Oral History of Isao Suzuki

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Bajorek: This is an interview of Mr. Isao Suzuki about the history of Hoya's Glass Substrate Development. The advent of mobile computers in the 1990s required hard disk drives (HDDs) with much higher shock robustness than possible with aluminum-based media. Although, it is counterintuitive, only glass-based media using chemically strengthened glass met the shock resistance and cost requirements of this application. From the outset, Hoya led the industry in developing and supplying such glass substrates. This oral history records the history of Hoya's contributions under the leadership of Mr. Isao Suzuki.

Bajorek: We'll start with the questions. Isao san, could you give us your full name, where you were born and where you grew up?

Suzuki: My name is Isao Suzuki. I was born in Tokyo, and grew up in Tokyo.

Bajorek: What were the schools that you attended? What were your majors and areas of interest?

Suzuki: I attended Tokyo Metropolitan University, where I obtained the degree of Bachelor of Science in Mechanical Engineering. The subject of my graduation thesis was related to the fatigue characteristics of aluminized iron alloy. The application of this material was for the engine valves of auto vehicles. This treatment improved the hardness and thermal resistance of iron alloy.

Bajorek: Could you summarize for us the companies you worked for, plus a brief description of your responsibilities and functions?

Suzuki: After I graduated from the University, I joined Hoya in 1966, and continued to work there for 49 years, almost a half of century. For the first eight years at Hoya, I was in their Technical Laboratory where I studied mechanical characteristics of optical glass, which is related to manufacturing of optical lenses, especially the grinding and lapping processes. In 1974, I moved to a new factory located in Nagasaka, Yamanashi Prefecture. The company decided to set up a new factory there for new products including photomask blanks and substrates for the semiconductor industry. I introduced a new double-side polishing machine in the substrate process, which is of our own design, and a new polishing process using colloidal silica slurry, as a slurry for glass polishing. Then I became development manager for technology and new products in the Nagasaka factory. I managed development in four fields.

- The first is precision machining technology, for example, the master plate for optical disk, and laser components for a laser fusion system,

- The second is thin film technology for optical thin film and EL (electro luminescent) display, and
- The third is lithographic technology for copy masks and encoders, and
- The fourth is OE--optoelectronic products, like laser oscillator, AOM (acousto optic modulator) and so on.

I started development of magnetic disks with glass substrate from 1984. I moved to San Jose in 1986 in order to continue the development of media and set up a new process of media production with glass substrates. I returned to Japan in December, 1988. From 1990 I was general manager of the Memory Disk Division, whose products were media and substrates. After reaching the retirement age of 60 ("Teinen"), I supported the Memory Disk Division's business as a senior technical staff member for technology and foreign affairs. I retired from Hoya last year, in March of 2015.

Bajorek: Who and what were your early influences at college or at work?

Suzuki: There were two Big Bosses. Dr. Izumitani. He was the head of our Technical Laboratory at Hoya. He taught me strongly that you should study hard and experiments should be done to get some physical meaning. Then, the experimental results obtained should be checked from the viewpoint of whether the result would be physically reasonable or not. He always studied so hard. Another Big Boss was Mr. Okutsu. He was an Executive Board of Directors member of Hoya. He was also the founder of the Nagasaka Factory, and brought the whole electronics industry into Hoya. He insisted on the importance of the development manager. He said the company always needs an excellent development leader. This leader should utilize researchers and the engineers well. The leader should have a clear vision of what he wants to do. Mr. Okutsu always said that to me. I learned so many things from these two Big Bosses.

Bajorek: What is your current position?

Suzuki: I am entirely retired. However, I am still an honorary board member of IDEMA (International Disk Drive Equipment and Materials Association) in Japan, and committee chairman for education.

Bajorek: When did Hoya start the data storage business for substrates as well as media?

Suzuki: Hoya started actual business of media from 1991. The substrate business started from 1994.

Bajorek: Why did Hoya decide to enter this market?

