Oral History of Takao Abe

Interviewed by:
Doug Fairbairn

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Fairbairn: Okay. Ah, we are here today to interview Dr. Takao Abe. It is June 20, 2016. We are in Tokyo, Japan at the New Otani Hotel and we would like to record your recollections of your personal life as well as the many contributions you have made in the area of silicon processing. So thank you for joining us. We are honored.

Abe: あー、ありがとうございます。[“Thank you “]

Fairbairn: We like to start these interviews with some personal background. We find it interesting to know how people have chosen the career path that they have. And it is one of the things that people in the future can learn from.

Fairbairn: So we would like to have you start with telling us briefly where and when you were born. Something about your family, what your father and mother were doing. Any children, any siblings, any brothers and sisters you have. And what life was like in your very early days, so please.

Abe: 私の生まれた所は、私は 1936 年 8 月 5 日生まれなんですけれども、生まれた所は北海道、まぁ日本の北にあるアイランド、北海道の、小樽市というところで生まれました。父親は、小樽市役所の港湾課という、ま、港を管理する課なんですけれども、そこで、いってみれば下級の職員で、仕事としては湾内に入ってくる船舶、当時は軍艦が、小さな軍艦が多かったんですけれども、その軍艦に飲料水を供給するハシケ船という、ま、水を持った、水を持って運ぶ、船の、船に乗っていて実際に船舶に水を供給するというそんな仕事をしていました。

Translator: I was born on the 5th of August, 1936 and in Otaru-city. That is a city in northern island of Japan and my father was a city employee and he was working for port authority. So he was kind of lower level officer, city officer; and he was providing drinking water to the vessels and ships that were coming in to the Otaru port, and back then most of the vessels were military vessels, smaller military vessels. And he was actually on the lighter boat to provide the water.

Abe: その父というのは、仙台松島の旅館の娘と、富山の薬売りという、富山県の薬売りが来て、そこで仲良くなって父が生まれたわけですけれども、生まれると同時に出産で父の母親は亡くなってしまったんですね。で、父は北海道の親戚に預けられて小樽市で育ったという、そしてそういう環境ですから小学校しか出ていない、卒業も小学校だけ、ちょっと詳しすぎますかね。

Translator: Maybe I got into too much details, but my father's mother was a daughter of Japanese inn that was located in Matsushima in Miyagi prefecture. And the grandfather, my father's father was a drug vendor. There is a famous type of drug vendor in Japan that is called the Drug Vendor from Toyama prefecture and he was one of them. And the grandfather came to Matsushima and met the daughter of the Japanese inn and my father was born. However, at his birth, his mother passed away so then he was fostered by one of his relatives who lived in Otaru. So he had some hardships and he just graduated from the primary school, but no higher education.

Fairbairn: Thank you. Do you have brothers and sisters?

Abe: 12 歳離れた兄と 8 歳離れた姉がいるんですけれども、年が離れすぎているので、ほとんど一人っ子のように穏やかに育ったんじゃないかなと思います

Translator: So my elder brother is 12 years older than I am, and my sister is 8 years older. So I was like an only child and no, almost no competition.

Abe: 母親の方は北海道の真ん中あたりの空知郡っていう、北海道、空知郡っていう所の貧しい農家の生まれだったんで、小学校もその周りにはなくて、小学校にも行ってなかったんですが、ま小樽に、昔で言う奉公、大きな商家に行儀見習いで出てきていて、そこで父と知り合った、ということですから、小学校も出ていないところで私は育ったという、母親は小学校も出ていない。

Translator: My mother is from a rural area in Hokkaido that is called Sorachi County. And there was no primary school around there and she came to Otaru City and she started working for a big merchant house learning manners at a very early age. So she hasn't even graduated from primary school. At that time Otaru city was bigger than Sapporo city.

Fairbairn: So when did you develop an interest in science and technology? What did you do growing up?

Abe: Yes. 小学校の頃は黙っていても成績が良かったんですけれど、中学高校に行くにしたがって成績が下がって、それでも親は何も言わなかったんですが、ま、そういう、親に教育がないということも影響があったのかもしれないのですが、私自身は近くにある北海道大学に入るということしか頭になくて、学力がないのにそれだけ思っていたので２年ほど浪人しました。

Translator: So when I was a primary school student I didn't really need to work hard to get a good score and it was easy. But when I went to junior high and high school then my performance degraded, but my parents were not really interested in my academic performance. Maybe they didn't have an educational background so that's why. But what I was thinking about is that we had a Hokkaido University in the neighborhood so I was just thinking about getting in to that university and study there. But because I didn't work hard during junior high school and high school ages, so I, it took me two additional years to succeed in the entrance exam for Hokkaido University

Fairbairn: When you entered the university did you know what you wanted to study?

