# Oral History of Griff Resor

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**Harry Sello:** Griff, I feel as though we've known each other for a long time. I hope we'll continue to know each other for a long time.

**Griff Resor:** Thank you.

**Sello:** I like to know all the gray hairs in the business that I could find.

**Resor:** Well, you don't have to worry, Harry. There's more coming every day.

**Sello:** If it's okay with you, I will scatter shoot to a number of the questions which I think we should talk about, those things that I said to you, a short list, and I think we can think of a lot more. I'd like to know more about how did you get started in this crazy semiconductor equipment business? Please tell us about that.

**Resor:** Well, I was originally going to go to Nigeria in the Peace Corps when I got out of Yale and I fell in love with a young—

<crew talk>

**Sello:** Tell us about your background, not as far back as birth--

**Resor:** Yeah.

**Sello:** --but how you got into the technical equipment for semiconductors business.

**Resor:** So I got into the semiconductor business sort of by accident, not completely. My undergraduate degree's in physics so I've been curious about systems and technology for a long time, but I was going to go to Nigeria in the Peace Corps and I fell in love with a young woman from Smith College and decided I'd better hang around. And if you know Massachusetts, Smith's not too far from Boston. It's actually further than I thought at the time but- so I settled in Boston and I got a job with a company that built opto-mechanical machinery for measuring properties in the air.

**Sello:** Are you officially trained as a physicist or an engineer or how does that fit--

**Resor:** I'd say physics, yeah. I actually went to college to be an engineer and found it too narrow, too constraining, and decided- so I switched to physics. I probably would have been a mechanical or civic-civil engineer when I went in but I'm just interested in more things, and Yale College is a liberal arts kind of background so I'm not sure you graduate with a bachelor's from Yale really equipped to do much of anything specific—

  

**Sello:** Yalies might not like to hear that.

**Resor:** Yeah.

**Sello:** Did you have any kind of a teacher who was your inspiration that caused you to go in your direction or was that your own--

**Resor:** Well, yeah, I'm kind of getting to that. So the key teacher was at Harvard Business School so there I am in the Boston area working in opto-mechanical machinery, ran into some friends who were attending Harvard Business School, and I have to tell you growing up as a physicist, business was the furthest thing from my mind but it sounded interesting. And so I went to Harvard and in my second year I had a professor called George Doriot and he taught-- Doriot, a French name, and he taught a course called manufacturing and he taught us a lot of practical things about business and he would bring in key speakers including Ken Olsen from DEC and a guy who had founded one of the first conglomerates and some of his connections were from the Manhattan Project. So it was a fascinating course and we had to do a study of a local Boston company, and so I found several companies and picked this one called the David W. Mann Company as a company to study.

**Sello:** Repeat that so it comes out loud and clear.

**Resor:** So we had to study a Boston company and I picked the David W. Mann Company as a company for us to study. We were a little team of students at Harvard.

**Sello:** Is Burton Wheeler tied into that or--

**Resor:** Burt was the general manager of that company. They were already a division of GCA but the world mostly didn't know that yet, and so we went out and picked a problem that they had. That was what we were supposed to do for this course, and in the process I discovered this- the transistor really at that point. Integrated circuits were just being talked about.

**Sello:** Tack a year onto this.

**Resor:** That was in 1965, the fall of '65, so they were already serving that market. The David W. Mann Company's original market was precision machinery for measuring aerial photographs and star plates that were the key to making accurate maps.

**Sello:** Do you think that might have had any connection with Sherman Fairchild and aerial cameras and Sherman was one of the big benefactors of the original Fairchild semiconductor?

**Resor:** Yeah, there was definitely a connection. They knew each other I'm sure because the- one of the things that the Mann Company had as a capability was down in a sort of vibration isolated room underground which was called the glass lab. They could make very special rulings. Many people have seen a picture through a submarine periscope and you'll see little rulings in there for aiming things or a fancy gun site, and if you look at a aerial camera photograph-- The ones I saw came from the moon but most of them were taken from airplanes on the earth. There's a focal plane plate in that camera that has little cross marks on it and the film changes its shape during development and those cross marks provide a local reference and improve the accuracy which you can measure the developed film. And so they were building those for people who built aerial cameras in the mapping business and Fairchild was one of those companies in Long Island, not in the Bay Area.

