--

Su: Yeah.

Fairbairn: Right. And what was the-- why had you originally gotten into the digital camera market? What were the applications you were addressing before the phone application came along?

Su: The company Primax purchased a traditional film camera company from Taiwan, because at that time the film business was, you know, declining and the company had a small team doing digital cameras, and it was very early and much more behind. For example, Fujifilm from Japan, as well as Kodak, which hired George Fisher from Motorola and was trying to do a digital camera. So Primax purchased the company having the thought that they could still make money from the traditional camera, but also made way into digital camera. But as usual, you know, things did not pan out as we expected — so the lifecycle for the traditional camera went much shorter, and the business for digital camera came out much faster. However, the mobile phone with camera first started with add-on. Next with embedded, you know, which overwhelmed everybody. So very soon that Apple came to us and asking about our capabilities of making a digital still camera as well as a mobile phone camera and accessory to help them design these two megapixel camera modules to go into the first iPhone.

Fairbairn: So I forget. Was the iPhone the first one that integrated the camera into the phone itself?

Su: They were not the first. There were smaller companies like Sony and others who tried integrated camera before. And it was much more for Nokia than Motorola at that time, because Nokia was the market leader. Motorola was declining as well. So for Nokia, we also made camera products from the first-generation camera headset to the next generation stand-alone camera, but you are able to take multiple pictures and connect through visual connectors with the mobile phones. We also made camera embedded in charger stand, so you could have front end camera when you are doing conference call. So the first generation of iPhone, the camera was all looking out, not looking at yourself.

Fairbairn: Okay. Yeah.

Su: And later on they have dual camera, etc.

Fairbairn: Right.

Su: They had also camera went into Notebook in the Mac.

Fairbairn: So you're already shipping to Nokia and to Motorola. Did you have your own brand or own stand-alone product that you sold as an accessory or just--

Su: No. This was all--

Fairbairn: --through those two companies?

Su: --for these brand companies, yeah.

Fairbairn: Okay.

Su: No own brands, yeah.

Fairbairn: Okay. So were you surprised when you got a call from Apple to do this or--

Su: It has been on our radar screen for Apple because Primax at that time was a big Notebook accessory company as well. So they were the number two mouse maker next to Logitech.

Fairbairn: Okay.

Su: But nothing under its own brand. But in terms of market share for OEM manufacturing, Primax was very large in mouse product, so Apple was a Primax customer for other products. But going into iPhone was pretty key, because iPhone surprised Nokia as well.

Fairbairn: So did-- when they approached you, did they tell you what the product was for or--

Su: Usually these brand companies were pretty secretive.

Fairbairn: Right.

Su: From the start.

Fairbairn: Especially Apple. <laughs>

Su: Even Moto and Nokia at that time. So I remember that Moto sent me through a fax asking our capability in making a camera accessory. The shape and form were not even close <laughs> to the final product. I answered back with a fax and we had a deal.

<laughter>

Su: Yeah. And some of the products, you know, were told to be, for example, rectangular in shape but they came back, the real product later, was oval in shape.

Fairbairn: <laughs>

Su: You know, many stories like that. So Apple was pretty secretive at that time. At that time we were not even able to communicate to our shareholders that we made products for Apple. So for the first few generation we would have paid a hefty penalty if we say we are Apple suppliers.

Fairbairn: Oh, I see.

Su: Not like today.

Fairbairn: Right.

Su: After Tim Cook had opened up this information to the public. So before, you know, we had to continuously deny that we made products for Apple.

Fairbairn: <laughs>

Su: Because the supply chain was pretty extensive in Taiwan, so almost like you could not really hold off people from-- <laughs>

Fairbairn: Right.

Su: --you know, knowing that you are making it for Apple.

Fairbairn: So Apple-- do you remember when you first were contacted by Apple, what year, what time frame?

Su: It was in 2005, just about two years before they launched the first iPhone in 2007.

Fairbairn: And did they have a very clear specification or they were just, you know, was it a general?

Su: Initially it wasn't too clear on the camera module itself, especially on the iPhone side, but we were told about the specs that had to go into the camera module. But pretty soon, because you have to know everything about the cameras, so more information came to us.