Abe: 勉強に入る前に、ちょっと話をしたいのは、小樽という所は山の多い所で、雪が多くてスキーをする、スキージャンプが非常に盛んだったんですね。で、勉強はしないけれどもスキーをやっていて、大学に入って勉強するつもりで入ったのに、山スキー部に入ってしまったんですよね。それで大学でも勉強しないで、ま、（フェアベインさん）が、どうしてその技術に興味を持ったんだっていう、その前にやることがあって、スキー部に入って自分の今までの劣等感から解放されて、スキーではまぁまぁ人の上に立てる、チームをまとめていけるというそういう自信をようやく持つようになった、まだ何をしようかってところには。

Translator: Maybe I should touch up on the skiing before talking about what I studied in Hokkaido University. And the town where I was born has a lot of snow bowls or ski jumps or the ski slopes and so on. So I skied very much and spent too much time skiing rather than studying. And even after I entered into Hokkaido University I joined the mountain ski club. I wanted to study in Hokkaido University, however, I found the mountain ski club there and I joined the club so I spent too much time in mountain skiing again. So Mr. Fairbairn was interested in what I studied and what we need for academic career, but it's important to talk about this skiing experience. Because I joined that mountain ski club I could overcome my inferiority complex and because my academic performance was not good in junior high and high school, but

because I worked very hard in mountain skiing and in the university, I could show my leadership in leading the team and once I was called as God of skiing in the club. For many years I had felt the basic research more interesting obscurely.

Fairbairn: So a very important lesson!

Abe: あぁ、そうですね。
{Here the translator does not translate Abe's Japanese, since Abe is only agreeing with the Fairbairn's response.}

Fairbairn: So what classes or what did you study during your university time, when you were not skiing?

Abe: University time? Yes…

Abe: フィジックス。物理のマスターコースは卒業できる見込みであったが、こんな状態でドクターに行くべきかどうか迷っていたんですね。

Translator: So up to the master course in graduate school, I majored in physics, but I was wondering if I should keep studying physics in a physics PhD course or not.

Fairbairn: Were the kids you grew up with in Hokkaido, did they go on to university? Or were you the only from your family to go on to university?

Abe: Yes, yes. 兄弟はみんな高校で、私だけ。

Translator: So my brother and sister stopped at the high school.

Abe: 家の中で私が大学に行くって誰も期待していなかった。

Translator: So no member in my family expected me to go to university.

Fairbairn: But you, there was something you wanted to do that.

Abe: Yes, yeah. 何かその、役に立ちたい、基本的なことで役に立ちたいというのは大学に入ってから強く思いました。

Translator: So after I joined university, I started to feel that I wanted to be helpful to people.

Abe: まぁ偶然なんですけれども、化学科、私はフィジックスで、ケミストリーを 20 年前に出た人が 50 年前の信越半導体の社長だったんですね、その方が、仕事を始めるんで、物理学科から一人学生を採用したいという連絡があって、その時にほかの人は全部就職が決まっていたんですが、私だけ残っていたので、それじゃあ信越半導体に面接試験に行ってみようという、まぁ、ドクターに行くか就職するかという時でした。

Translator: So while I was wondering if I should go to the post graduate course or I should get the job, it just happened that the president of Shin-Etsu Handotai was the graduate. He graduated from Hokkaido University and his major was Chemistry, 20 years earlier than I did. And he was looking for a physics student for his company and the other students already decided where to go and it was only me who was free. And then as I was wondering if should go take a physics PhD course or get the job, so I decided to take the job.

Abe: それであの、その方の面接があったんですけれども、その時に一つだけ、こうずっと思っていた、世の中に役に立つ何かを残したいので、会社に入って基礎研究をやらせてほしい、とその面接の社長に言ったんですね。

Translator: So I went there and I was interviewed by the president and as I was thinking that I wanted to do something that can be helpful to the people, so I said to him that I'd like to be involved in basic research.

Fairbairn: This is at Shin-Etsu?

Abe: Yes Shin-Etsu Handotai.

Fairbairn: And was that company nearby, or was it in Tokyo? Where was the company?

Abe: Head office of course very close to Tokyo Station, Shin-Etsu Company.

Fairbairn: Is that where you went to work?