Suzuki: We started development for magnetic disk media with glass substrate from 1984. At that time, we were looking for a new product, independent of photomasks, photomask blanks, and OE products, to expand the Electronics Division's business. Maxtor pushed us to provide media with glass substrates, they requested a very smooth media. That was our first motivation to start the development of media. We already had very excellent process technology in substrate and sputtering processes for products requiring defect free properties such as photomask blanks. This is another reason why we decided to start development of media, however, we didn't have enough knowledge about HDD, and media and heads. We had to learn about heads and media from the first step. Several months later, after starting our development, we shipped media samples on glass substrates to Maxtor for their evaluation. The first sample media showed good magnetic performance, low noise and low defect levels, even though these samples were made by experimental sputtering equipment. Maxtor's next request was something strange. They asked us to prepare a media with glass substrate without texturing and lubricant. Then we faced the stiction problem. It was not so easy to solve this problem. However, my top management decided to continue development in the USA near a potential customer. Hoya purchased a facility from Ampex in 1986. Ampex had produced media with plating in this factory. We didn't have any interest in their plating equipment, but we could obtain the ZV-1200 as a production sputtering machine, and much of their testing equipment. Hoya established HEC (Hoya Electronics Corporation) there. In HEC we tried several ways to solve the stiction problem, such as, mechanical texture, sputtered texture and so on. These developments were carried out collaboratively with colleagues in Nagasaka. Although we did not achieve a good process to avoid stiction reproducibly, during these developments there were many important findings made. At last, we were able to solve the stiction problem with the SX-Coat (colloidal silica coating). The basic idea of the SX coat came from Nagasaka. HEC engineers refined it to become a stable process technology. Then we were able to get into the media market for HDD.

Bajorek: Who made the ZV-1200 machine?

Suzuki: Leybold

Bajorek: Glass is very fragile. Chemically strengthened glass is stronger. How difficult was it to persuade hard disk drive makers to use glass media to achieve shock robustness?

Suzuki: Yes, everybody knows that glass is hard but fragile. We prepared many data showing the toughness of chemically strengthened glass. We prepared testing equipment for dropping glass repeatedly onto the floor. We demonstrated it in exhibitions like Diskcon 1989, and others. However, no one worried about it after Toshiba succeeded in the 2.5 inch drive market. This is my feeling.

Bajorek: Why did Hoya select the pressed glass manufacturing method for the substrates?

Suzuki: Molding glass is one of Hoya's core technologies. This was applied for glassware and lens material for cameras as Hoya's products. Hoya had already developed a 3D production system for a lens material. 3D means direct melt, direct press, and direct anneal. This system is very suitable for many types of glass production in one line. If the volume required is limited, this system works very effectively. On the other hand, the float process needs extremely huge volume. For a small quantity product, the float process does not work effectively and economically. Moreover floated glass cannot be applied for just any type of glass. Glass composition is limited to apply this process. This is why we selected a pressed process for our glass material production.

Bajorek: Did Hoya evaluate other glass manufacturing methods, such as down-drawn glass?

Suzuki: Yes, we tried the fusion method. Substrates for display panels are produced with this fusion method. At that time, Hoya had a joint venture company with NSG, for the production of display substrates by the fusion process. However, we gave up using this process for disk substrate because the flatness was not good enough. The cost was also getting higher to improve the flatness.

Bajorek: Who were the key individuals responsible for implementing this strategy and plan?

Suzuki: Mr. Uchiya who was an executive on Hoya’s Board of Directors in Japan, and the president of HEC. He decided to start the media development and move the development activity to the USA. Under his leadership, we could continue media development.

Bajorek: Did Hoya start by supplying substrates or did it start by supplying media for the hard disk drive market?

Suzuki: Media was first, we intended to enter in the HDD market with media from the beginning. When we started development of media, we didn't need any development for substrates. We had enough experience for the disk-shaped product, like optical disks. However, we could not expect any customers for glass substrates in the HDD market at that time. We had to prove better media performance with glass substrate at first.

Bajorek: Who were the main customers for both media and later glass substrates in the early days of the business?

Suzuki: The first actual customer of Hoya media was Toshiba. We had supplied media samples to some HDD manufacturers such as Areal Technology and so on. The actual start of our business in the HDD market was with Toshiba, in 1991. Then IBM, followed. Seagate and Fujitsu tried to use Hoya media. IBM was the first customer for substrates, we started supplying substrates to IBM from 1994.

Bajorek: What were the first HDD products that used Hoya media and Hoya substrates?

Suzuki: The first HDD that used Hoya media was Toshiba's 43 megabyte, 2.5 inch drive with one platter. The model name was M-40. The first HDD that used Hoya substrate was IBM's Wakasa, 2.5 inch drive which shipped in 1994.

Bajorek: Hoya's early media used a colloidal silica overcoat, you call it the SX process. Was it successful?