Fairbairn: And how unique was their request? Was their, was what they were asking for, fairly easy to accomplish or did it require some significant development on your part?

Su: A few things that came to mind, Apple was pretty involved in terms of every product design. As I mentioned, as OEM, ODM supplier, we are pretty good when it comes to our own modules, components or our subsistent products, but Apple, having many young, bright engineers, they claim to be designed in California.

Fairbairn: Right. <laughs>

Su: They were more involved than other companies' engineers, and also their product requirements sometimes involved taking a risk to what we normally were used to. So for example, where other companies require the product itself not to be failing after dropping from 1.5 meter high at that time. Apple tried to lower the spec to 1 meter, so you could imagine a tall person holding up a phone next to his or her ear. It's roughly 1.5 meter, but because many of Apple's design challenge the frontier of the technical specs, including tolerances, including dimension, so our engineers would have to squeeze everything and sometimes that involved a tradeoff in other reliability specs. So that's one thing. The other thing is at that time everybody knew him and knows him nowadays. Steve Jobs was everywhere in the design.

<laughter>

Su: Even in the camera modules, so with every camera normally that you would have this filter film on top of the sort of like a cover, plastic cover, for the camera module, at that time, with the digital still camera, people are used to seeing the color in red or green. That's just because of the frequency, the spectrum, of that film. But however, Steve Jobs want it to be blueish [in color], <laughs> and you can have bluish

but the difficulty was that it's a challenge on the manufacturing side. You had to change your overall production and you had to sacrifice some of the yield just to have bluish film.

<laughter>

Su: Even the--

Fairbairn: On the cover?

Su: On the cover.

Fairbairn: The plastic cover on the--

Su: So on the first iPhone it's a metal cover on the back, and surrounding the camera module was this black plastic, and underneath the, or right on the hole, was this bluish film. It had no effect on the photo imaging because it's not through the visible spectrum, the spectrum range. However, it looks good.

Fairbairn: <laughs>

Su: With the rest of the iPhone. Yeah.

Fairbairn: I see.

Su: So one requirement was they want bluish film and in the very early stage before we could even work with the film supplier to change their manufacturing process. We literally had to hand-pick all the films that, you know, looked bluish just to make the product requirement.

Fairbairn: Right.

Su: The next requirement was that they required this film to be perfectly placed in the center of the hole, and that required some engineering invention on the manufacturing line, so we had to design some semi-automatic equipment just to align many things.

<laughter>

Su: In the assembly line, yeah.

Fairbairn: So were there technical challenges in the camera module itself in terms of the image-making quality or whatever that were also difficult?

Su: They had a lot of requirements on the image quality at that time for the camera modules [which are different from those] for typical electronic products, for which you manufactured in an open space, meaning no requirements on overall particle amount on single image.

Fairbairn: Mm-hm. Don't need a clean room or anything like--

Su: You don't need a clean room. You need the air to be clean.

Fairbairn: Right.

Su: But for mobile phone camera [was more challenging], because of the way that we assembled the sensor, which was from Micron and the lens from Taiwan Largan at the time. Today they are still the biggest suppliers to Apple on camera module, but when you have to assemble them you need to do it in a clean room and for that type of requirement at that time for Primax it was a first. We sort of did it for a typical digital still camera, but it was in very low-particle production environment and not like manufacturing a mobile phone. For not too big quantity, you could literally do it very carefully, but for a camera module at that time, in the order of millions, then we had to do it in a class 1,000 clean room and 100 bench production environment. And Apple at that time, compared to other mobile phone companies, they were very particular about the image quality. So literally for every mobile phone camera going out through the manufacturing process, we literally had to compensate digitally on every sensor's output.

Fairbairn: Mm. And who did you-- was there a primary person that you interfaced with at Apple? Who was the major contact you used?

Su: We interfaced with Apple's sourcing and project management group at that time, and so it was a few people from the Cupertino area.

Fairbairn: Mm-hm.

Su: Yeah. And for camera module, we mostly worked with Leanne, still working for Apple at this time.

<laughter>

Fairbairn: Leanne?

Su: Yeah, Leanne. From the sourcing and project management group.

Fairbairn: Oh, I see.

Su: Yeah.

Fairbairn: And when did you realize what type of product this camera module was going to go into?