Abe: No, no. Factory, factory is in Gunma prefecture, around 120 km far from Tokyo.
それで面接の時に私が社長に基礎研究をやらせてほしいと言ったら、基礎研究は、戦後アメリカの研究所、ベルテレフォンなど、たくさんの研究所で１０年間、シリコンに関しての基礎研究がすでに終わっている、あなたがする必要はないと、だからあなたは採用しない、という風にそこで言われて、面接室から出て行かれたんですよ。

Translator: So while I was interviewed I mentioned that I'd like to be involved in basic research, however, the president said that we are a just starting silicon crystal growing company in 1960, so I don't hire you he mentioned and then he went out the job interview room.
{The translator states it as "advanced researches." As for missing or mistyped words, "factors or questions" was mistyped as "factors and questions." In the last line the translator stutters" answered or solved, so I, we, I don't hire you he mentioned", but was left as above to avoid confusion.}

Fairbairn: What year did you join Shin-Etsu?

Abe: 1964.

Fairbairn: Sixty-four?

Abe: Almost fifty-two years ago.

Fairbairn: So they did not want you to do basic research, did you know anything about silicon or the importance that silicon would have at the time? Or was it just a job they were interested in having you do?

Abe: そうですね。当時シリコンについて関心のある人っていうのは、ほとんど、科学者でも少なかったと思います。

Translator: Even among the scientists, almost nobody was interested in silicon back then.

Abe: 知られていたのはゲルマニウムで、ゲルマニウムでトランジスタが、出ているもので作られて。それをソニーの社長、井深さんでしたね、が特許を買ってトランジスターラジオを作って世界中に広めた、っていうぐらいで。ゲルマニウムのことは皆さん多少は知っていてもシリコンのことはあまり知らなかったと思います。

Translator: Some people knew about germanium and it was germanium that was used in Bell Labs for their inventions with Nobel prize and Mr. Ibuka of Sony bought that patent and he manufactured transistor radio, so almost nobody knew about silicon.

Fairbairn: Was Shin-Etsu making silicon wafers when you joined the company?

Abe: Yes, but 技術は、しかしあの、ドイツのシーメンスから技術を導入したので、非常にスムーズにインゴットをまず作って、それをスライスしてポリッシュして、という。
ほんのその、小指ぐらいの太さですね。10 ミリ以下でしたけどね。

Translator: Very thin one, but it was less than 10 mm, but they introduced all the technology from Siemens in Germany, so all the equipment was the latest one. And they created ingot and sliced them.

Fairbairn: But very small.

Abe: Very small.

Translator: Very small, less than 10 mm. Did Abe say this in Japanese (above) after 'very small'?
{Abe states his answer is in English, the translator states this to verify the Fairbairn's question. (Though this can likely be omitted as she is not actually translating Abe himself.)}

Fairbairn: So what were they interested in having you do?

Abe: Yes, growing crystal surfaces were very very beautiful if their crystals were dislocation free. Also we checked the cut surface by some preferential etching, etch pit shapes observed by optical microscope were also beautiful. I was very interested in such things.
会社の方は結晶を成長させる、クリスタルを成長させて、長い、できるだけ太い結晶を成長させる、そういう生産をさせたいと考えていた、と思います。

Translator: So they wanted me to work on a better way of crystal growth and they wanted to manufacture bigger diameter crystals.

Fairbairn: Bigger ingots. Were the customers mainly Japanese companies? Were you selling wafers to other Japanese companies?

Abe: その当時は、日本の顧客というよりはアメリカの顧客の方がま、買ってくれる、というかもちろん日本でもやっていましたけれど。

Translator: Back then the US customers were better customers then the Japanese companies.

Fairbairn: So was silicon an important product for Shin-Etsu or did they see that it was an important product for the future?

Abe: 当時は非常に小さくて、生産性も、小さくて短い、ま、これはどういう風に売っても会社としての利益というか売り上げにはほとんど寄与しない、非常に小さな部門でしたね。

Translator: So back then, the bare silicon and the alloy silicon was too small and was not a productive system manufacturing and even if they sell a lot it was not really profitable, so it was just a very small business unit, department, in the company.

Fairbairn: So, what steps did you take to improve the product to reduce defects and impurities and make larger?

Abe: Yes. Most important steps. そうですね。結晶から転位を取り除くことが、今フェアベインさんが言われた、一番重要な仕事で、それを我々の言葉で言うとダッシュネッキングと言う、これは Bell Labs のインド人なんですけれども、ダッシュが考えた、首のように細くいったん、

体で言うと首のようにいったん細くすることによって、欠陥が首のところで抜けていく、そういう技術をいかにくり抜けていくか、技術者が、オペレーターが操作をしていくかによって結晶の出来上がり方が全然違っていたんですね。

Translator: The most important mission to me is, as you mentioned, to minimize the defects in the crystal and the technology or technique that was available back then was called Dash-necking; and I think that Dash is the name of the person, one of the Indian researchers in Bell Labs and by making the silicon like a neck, a very thin part or the body, then you can reduce the number of dislocations and to sophisticate that process the operator's intuition was very important.