Suzuki: Yes. It showed excellent performance. We named this silica overcoat layer as ‘SX coat’. The layer was formed by sol-gel process with particles of colloidal silica. The magnetic layer should be sputtered first on the smooth surface of glass substrate. The overcoat layer should have proper roughness to avoid stiction with the head. This was our concept of SX coat, without this technology I think Hoya could not get into the HDD market.

Bajorek: Could you tell us how each of the product lines, substrates and media evolved over time? And what percentage of each product made up Hoya's business?

Suzuki: In the substrate process, basically we continued to use the same type of equipment. On the other hand we changed materials and operating conditions used in each step of the process. For example, the polishing slurry, polishing pad, and chemical solutions for washing were adjusted in order to meet customer's requirements. We tried to modify something on the production equipment at times, especially when we expanded a production capacity or setup a new factory. After confirming the effectiveness of such modifications in the new line, these modifications would be applied to equipment in existing production lines gradually. For media process we had to change the type of sputter machine in order to meet customer requirements on quality, performance and cost. We started our media process with the ZV-1200 sputtering machine. We changed it to A400, M12 and finally Anelva. These changes and/or modifications in both processes were usually done during the qualification for the next generation product.

Bajorek: Hoya developed a special relationship with IBM for substrates and media. Could you describe how this came about, and what its key aspects were and how it affected Hoya's business?

Suzuki: That was a top-down decision. I suppose top management of Hoya worried we did not have a wide technical base, and enough knowledge of the media and substrate business in the HDD market. That was their concern for the future of MD business. Then they wished to establish a special relationship with IBM in order to compensate for our weakness, because IBM was a giant in the HDD industry. This is my suspicion, and I think this was a good decision that we could develop a stable business relationship with IBM.

Bajorek: Who were Hoya's main competitors in this business during the early days and now?

Suzuki: NSG (Nippon Sheet Glass) started a media development at almost the same time Hoya started. Maxtor pushed them also. NSG and Konica-Minolta have gone out of the business already. Ohara stopped their supply of crystallized glass material. Then only Asahi remains as a competitor for Hoya in the glass substrate market.

Bajorek: When did Hoya purchase NSG's glass substrate and media business?

Suzuki: In 2004 Hoya assimilated NSG's glass substrate activity for the HDD application.

Bajorek: What were some of the challenges of integrating these two businesses?

Suzuki: NSG had established good discipline to control their local employees. We were able to understand their process very quickly after the transfer, and we continued to use NSG material in their factory. This integration was done relatively smoothly. However, we had to change and/or modify some parts of their process to Hoya's style, in order to improve their productivity and profitability. In order to improve their quality, we introduced Hoya's polishing machine and washing line in their process.

Bajorek: What were the glass compositions that were used and why, by both Hoya and NSG?

Suzuki: Hoya's material N5 is the alumino-silicate glass, especially designed for chemical strengthening. N5 has no alkaline earth materials. This glass can achieve a deeper and highly stressed compressive layer on the surface. NSG's material is also alumino-silicate, but contains alkaline earth oxides. I suppose NSG’s glass composition was designed to meet requirements for the float glass process.

Bajorek: What were the sizes of both the substrates and the media that have been produced?

Suzuki: The sizes were 1.0 inch, 2.5 inch, and 3.5 inch. Hoya produced mainly 2.5 inch for both substrate and media. One inch was mostly for media, and 3.5 inch mostly for substrates. Other sizes, like 0.85 inch and 1.8 inch plus 54 millimeter sizes were produced in very limited volumes. When we started media development in 1984 the size was 5.25 inch (130 mm).

Bajorek: How were the substrates and media developed? What were some of the challenges faced by R&D? By manufacturing? How were some of the problems solved? Can you give us some examples in those areas?

Suzuki: For the substrate, in the early stage after starting a business in HDD market, we didn't know that waviness and edge shape were important quality parameters for substrates. We understood that these qualities should be important to keep stable flying of the head on the media. Fortunately, we had enough experience to reduce such a waviness and ski jump. We could then meet the customer requirements at that time. However, a smoother surface, lower micro-waviness, lower defect rates and contamination are always the parameters to be improved. Technology for media was changing very rapidly. I told about SX coat already, which was a key technology for Hoya. We could enter into the HDD market with this overcoat. However, flying height reduction was progressing very fast and unexpectedly in the 1990s. We could not continue to use the SX coat, and we had to change the overcoat material from SX to usual carbon in the second half of the 1990s. Then we introduced our “NX” process to avoid stiction. This process was a combination of polishing condition, and an etching action in the cleaning process. We could obtain a roughened surface on the glass substrate with this process. The characteristics of our N5 glass were compatible with this process. However, the NX process needed a tighter process control, which was another problem for production. Then HDD technology moved to ramp load from CSS (contact start stop). That was lucky and good for Hoya.