Su: Oh, we knew it was for mobile phones from the start.

Fairbairn: You knew it was for mobile phone.

Su: Yeah.

Fairbairn: Okay.

Su: Because it's an embedded product, so nothing on the outside. <laughs>

Fairbairn: Right.

Su: So we knew it was for mobile phones and other company also tried at that time/ so...

Fairbairn: And--

Su: We just did not know what the phone would look like.

Fairbairn: Right. And so the actual imaging semiconductor was from Micron. Is that right?

Su: Yes.

Fairbairn: And was Micron a traditional supplier for you for your other digital camera work or was this different?

Su: They were not the only one. There were other sensors. For example, OmniVision was available at the time, but Micron at that time was the best sensor. The image sensor was two megapixel and the lens from Largan at that time. Largan from Taiwan wasn't the world's best in terms of camera module lens, but they were more effective, cost-efficient, than Japanese lens provider. Today, because of Apple and other products, Largan now is the market leader for camera lens.

Fairbairn: Mm. Is Micron still a supplier?

Su: Yes.

Fairbairn: So was this-- you started working with Apple in 2005, was this sort of all-consuming? I mean, did it take-- it required your full attention or was it just another program that had--

Su: I was in charge of all the accessories that went into mobile phones. So for a few years Nokia was my biggest customer. In the first few years for Apple we knew it would be big because in 2005 that you had seen iPod coming out. But no one could expect iPhone to be that big, coming before 2007.

Fairbairn: Right.

Su: But we definitely know that for a high-end product it would have its place, just because of history. We just did not expect it to dominate in quantity as well.

Fairbairn: <laughs> Right.

Su: And I want to tell you a good story that I've learned between transitioning from Nokia to Apple. So iPod came out around year 2000, 2001 or so, so at that time, Nokia would have a supplier day every year. So I was in Finland many trips and I visit Finland every month except July, when most of Europeans did not work.

<laughter>

Su: They took the whole month off. But there was one supplier day there, roughly around 2003 and 2004. The CEO of Nokia came out and announced to the suppliers two major objective. One objective

was that they would increase their market share from 35% at that time to 40%. This was their commitment to the board of the company.

Fairbairn: Yeah.

Su: Yeah. And also to the shareholders.

Fairbairn: Right.

Su: The next big commitment that CEO made at that supplier is that they would own the online music space because Apple just introduced iTunes no more than two to three years. It was a major success. So Nokia said that, "We own the mobile phone and we could own the online music space." The next year I went to the supplier day that the same CEO announced to the audience that after one year of unsuccessful business, ramping from 35% to 40%. You know why? It was because all their customers, AT&T, Orange, etc, said, "Nokia should not own our customers. We should own the online music space." Because at that time, as big as Nokia was, they had to sell their phones through their telecom operators, not direct sales like Apple did it later.

Fairbairn: Right.

Su: So they resisted buying Nokia phones, they tried to sell other phones. So Nokia market share did not go up from 35% but went down and that was a bigger commitment than getting into the music space. So the following year, the CEO of Nokia said to people they would try it again moving from 35% to 40% but they withdrew from online music and that gave in to Apple. I saw that as a major turning point for Apple but also given credit to Steve Jobs and his crew, making iPhone the phones that everybody liked. However, for an incumbent leader at that time to self reinvent as a channel to the consumers, instead of going through operator, was very, very hard.

Fairbairn: So Apple did go directly to the consumer.

Su: They had no other way because no one would give revenue share <laughs> to Apple. So at that time, even mobile phone was the biggest device, much bigger than notebook, also the camera was coming in just in the early stage, people saw this as a major business and at that time. All the channels were controlled by the operators. They controlled your monthly programs and the phones needed to be sold by the telecom operators. So Apple had no other way but try to go direct to the consumers. Steve Jobs had his personal marketing genius and tried to use the consumer to pull demand from the operators. And later operators even shared revenues with Apple, but not with previous mobile phone leaders. So it

was a good story telling people that as an incumbent, usually you are destined to fall because it's very hard for you to cut your arms and legs to reinvent yourself.

Fairbairn: Right, right. So I forget, did Nokia then go direct or they always worked through the operators even after Apple?