Fairbairn: Did you study the work being done at Bell Labs or Siemens or other places? Or did you travel to their facilities?

Abe: 何回もベルラボにも行きました。それからシーメンスにも。技術を導入したのはシーメンスなんで、シーメンスにはしょっちゅう行きました。

Translator: Yes I went to Bell Lab and to Siemens, I visited Siemens as well quite frequently because our production technology was from Siemens.

Fairbairn: And were they very open and helpful to you?

Abe: Yes, 驚くようにオープンでしたね。

Translator: Yes, they were surprisingly open.

Fairbairn: When you said that when you first joined, very few people realized the importance of silicon. How long did it take before it became clear to you and the people in the company that this was the most important material?

Abe: そうですね。やっぱり大きくそういう認識が出てきたというのは、IC が、テキサスインストルメントの人の発明で、IC というものが世の中変えて行くんじゃないかという、1970 年以降、急速にそういう認識が広まって、需要も高まってきましたね。で、そういうことが可能

な、技術的に可能なターニングポイントというのは、ターニングポイントというか、可能な技術になったのは、先ほど言った欠陥を結晶から取り出す、除く、ダッシュネッキングだったんですよ。それが今日の大量生産を可能にする非常に大きなポイントだったんですね。

Translator: So inflection point has come with the another Nobel prize invention of IC that was invented by a researcher In Texas Instrument. So after 1970 and then the needs for IC expanded and techniques to minimize the defects became available so with that a technique called dash-necking. And, it was an enabler for present mass production.

Fairbairn: So when did silicon wafer manufacturing become very important to Shin-Etsu, when did it go from being a small business unit to a major production item?

Abe: そうですね。1990 年までは、生産が大きく伸びるとまた数年間下がる、ということを繰り返していて、大きく伸びそうだっていう時に会社としては、小さな会社としては、大投資をするのだけれども必ず下がるという、シリコンサイクルというものがありまして、本当に会社のためになるんだろうかということが 1990 年頃までは、そういう景気が良い、不景気、ということが続いて、なかなか会社にとっては本当に、収入源になるのかということがあったと思いますけれども、それ以降はかなり安定して、要するに他の会社が淘汰されて、ということになりますかね。

Translator: So up until 1990 we were bound by so called silicon cycle so we made a huge investment to grow toward the future. Then because of the fluctuations of the silicon economy or the macro economy it went down. And we grew again and it went down, so it was continuum of up and down. And so up until 1990 we were not that confident. However, after then maybe many companies went away and just few companies survived then we became more confident.

Abe: それはアメリカでも同じなんですよ。アメリカでもたくさん、というか数社やっていたんですけれど、だんだんやめていく、遂にはアメリカの資本でやっている会社っていうのはアメリカにはなくなりましたね。

Translator: So I think the situation was same in the United States and it was a process of selection and survival. I don't think there is any US company that is manufacturing silicon with the US capital.

Fairbairn: So, you said earlier that in the early days the American companies were better customers than the Japanese customers, but by mid 1970s or 1980s Japanese companies were manufacturing much higher quality integrated circuits than the United States. When did that, what were the important steps? Did the government play any important roles in steering you in that direction?

Abe: Yes, yes.

Abe: 我々は、多くの基礎研究は先ほど言いましたように、はるか昔にやめて、そのあとの、結晶をどうやって引き上げるか、それをスライスして綺麗なウエハーにどうやって仕上げるか、その一つ一つが、アメリカに輸出することによって、アメリカのカスタマーが教えてくれるんですね。ですからどんどんどんどん我々の技術が上がっていく、という時代がありました。その分アメリカでの生産は下がっていったと思います。それが 1990 年までだったと思いますが、1990 年が過ぎると、今度はお客様は、あ、その前に日本があまりに作りすぎて、日米半導体戦争というか、半導体で貿易摩擦がありましたね。

Translator: So all the basic researches that were necessary for silicon manufacturing was maybe done in the United States, but we accumulated our know-how on how to pulling, pull up the crystal and how to polish the wafer and our customers in the United States were very good teachers for us. So to meet their requirements, we tried to sophisticate our techniques and our customers in the United States were very kind to tell us what we need to do, needed to do in the early stage. So then we repeated the continuous improvement process and our efforts continued to 1990. And after 1990 we established certain technologies or techniques that are necessary and also we have to go through, had to go through that the semiconductor conflict between the Japan and US.

Fairbairn: Did your…, I understand that the US customers were very helpful, but did most of the volume switch to Japanese customers during the 1980s? Who were they the biggest customers?