Bajorek: Could you tell us in what form was the glass substrate sold in as blanks or in a finished form ready to coat with the thin film layers? And could you give us a sense of the mix of those products?

Suzuki: We sold nearly 100% finished substrates ready to sputter. We sold very limited volume as blanks to Toyo Kohan.

Bajorek: What were some of the challenges faced in selling the substrates with increasingly demanding defect requirements?

Suzuki: Substrates required continuous reduction of roughness, micro- and nano-waviness, and defects and contamination. These requirements became even more severe after perpendicular recording and DFH heads were introduced in the HDD market. The improvements were done mainly in the processes of polishing and cleaning. In the polishing process, we tried to optimize a type of polishing slurry and pad, as well as process conditions, first separately and then in combination. In the cleaning process, optimization of mechanical cleaning plus selection of additives and chemicals in the detergents were important. We continued these developments for polishing slurry, polishing pad and detergent chemicals collaboratively with each supplier.

Bajorek: How important was the disk cleaning process for improving the quality of the substrates? What were some of the key innovations that Hoya contributed in this area?

Suzuki: The cleaning process is very important to remove particles and organic residues attached on surfaces of the substrate during the polishing process. In this process, a certain kind of chemical would

be added for etching the glass surface slightly. This etching action with a chemical solution is very effective to remove particles, but the glass surface is also roughened by this etching action. The type of chemicals should be selected carefully. A mechanical cleaning with a scrub machine is used jointly in this process. A lot of know-how was accumulated in developing this process.

Bajorek: The users of substrates started to demand automatic optical inspection (AOI) at some point. Can you recall some of the challenges to implement this, and how was it solved?

Suzuki: We are using AOI at 100 % for final inspection in substrate production right now. Hoya used AOI at first in the substrate process for photomask blanks, from the early 1980s. This AOI was developed by Hitachi Deco. For magnetic disk we developed a fully automated substrate production line in Nagasaka, with limited volume, in the second half of 1980s. In this trial production line, we investigated introduction of AOI with Hitachi Deco. We didn't have any concern for checking a transparent disk with the AOI. Our concern was cost because AOI equipment was so expensive. Defect detectability, throughput, and stable operation rate were challenges to introduce AOI in our production. Hitachi Deco improved their system to meet our requirements. The most important benefit of introducing this system was that reliability of inspection results was improved. By this stable inspection result with AOI, we could understand properly the effects of improvement actions which were taken in our process. Then we achieved high and stable production yield in each factory.

Bajorek: Do you use an optical surface analyzer (OSA) as well?

Suzuki: Yes, yes. OSA is used practically for the DFA (defect failure analysis).

Bajorek: Where were the substrates and media manufactured?

Suzuki: Substrates were manufactured in Nagasaka, Japan, at first. Then in Thailand, the Philippines, Vietnam, and Shenzhen, China. The Shenzhen and Philippines factories have been closed. Media were manufactured in San Jose, US, at first. Then in Nagasaka and Singapore. The media activities in Hoya were transferred to WD in 2010.

Bajorek: How did Hoya organize this business in Japan, in Singapore and in Thailand?

Suzuki: The MD Division was originally headquartered in Japan. At present, our Headquarters for the MD Division is in Vietnam.

Bajorek: Which were the principal operations and locations for R&D?

Suzuki: R&D for the substrate process, was done in Japan, in Nagasaka and Akishima.

Bajorek: Who were Hoya's main customers, both in the past and now?

Suzuki: Originally, Toshiba, IBM, Fujitsu, Seagate, and Western Digital. Currently, Seagate, HGST, Western Digital, Showa Denko, and Fuji Denki.

Bajorek: There was a technology transition from contact start-stop, also known as CSS to ramp load/unload in the early 1990s. Did it influence the introduction and development of glass substrates? If so, how?

Suzuki: That depended on the customer. IBM adopted ramp load/unload first in the HDD market. Other HDD manufacturers continued to use CSS in their drives up to the second half of the 1990s. Then we faced the stiction problem again, as I discussed previously. In any case, this transition away from CSS was good for glass media and substrates because it made us free from the concerns of stiction.