Su: A few years later, after they withdrew from the music online space, they tried to go back in again with online music, with gaming but Apple was already big. And history tends to repeat itself. Nokia overtook Motorola, majority because of its UI/UX was much more friendly than the Motorola phone which was an engineer's darling but not to the normal consumer. You had to go through the menu to get to how you want to access. People often give credit to Apple for what they do today with the touch screen and other applications, but at that time, Nokia had similar advantage over Motorola but they were not able to reinvent itself with a better OS operating system. So Symbian at that time was good for Nokia but it was not as good as Apple's in terms of simplicity.

Fairbairn: Right.

Su: Yeah. So simplicity will be the key thing, so Nokia was better than Motorola in UI/UX but much less than Apple.

Fairbairn: Than Apple, yeah.

Su: Yeah, so who knows who else could overtake Apple in the future? It had to be still going back to the consumers who need to feel good about it and feel that it's easy to use.

Fairbairn: Right. So you continued working with Apple through two or three generations of iPhones, is that correct?

Su: Yeah, I left Primax after two generations of iPhones. The company after I left continued to be Apple's supplier at least on the mobile phone. Later it was for Mac and the track pad, mouse, and other products. So I left the company in 2008.

Fairbairn: So just to dig a little deeper there, did you make frequent trips or did maybe somebody in your group make frequent trips to Cupertino to work with Apple, did they come to your place, what was the mode of interaction?

Su: It was mutual. So there were many trips that we came to Cupertino for business discussion, for new ideas, for products review, etc. There were even short trips. I remember there was one trip that my VP Brian and myself took a long flight from Taiwan, roughly 12 hours or so, came into Cupertino for one hour of meeting then we went back...

Fairbairn: Twelve hours?

Su: ...on the same day.

Fairbairn: On the same day.

Su: On the same day. But not directly, we went back going through Japan to visit Nokia sourcing and then we went through airport hotel in Bangkok, slept at the airport hostel for one night, and went to Nokia Finland, Helsinki for a meeting. But that was the time. Then on the Apple side, because they claimed to be involved in design so compared to other mobile phone manufacturers, their engineers tended to be more involved in the products or modules themselves. So they came by waves literally to our design center in Taiwan and to our manufacturing in China. They were young and very good at learning. So I remember at the very first generation of the camera module, our people would have to teach them about some product and technical knowledge. So for example, optics, lenses, etc., but they were young talents from universities, even the sourcing people, engineering people were all fast learners. So by the time that second generation, they got very good in many of the technical aspects. They knew how to ask questions and learn. And a few things that impressed us was that they came dressed with shorts and sandals.

<laughter>

Su: True Apple spirit and at that time. It was a good team spirit from both sides. Yeah! So we were in factory, we were at dinner, sometimes singing at Karaoke, etc.

Fairbairn: Karaoke?

Su: Yeah. But it was a good team bonding.

Fairbairn: So did they have another competitive company also doing the same thing at the same time?

Su: Not the very first time, so usually all the OEM, ODM business for product design might have two suppliers working together but usually because sometimes these designs would have to be standardized at least in specs, dimensions, etc. So in the early phase there might be some competing proposals but

very soon they would lock into one design. Then later on in the production stage they would have some dual sourcing as a minimum standard just because of risk management. In the first couple of iPhone generations, we were the only one. But when it came to production, later on, Foxconn, Hon Hai, they would share part of the production volume. But we were the majority share - usually it was like a 60/40 or a 70/30 split.

Fairbairn: So early on, well at least through that first generation and in the second generation, it sounds like there was a very cooperative team spirit working in-- you were both working hard together to achieve this goal, is that right?

Su: Yes, yes, yes, yeah.

Fairbairn: So it sounds like there were not-- I mean they had some, certain specifications and certain requirements that were unusual or different but overall it was not a major technical challenge to do what they were asking, is that correct?