Abe: Yes, but they are comparable but they were Hitachi, Toshiba, NEC, Fujitsu, Mitsubishi, Sony and so on.

Fairbairn: Who were the biggest competitors? What other Japanese companies were your biggest competitors in silicon wafer manufacturing?

Abe: 当時ですか？

Abe: みんな同じぐらいなんですがね。どこが我々の次かって言うと、ま、無理して言うと住友スチックス、住友系ですね、それと三菱マテリアル。

Translator: So all the companies, all the Japanese silicon manufactures are about the same size. However, maybe the strongest ones were Sumitomo Sticks that is a company of Sumitomo group and also Mitsubishi Material.

Abe: その住友グループ、それから三菱マテリアル、それからコマツ、この 3 社が今 SUMCO っていう会社を作って我々とま、同じぐらいの勢力になっています。

Translator: So now Sumitomo Sticks and Mitsubishi Material and Komatsu got together and they created a company called SUMCO. Then it is about the same size as our company now.

Fairbairn: So are you doing the basic research now?

Abe: Yes.

Fairbairn: When did that begin? You said that before basic research was done in the US or maybe Siemens, when did Shin-Etsu undertake its own basic research?

Abe: 基本的には信越半導体、田村社長から始まって現在のオーナーのベーシックリサーチは、やらないんですよね。その中で私だけが、どうゆうかやらせてもらっている、という状態なんですけど。

Translator: So the, from the very beginning starting the days with Mr. Tamura was the president who hired me and the current owner. They were not really interested in basic research and I was the only person who was painfully in basic research in Shin-Etsu semiconductor.

Abe: ベーシックリサーチというのは何なのかということを繰り返しになりますが、ダッシュネッキングで転位という欠陥を減らしたので、直径も大きくできて、スピードも上げられて、今日の大量生産を可能にしたんです。

Translator: So may I talk about basic research that I am working on? So with Dash-necking technique we could grow the dislocation-free crystals, owing to it we could enlarge the diameter and we could accelerate the speed to pull up the crystal.

Abe: それまで、結晶は非常に完全になったと思って、大量生産も可能になったと思っていたんですが、実はまだそのシリコン原子が足りない所、シリコン原子が多すぎる所がシリコン結晶内に存在していて、それぞれが集合欠陥を作るっていうことが 1990 年から 2000 年にかけて判りかけてきたんですね。

Translator: So I, we thought that dislocation-free silicon crystal is perfect and mass production is now possible. However, but between 1990 and 2000 we came to know that where silicon is or silicon density is scarce or where silicon is too much. There are other types of defects.

Abe: *{Abe corrected the year period during the conversation with the translator.}*

Abe: 非常にわかりやすい例として、原子モデルで原子が格子点にあるわけですけれども、それが、格子点にあるべき原子がなくなった状態を空孔、それらが集まった状態をボイド（Void）と呼びますが、空になった部分です。デバイスは必ずシルコンウエハー上に酸化膜をつけますが、そこが酸化膜にならず穴になってしまいます。酸化膜の上下で電圧をかけても極微細な穴を通して電気が流れてしまい、デバイスとしては働かなくなったというのが 1990 年から 2000 年かけて、{after a short conversation with the translator} 、10 年間で大問題になったんですね。

Translator: So there is an atomic model with silicon atoms on lattices. Lack of silicon atom is called as a vacancy in crystal. Vacancies tend to aggregate by themselves to make voids. In

device process when the surface is oxidized, holes are created in oxide layer using crystals with voids. When the voltage is applied between oxide surface and crystal through the oxide layer, the electric current is punched through. It was a big problem during 1990 to 2000.

{The translator confirmed Abe's words.}

Abe: 突き抜けてしまいますね。穴です。

Translator: If the voltage is applied, then void is whole so it goes through and you cannot have the necessary resistance. That's a problem, and that problem became serious between 1990 and 2000, in 10 years.

Fairbairn: Was that problem made worse with the shrinking of the geometries?

Abe: Yes, yes. Shrinking thinner oxide layer.この流れはずっと続くと思うんですね。

Translator: And that trend will continue. It can never change.

Abe: ですから結晶は完全でないといけないという、なぜそういう穴ができるか、余分なシリコンができるか、それを追求することが、将来続いていくシリコンの完全性に、必ず関係すると思うんですけれども、そこにすでに 34 年前に、理論的になぜ穴があるか、なぜ余分なシリコンがあるかというモデルを立てた人がいまして、それは（ボロンコフ）という人なんですけれども、その理論が正しくないということだけで、私は今元気でやっているという{smiling}。

Translator: So because that trend will continue and it can never change, so we have to pursue an even higher level of perfection in the crystal. And about the existence of those voids and the location of too much silicon which is called as Dislocation loops. Voronkov established the theory 34 years ago about the reason why there are voids and too much silicon. Because I keep working on the antithesis to this theory, I'm going well and I'm very active.