Bajorek: Can you describe examples of the best successes as well as the worst failures?

Suzuki: After starting the business, expansion of production capacity for substrate and media was too slow. We tried to increase our production capacity in Japan and overseas, but timing was too late. Expansion speed did not meet the increasing demand from customers. We were in a panic. We could not supply the volumes required for every customer in the timeframe of middle 1990s. That was my fault. I should have asked for investment approval from top management to expand production capacity much earlier. Hoya accomplished overseas production successfully. I think that was the best for Hoya in Hoya's MD business. Especially, the Vietnam factory was very successful. We put our experience obtained in operation of the Thailand factory and installed the newest equipment in each process of the Vietnam factory. Then our Vietnam factory was able to ramp up smoothly and became the leader factory for quality, production yield, and cost. The management of MD Division was able to lead these three factories, Thailand, Philippines and Vietnam, to compete and collaborate with each other in order to improve the quality, yield and cost.

Bajorek: Could you give us a sense what is the worldwide market for glass substrate measured in units and what is Hoya's share?

Suzuki: As you know, shipping volume of HDD is decreasing year by year, so substrate shipping volume also decreased. Current shipping volume of substrates will be around 65 percent of peak volume, which was achieved in 2012. According to the newest Trend Focus forecast, Hoya’s substrate shipping volume

in first quarter of 2016 was 75 million pieces. That is 25 million parts per month. Hoya's share was 93% in the glass market, and 34% in the total disk market including aluminum substrate.

Bajorek: Did the industry ever succeed in developing alternative competitive solutions to glass substrates?

Suzuki: In the past, there were topics on new substrate materials; like composites, silicon carbide, and silicon crystal, but I did not hear of any such topics currently.

Bajorek: The media industry started to use increasingly higher temperatures for longitudinal media, reaching as high as 250 degrees centigrade. Were there special challenges to adapt the glass substrates to the higher temperatures?

Suzuki: Glass Transition Temperature (Tg), of current material is 504 degrees centigrade. Thus a glass substrate has enough heat resistance for current media process. Hoya prepared three kinds of new material for the HAMR (heat assisted magnetic recording) application, with Tg ranges from 675 to 740 degrees centigrade. These substrates are being evaluated by customers.

Bajorek: Was there any impact to glass composition or processing when the industry switched to perpendicular magnetic recording?

Suzuki: The glass type itself was the same, but the customer requirements for substrate quality was getting more severe.

Bajorek: What were the challenges of developing substrates applicable for HAMR media, and are they ready from a viewpoint of technology and manufacturability?

Suzuki: Heat resistance of substrates should be improved for the HAMR application. Hoya has already proposed three type of substrate to customers for HAMR, which were applicable to volume production. These are now being evaluated by customers.

Bajorek: What do you think was the key to Hoya's longevity and success in the substrate business?

Suzuki: I think Hoya was lucky. As I told you, we had a hard time in the early stage of our business, but we were able to expand production capacity in a timely fashion to meet market demand after that. Overseas operation was one of the important keys. We could realize low-cost and huge volume production in our overseas operations. The Vietnam factory was very successful. We were able to lead

three factories located in Thailand, the Philippines and Vietnam to compete with each other for improvement on cost, yield and quality, and at the same time, to collaborate with each other for these improvements. The quality of Hoya's substrate was good, and to keep good quality always was another key for our continuing business in HDD market.

Bajorek: How many substrates did Hoya produce since its inception as a business, and how many drives were made using Hoya substrates?

Suzuki: I'm not sure, but I guess Hoya produced more than 4 billion pieces of substrate, and these substrates were used in more than 2.5 billion units of drives.

Bajorek: What is Hoya's outlook for the future of hard disk drives as well as substrates and disks?

Suzuki: The market environment for HDD is changing, the notebook and PC market are shrinking. On the other hand, high storage capacity HDDs are expected to expand because data that will need to be stored is predicted to increase explosively in the future. The HDD industry will change to meet such demand change in the market. Hoya is ready to contribute to such change in the HDD industry.

Bajorek: Well, this is the end of my questions. Are there any other subjects that you would like to talk about?

Suzuki: Thank you very much.

Bajorek: I want to thank you for the opportunity to be able to do this interview. And I want to congratulate you on the exceptional success that Hoya had in this business. And I'm sure it could not have happened as well without your leadership. Thank you very much.

Suzuki: Thank you very much.

END OF THE INTERVIEW