Su: It was not a technical innovation but it was an engineering integration. So usually like it's very typical of iPhone, you have this touch screen, you have for example Siri but majority of it is not new technology but putting it together and also designing it in a way that people like it or it is as simple as kids stuff. I think that was the key for Apple's early success. I remember during the peak days of Nokia, Nokia would show a photo of a soccer star, Beckham arriving at Tokyo. All the fans and also media would bring out the camera and taking pictures of Beckham. And they would count how many cameras were phones versus how many cameras are digital still camera to show the progress. But similarly with iPhone, it's certainly an icon and it was the ability to be accepted by the consumer and also respected by manufacturers like us who were very involved. I had one phone stand without any electronic function, but a stand that supports the iPhone in the first two generations. Literally at that time because contrary to other mobile phone makers Apple would announce the new phone models and have the product ready [rather than] in three months like other people. Apple, Steve Jobs, would announce it on the same day and you could buy it after the announcement. But before then, it's totally secretive and confidential. So you can imagine for the supply chain, we would have to manufacture it, ship it across the ocean or by airplane and arrive it just before the announcement date, everything needs to be very hush, hush so people would be surprised right after the announcement and that was a major challenge. So there was one phone stand, just two days before the announcement, Steve Jobs took a look of every product that he was about to introduce and decided that that stand was too close to another product. So he decided to not announce it. Not announcing it was a nice word than "killing" it...

<laughter>

Su: ...was the reality. So you could imagine, we had products in their warehouse ready to go into the stores, we had products that's in shipment, we had products in our factory and we killed the total product. We killed it! And obviously Apple compensated us with some revenues from the next product but it was a total nightmare for everybody. But that was the Apple way. And later on because Steve Jobs' way of doing it, it was not possible to keep everything so secretive before the announcement. So later on they changed that practice. But I remember through the first two generations of the phones, they were doing things different than others - announcing it and right away you could buy it. Now they announce it and maybe you could buy it one month or two to three months late. If it is like before then it was too hard to keep everything secret.

<laughter>

Su: Yeah, you have thousands of people working on this product and that's why you see some photos leaking now, etc.

Fairbairn: So did you see any leaked photos or whatever of the iPhone before it was announced, did you ever know what the end product...

Su: There were always rumors and false pictures at that time. But for us, we worked on the module and did not touch the whole phone, so we tended to stay out of it a bit easier. But at that time we kept everything confidential and for all the phones that were used to test the camera modules usually they were in a secret box to protect its appearance from been seen if used outside. So that's the normal practice with Nokia and Motorola. Even with camera module makers or accessory makers, we had to test the phones at some point together and as a reputable manufacturing partner, we would honor those practices. So at the time, we all used code names in our manufacturing factory. We were not allowed to say anywhere outside of our own group that, "Oh, this is for Nokia phone, and this is for iPhone." So I remember that for Apple's phone, at least the two generations, our code name is Q, for Nokia it was X.

<laughter>

Su: So we'd say, "Oh, X project..., X customer...", and we tried to keep our reputation that way.

Fairbairn: Right. And so I know Apple had their engineers working behind locked doors and very limited access, did you have a similar kind of thing to protect your...

Su: Yeah, we would have to have this, we call China wall. So different teams working for different customers, all the projects or documents literally should not disclose customer names, and that's why we had these code names for different customers and projects. We also had SOPs of carrying phones or our

modules in transition from one engineering room to another factory. And in the factory we would have very high security of keeping the workers, not taking any parts or products out. But as you know that this was a big logistic management, literally thousands of people had in their hands these type of products but it was up to our manufacturing management to keep everything the way that customer wanted it.

Fairbairn: Right.

Su: One other story that I like to share is that because the way that we set up this cleanroom, so at one time, there's a group of Apple engineers coming to our factory. And we knew that Apple came to us after some stint of working with Japanese vendors and at that time. We all knew that Japanese were leaders of the camera and digital still camera, so it was no surprise that they had gone to Japan to ask for vendors to work with them. And we showed Apple customers through our manufacturing line in southern part of China. I estimated roughly I had 250 people working on certain capacity of line in the cleanroom facility. So I asked my Apple customer at that time, their previous vendor in Japan because of their reputation of being highly automated. In China that I knew that we had some advantage of labor quality and cost but not in terms of automation, so I asked the customer the question that how many people there were for similar capacity in Japan. I remember he showed me two fingers. Since I had 250 people so I was thinking about 20 people in the Japanese vendor. I knew our labor productivity ratio was maybe 3-4 times lower but definitely not in tens. But he told me it meant two people.

Fairbairn: Two people?