Fairbairn: Can you, thank you, can take a step back, what was the major breakthrough or breakthroughs to be able to go from, I think, 150 mm to 300 mm wafers? What were the major problems you had to solve?

Abe: それの大きなプロブレムとしては、ダイアメターが 1m で，例えばそこに融液が、シリコンの融液ですね、溜まって、そうすると必ず周りで加熱されるので、対流が起きるわけですね。その対流は精密な結晶が成長するには非常に禍になるわけで、その対流を何とか抑えない限り精密な構造のシリコン結晶はできない、という事をソニーの研究者が見出して、あとで名前出てきますが、磁場をかけてその対流を防いだのです。

Translator: So the problem there is around the basic way to make silicon. So {the translator confirmed Abe's words.}

Abe: ここにシリコンを溶かして融液を溜めるんですね。

Translator: So the melt is in the pot that has a one meter diameter and the heat comes from the peripheral, then convection occurs inside the melt. And convection is harmful to the perfection of the silicon structure. And I can't remember the name of the person right now, but I will remember later, one person from Sony tried to solve the problem. And using electric, electromagnetic field or applying electromagnetic field you can reduce or solve that problem of convection.
{Transcriber's note: the translator mistranslated "magnetic field" to "electromagnetic field."}

Fairbairn: Now we are trying to go from 300 to 450, right? Is 450 mm wafer in production now or still?

Abe: 僕ももうその、10 年以上検討を始めていますが、その、我々10 年前から 450 mm の結晶は作ることはできるのですけれども、お客さんの方がまだスタートしていない、それはまぁ、お金がかかりすぎる、その設備が、ていうのは 450 mm を使って、その、会社としてやってける会社が世界中にもう限られてきてしまって、その人たちの判断を待っているという所です。

Translator: So we have been discussing 450 mm for ten years now and we can make 450 mm since ten years ago. However, our customers are hesitant to use that because it requires huge investment and equipment and are quite, very limited number of companies can be profitable using 450 mm.

Fairbairn: So you can make it, but whether the industry can use it cost effectively is another question. I understand. Tell me about the areas that your current research in what are the major problems that you are trying to solve today. Trying to improve the quality of the 300 mm wafer, is that the major?

Abe: 今の会社が何・・・*{asking the translator what was the question.}*

Abe: 結果的には 300 mm に通じることだと思います、もちろん通じることだからやっているんですけれども、何をやっているかというと、この仕事に関係した人が 100% 信じているボロンコフと言う人の考え方が、実験に基づいていない、イマジネーションに基づいた考えなので、私は徹底的に実験に基づいて証明しようとしている、自分の考えを証明しようとしている、そこが全く違う。

Translator: So what I'm doing right now will be contributing to the improvement of 300 mm wafer of course, however, my focus is to sophisticate my research or theory against the Voronkov's theory. The Voronkov's theory is trusted by so many people in this industry and they just, it's like religious and they just believe it. But his theory is not based on experiment and it's an imaginary product of his thinking and he just worked on his desktop. So I want to prove his theory is wrong based upon the experiments.

Fairbairn: If you could prove that it is wrong, does that lead to some better solutions for current problems?

Abe: I think so, yeah.

Fairbairn: Is it, how close do you think you are to being able to make that contribution?

Abe: 自分ではある程度到達点と思ってはいるんですけれど、実際に結果を、実際に生産している人達は、そういうモデルに直接依らずに、毎日の、まぁ、ここまで言っていいのかどうかわからないんだけど、トライ アンド エラーで、品質を改善しているんですよ。お客さんに言われたから、お客さんに言われた点を改善するっていう。それには理屈よりはやってみるという段階がずっと長く続いていると思っていて、そういうことに私の結論が理解されれば、必ずそ

の容易に、トライ アンド エラーが解決する、トライ アンド エラーに方向性が出てきて解決していけるんではないかという風に思っている。空孔や格子間シリコンの問題は我々のモデルによって合理的に考え易くなると思う。

Translator: So I think I have already established my theory and it's very, I've already done that or I have already achieved what I wanted to do. However, people who are working on silicon is not dependent upon the model so they are repeating trial and error during their daily operations. And they continuously improve the quality. So they try to follow or try to achieve what their customer said and this kind of trial and error process continues and has been continuing for many years. And if I can achieve or if I show a conclusion or establish theory then that'll be helpful to accelerate their process of improvement. And I don't think just my model can solve all the complex problem issues around silicon but it should be the essence on behavior of vacancies and silicon interstitials.