Su: Two people! It was a highly automated production line. So my next question was that, then why did you transfer the order from Japan to a Taiwanese manufacturer like us doing this in China? And it was then things sort of got unveiled later that usually Japanese manufacturing lines were highly automated and so they could do everything with very few people and obviously a line like that with two people. But it would have to be fully automated, and heavily engineering design. However, when you worked with Apple, one thing was that Steve Jobs made changes all the time, so he changed the specs, he changed the idea and the minute he changed it, all the Apple's engineering team, the Taiwan manufacturing team, all had to change accordingly. We had to do it right there and right at that time at the production line! With a fully automated manufacturing line, you could not possibly do that kind of changes on the fly...

Fairbairn: I see.

Su: ...within one day or two, it would have to be weeks or months because you had to do all the...

Fairbairn: Reprogram everything.

Su: ...re-programming, re-fixturing, the tooling design, and with Japanese style everything had to be re-qualified. And for us in Taiwan, we tended to do what the customer asked us to do.

Fairbairn: <laughs>

Su: So I just remember this, two people! And I still remember it today. So today that we are talking a lot about industrial 4.0. It's about combining the expertise from both countries that the manufacturing style that you need to have automation, you need to have this cyber physical combination type of systems. By the end of the day, you need to be flexible to accommodate something like Apple's design style, do it on the fly, everything for the consumers. As for manufacturing suppliers and their engineering team, you just had to do it and do it within hours.

Fairbairn: <laughs> That's a great story, thank you for sharing that. So is there anything, do you have any other stories like that or any-- well, let me ask you one thing, so Micron was the source of the imaging thing, was that a standard product for them or did they have to do any customization to meet the requirements for...

Su: In the first couple of generations of iPhones, it was a semi-customized specs. At that time, Micron's CEO was a good friend of Steve Jobs so they were flying together, etc. That was the time for their ex-CEO as a pilot, as a hobby. But remember that Micron was in the digital still camera, so this whole mobile camera, I would say that it was through the market leaders like Nokia and Apple that really took it to the next stage. So for the sensors, obviously the pixel image size and the way it is calibrated, they would have to do some customization for mobile phones. And now this is the standard, so most of these sensor companies see mobile phone business in the future maybe as IoT devices. This will be big business for them.

Fairbairn: Sure, sure. Okay, so are there any other things you think we should cover with respect to the program with Apple, is that sort of...

Su: That's pretty much everything, yeah. Obviously Foxconn was there, Hon Hai was there, big manufacturing partner at that time. We worked with them and also we had to compete with them because of the dual sourcing policy and there were many war stories. But Apple was pretty good to us because as a small and medium company we were much smaller than Hon Hai at that time. We did our part pretty good especially they asked a lot of these ID specs that were very extreme. We were able to use manual way and also semi-automated way in terms of assembly inspection and design. And we were the first supply leader and Apple would take our design or the manufacturing equipment and share with Hon Hai, <laughs>, yeah, because they were the other partner! So there were a lot of stories.

Fairbairn: So Hon Hai and Foxconn, are they just in...

Su: They're the same company, yeah.

Fairbairn: ...China or are they...

Su: They were in China already, yeah. So we were shipping from one factory to another factory.

Fairbairn: Did they have a factory in Taiwan or own...

Su: By that time it was all in China already, but all the R&D people were mostly in Taiwan for us. Hon Hai had some manufacturing engineering in China, but all the factories were in China already.

Fairbairn: Yeah, that's what I thought. Okay. So you left Primax in...

Su: In 2008.

Fairbairn: ...2008...

Su: Yeah.

Fairbairn: ...and where did you go from there?

Su: I went back to consulting in China from 2008 to 2009 by working for Roland Berger, a strategy consulting company from Germany. Then in end of 2009, I came back to Taiwan working for ITRI.

Fairbairn: And what brought back there and what has been role at ITRI, you've been at ITRI since then?

Su: In 2009, it was through a headhunter asking for a person with consulting experience coming to ITRI to lead a group of market research team working advanced technology trends and also industry trends. So today I have roughly around 250 people working for me on different types of high tech manufacturing and also a little bit of service and agriculture. So for ITRI, it's the largest NGO institute working commercialization of advanced applied technology. We are like a SRI organization, you know, in U.S. and like Fraunhofer in Germany.