Fairbairn: So if you can see your theory and model adopted, will you then decide it's time to retire?

Abe: それはいつも考えていますけども、実際に皆さんが理解するっていうことは、やっぱり 10 年はかかるんじゃないかなと。一応、曲がりなりにも製品ができて LSI が使われているわけなんで、私の考えが本当に理解されるっていうのは、少し時間がかかる、それまで気持ちとしてはあっても、続いていくかどうかわかりませんね。

Translator: I'm always dreaming about it, but I think even after I establish a theory and show the model to the world, it will take another ten years or so for all the people to understand and utilize that theory in the production. So maybe I have to continue my enlightenment in order to end.

Fairbairn: Is there anyone else in the industry working on the same theory as yours? Do you have a colleague who has the same passion and commitment that you do?

Abe: 要するに同僚の人がいなければここまでやってこれなかったと思うんですけれども、一人は大学、一人は同じ会社で、私の見出したことに共感して同意してやってくれる人、ですから二人いる、ということで。

Translator: Yes I have two very important colleagues and without their help I couldn't continue my research. One is in a university and the other is in my real colleague in my company. They try to sophisticate or work on what I've found and without their help I couldn't this.

Abe: 学問の世界って非常にその、不思議に思うんですけれども、偉い人が何か昔言うと、そのモデルに自分の実験を合わせて解釈するっていう、そういう流れがどうしても人間にはあるのかなぁという風にいつも不思議に思っています。

Translator: So I'm always wondering about what happens in academy and one very famous or excellent scientist says something, then people try to think about things based upon that model that was established by that person. And it's very difficult to get out of that framework.

Fairbairn: So this might be a good time to go back and see, especially in the prologue and other areas that you have written, what other things would you like to cover or tell us about that I have not covered in the questions that I have asked?

Abe: そうですね。だいたい・・・*{Abe is thinking if they covered all in the prologue.}*

Fairbairn: Did we cover everything in the prologue?

Abe: そうですね。あの、2 番目なんかはちょっとまだ出てないですね。

Translator: Some points in the prologue number two were not covered maybe.

Fairbairn: Okay then please tell me about that.

Abe:プロローグの 2 番目ですけれども…

Translator: So second bullet point under prologue number two.

Abe: シリコン表面は非常に精密な寸法で磨かれ、結晶の純度も高い、そこに現在でもデバイスが埋め込まれているわけですけれども、それでは将来十分に LSI としての機能が発揮できない

ということで、表面の下に酸化膜を埋め込むという、それが 1980 年代に一時大きな問題になりまして、世界的に、シリコン表面の下に酸化膜、これをどうやって作るかということなんですけれども、当時非常に広く、たくさんの人が興味を持ってやったのは、酸素イオンを加速して表面に打ち込んで加熱すると、あるところに酸素とシリコン原子が結合して、酸化膜層ができる、その方法を当時サイモックスという技術として、これがまぁ将来の LSI に使われるだろうということで、10 年間以上研究した時代があったんですけれども、その時に非常にその、私はその、無理があるということで、人のやることにはなかなかなじまないということで考え出したのが、酸化膜をつけるのは非常に、我々にとって容易なことで、それも完全性の高い酸化膜、容易なことなんで、それにま、余分になるんですが、もう 1 枚のウエハを張り合わせて、もう 1 枚のウエハの方を削り取って SOI 構造というものを作ろうとしたんですね。で、それが、サイモックスが皆さんにあきらめられて、特性は出ません、ということになって、私が発想して作り出した貼り合わせ SOI ウエーハだけが生き残って Power devices ばかりでなく、SOITECH 社の Smart Cut と組み合わせて depleted SOI, Si phonics, RF devices に使われ、発展してしている。ちょっと長すぎますか。

Translator: In 1980s the silicon on insulator (SOI) wafers were requested to fulfill all the functionality that are required for LSI with higher speed and lower energy consumption. People were studying how to solve these issues and the many people were interested in that area. They are the used in oxygen ion for SIMOX (separation by implanted oxygen), and accelerating oxygen ion and shooting it to the surface. Then you can have the ion in a certain place where you would like to have oxygen ions and they were researching on that subject for ten years or so in the areas of LSI studies. However, I didn't really agree with that idea and I thought there were certain limitations and we have to overcome that. And it was quite easy to create an oxidized layer perfectly, so why don't we put another wafer on top of that. Then we just grind it out. It takes an extra wafer, however, it's easier to create then more perfect SOI structure. So we proposed bonded SOI wafer methodology and many people later gave up with the idea of SIMOX and today bonded SOI wafer is continuously used for power devices, fully depleted CMOS, Si Photonics and RF devices.

Fairbairn: Are there other sections there that we should cover?

Abe: 大体良いです。

Translator: I think everything is done.

Fairbairn: So, one last question that is, you've devoted your career to improving the quality of the silicon and so forth. What, is there anything coming that will replace silicon or is your company looking at other technologies beyond silicon?

Abe: それこそあの、このテレビの前で話ができないことですよね。(Smiling)

Translator: That's something I cannot talk about in front of the camera.

Abe: ただシリコンに関して言えば、ま、考えられる限りあり得ない、と。こういう素材っていうのは、全く、いくらでも純度を上げられる、いくらでも完全性を高められる、これに代わる素材っていうのは、私の知る限りない、と。

Translator: I think silicon is irreplaceable. There is no such material with which we can improve the purity and we can pursue perfection. As long as I know there is no such material that can replace silicon.

Fairbairn: Okay that is all my questions, if there's any final remark you'd like to make about the challenges for the future or where you think that the biggest improvements need to be made, for the person who follows you, for the young man like yourself who's joining the company. What would you tell him that the important challenge for him to undertake is?

Abe: そうですね・・・

Abe: 毎日それは若い人と一緒に暮らしているから、そういうことを言いたいと思います。ま、あれば。ただそれは言って分かることではないので、その人が何を感じてくれるか、ということじゃないかと思うんですがね。私が誰かに言われたから、頑張っているわけではなく、自分自身がやりたいからやっているっていうだけの話で、これを若い人に言って、あぁそうですかって言う人は、私はいないと思っているんですけれど。

Translator: So I work with young people every day so I'd like to say something to them. However, it's more important for them to find what they want to do. And they need to feel where the challenges are. It was like me, it's not that I'm working on this subject because someone else told me to do.

Fairbairn: Looking back, is there one time or event or accomplishment or breakthrough that you felt was the most important or meaningful for you professionally that you would want to highlight for what you have accomplished in your career?

Abe: やはりあのテレビで、というか、これが記録に残るっていうことで、話せないっていうことがありますよね。(Smiling)

Translator: There are things I cannot talk about in front of the camera again.

Abe: それはとても無理な話で、私がそういう発想をしなければ、会社自体がこう、変わっていた、という場面もありますが、それは言えない。それはま、あの、どういうことかっていうと、誰も期待していない、あなたには何も期待してないっていう所で、しかし非常に大事な、会社にとって大きなダメージになるっていう、あるいは大きなプラスになるっていう、そういうことを考えるのが好きで、そういうことはいくつかやってきました。

Translator: Sorry I cannot give you any details about what I did, but no one expected me to do a certain thing. However, these new ways of thinking or thoughts changed the course of my company's business. And as a result, those things saved the company or it could mitigate the damages to the company.

Fairbairn: I always have one more question. Is there someone that you have worked with at your company, or university, or maybe another company who has had the most influence or who has helped you the most in your career? Who would you recognize as being one of the most important mentors or colleagues or people that helped you be successful?

Abe: そうですね・・・

Abe: 現在私が、の年齢で、毎年国際会議に出たり、国内の会議に出たり、そして毎日自分の思っているモデルを確立するために仕事をさせてくれている人は誰かっていうと、現在の会社のオーナーになります。金川さんっていう、金川さんって信越化学の会長です。その金川会長の支援を受けて現在も研究をさせて頂いております。

人の考え次第でどうにでもなるんですけれども、やらせていただいているということなんですかね。それと、ずっと最初に出てきた田村社長という人が、お前はだめだ、一番役に立たないと言いながら、（エフゼット課長）にまずして、そのあと国際会議を、小さな国際会議をさせてもらったということは、私のやろうとしていることをちょっと理解して、その当時から理解していただいたのかな、という。その人には。

Abe: エフゼット製造課長、エフゼットプロテインゾーンっていう。

Translator: So at my age I still go to international conferences and domestic conferences and I'm working on the establishment of my model. And my recognition or my thanks go to the current owner of Shin-Etsu Chemical chairman, Mr. Kanagawa, and also president Tamura who hired me and he was very helpful. Although verbally he mentioned that "you are a waste to the company and what you are doing is not helping our company at all." However, he promoted me as FZ manufacturing manager and he let me hold an international conference in 1983 on the semiconductor silicon at Isobe R & D center where I work everyday. So my thanks goes to these people.

Fairbairn: Did he finally acknowledge that you were doing the right thing?

Abe: I believe…

Abe: そうだったと私は思います。

Translator: Yes, I believe so.

Fairbairn: Okay. Thank you very much. We very much appreciate for taking your time, we know it was a long journey to get here. Thank you very much.

END OF INTERVIEW