Fairbairn: So you're doing actual research work...

Su: My organization works on different industries, economics and technology trends. I do not do any R&D, but majority of ITRI's nearly 6,000 engineers working in the actual R&D labs.

Fairbairn: Is some of that work in autonomous vehicles?

Su: Oh, yes, yeah. It's just about everything except defense I would say. So we work on autonomous vehicle, AR/VR, and artificial intelligence, etc. In U.S. we are a constant award winner in R&D 100 awards. So every year we would win roughly around 3-6 R&D 100 awards, you know, out of 100 awards that we would win three to six, so usually we are either the first or the second winner in terms of the number of awards in R&D 100 since 2008. And we receive about 3 patents awarded every day. So in U.S. we are the largest non-private corporate entity that has this highest patents awarded because previously it was like Bell Labs which now was separated into different entities. Companies like IBM are much bigger but they are private entities. But for a non-private entity, ITRI is up there in terms of technical achievement.

Fairbairn: So what is the state of manufacturing and high-tech manufacturing and development in Taiwan, my impression is that it had a very strong period in manufacturing personal computers and that sort of thing, how has that changed, what is the major activity now, what are the challenges?

Su: For example, mobile phones, most of it were moved out of Taiwan, HTC has some manufacturing left in Taiwan but HTC's share is not big nowadays. The majority of the manufacturing in Taiwan would focus still on semiconductors. For example, TSMC in foundry, MediaTek in logic IC and also packaging. Among the other semiconductor in other industries, the largest ones are display panel makers and also LEDs. LEDs, these are still big in Taiwan. And the next industry after semiconductor industry would be LEDs... No, I'm sorry. It would be in machinery, so like tool machines, they are still in Taiwan.

Fairbairn: What areas are you trying to move Taiwan into, what areas would you like to grow substantially?

Su: Semiconductor by far is the world leading competency for us in Taiwan. And also we have calculated its proliferating impact on other industries, backward and forward, and also its indirect impact on consumption. So that was very big for us. So for us to move forward, obviously we need to leverage this industry for others. So for example, we are trying to leverage it for Internet of Things based on the semiconductors and also even we are not a big country when it comes to artificial intelligence development like U.S., China and Europe. However with our expertise in the IC design, we could combine some of the algorithms in embedded ICs and put it in some edge devices. As we look into the future, not everything will be in the cloud, so when it comes to local computing, again, they will have to leverage these semiconductor ICs, etc. And that's where that we'll be able to have a bit of our advantages. So for

the past 20 years or so, Taiwan was not successful in pure software business, so like Internet, etc. But now we are talking about IoT, AI embedded in IC, that's where Taiwan could come back again.

Fairbairn: And part of your program is also to cooperate with universities in the United States or elsewhere to tap into their R&D programs, is that...

Su: R&D program and also collaboration. So we have a long history of collaborating with universities from U.S. Today maybe roughly seven or eight ongoing programs including Stanford and Berkeley. And because of U.S. direction in bringing back manufacturing jobs to the U.S. and also putting investment in the advanced manufacturing technology, we also participated in some of the programs, for example, flexible electronics, 3D printing, etc. Because we view it as that by working with U.S. on these forefronts of technology development, we also help put some of the Taiwanese companies in the ecosystem, not by ourselves. Because we do not view Taiwan being a country that can continue to do mass manufacturing, but getting to this high end manufacturing, working with market leaders like U.S. and German companies, Taiwan indirectly will benefit some of the companies' headquarters in Taiwan. For example, Shell Gas Oil is a big company in U.S. We have petrochemical companies that are going to U.S. for the investment. Ideally for a country, we'd like to keep it in Taiwan but we know it's not possible to do that, so how to have investment in U.S. and also have some indirect benefits for the headquarters located in Taiwan and that's going to be our direction.

Fairbairn: Okay. All right. Thank you very much, is there anything else that you wanted to cover with respect to your current activities?

Su: That's pretty much it.

Fairbairn: Okay.

Su: Yeah, I think that Taiwan being a small country, we want to be a strategic part of the whole ecosystem including many of these innovations coming out of U.S.

END OF THE INTERVIEW