**Sello:** That's my recollection as well that Fairchild started out here because we knew Sherman Fairchild. He was our benefactor at Fairchild and he lived in Long Island and we didn't want to move out there so we started out here, thank goodness.

**Resor:** That's what I heard. Yeah, I guess we could say he was maybe one of the early venture capitalists.

**Sello:** That's right.

**Resor:** And actually my professor at Harvard, George Doriot, was on the board- one of the founders of American Research and Development, which was one of the first venture companies in the Boston area.

**Sello:** How did that lead into—

<crew talk>

**Sello:** We were talking about your early professional history, Griff, so please continue this Harry Sello asking you questions and you are--

**Resor:** I'm Griff Resor and--

**Sello:** Where did you come from?

**Resor:** I live in the Boston area now and I grew up in Cincinnati, Ohio.

**Sello:** All the time you've been in this technical business you lived out there.

**Resor:** That's right. Yeah, I went east for college, Yale University, got my bachelor's degree in physics, and stayed in that area.

**Sello:** Where your family was you stayed.

**Resor:** Well, my parents were still in Cincinnati. Yeah.

**Sello:** That's not too far from Boston.

**Resor:** So-- No. It's a 16-hour drive nonstop.

**Sello:** In that same vein, my story is not quite the same. I was brought up and educated in Chicago, Illinois, a city which has gotten to be known very well in recent years, not always with the best of intentions or history--

**Resor:** Yeah.

**Sello:** --but early in my career I had a chance to come out to what we now call Silicon Valley and once I had tasted that I never left. I still have family back in Chicago. I am out here and thus it shall remain because they are strict Chicagoans, Harry Sello, Chicagoan, now Silicon Valley. Anyway, your early professional years were sort of a transition kind of thing from academic orientation or scientific--

**Resor:** Yeah, I'd say I graduated not really knowing what I wanted to do but business wasn't on the list, and by- as I said I fell in love with a young woman who was still at Smith College and so that caused me to have to settle down and find a real job, and that job was in opto-mechanical machinery and that's how I really got interested in mechanics and optics and detecting chemicals and particles in the air used some of my physics, not just optics. And so I learned there that I was interested in a broad range of subjects and that's probably why I went into physics.

**Sello:** Did you have to change your emphasis in seeking work compared to what you thought you would be doing when you went to school?

**Resor:** Well, I don't know that I thought that far ahead but definitely the answer is yes. I had to focus on a real job and settle down and figure out what I liked to do, and as I mentioned then I met some of my friends from college and they were already at the Harvard Business School. And listening to them it sounded like a really good training and I was working in a small company in the Boston area and I could already see that understanding how business really worked was important, that it was easy to screw it up and not easy to get it right.

**Sello:** That sounds pretty lucky because it seems to me the business area is pretty far away from what you learned pedagogically in schools. Nobody teaches business or marketing even at Yale at that level I presume.

  

**Resor:** Yeah. Yale didn't even have a business school at that time. Yeah. Well, I was so unsure about what I was going to do that I told my wife to be that well, I would apply to Harvard and if I got in then maybe business was the right thing for me to do and if I didn't get in I'd have to think it over. So I didn't apply anywhere else and I got in and the rest is history.

**Sello:** But still you're not once the ivy league, always the ivy league. Right?

**Resor:** Well, I'll tell you dividing your allegiance between Yale and Harvard's tough but living in Cambridge it's pretty clear which side you have to be on and—

**Sello:** Is Wellesley near there somewhere?

**Resor:** Oh, yeah, yeah. So—

**Sello:** No connection with that.

**Resor:** Not really. No. Before my wife I had a connection with Bryn Mawr. That's a long way away.

**Sello:** I'm not going to pursue this--

**Resor:** Yeah, we should leave that alone.

**Sello:** --too far because we've taken it as far as we need to go as they say. In any case, what was critical to you about your early professional years as you got started in this mysterious scientific business so called?

**Resor:** Well, I think in some of our pre discussions, Harry, maybe you've picked on one thing that was interesting. Now that I'm explaining it to you, I realize I was trying to discover myself and I had a technical interest and I had a business interest, and probably from that time on I've always looked for both opportunities. There's one other ingredient that shaped my life and that's my junior year at Yale I went on tour of Latin America with the glee club and went through from Mexico all the way down to Argentina and back, and so I had a third thing I knew I wanted to do with my life and that was be in a business or be in an area that had a international component. And certainly semiconductors have met that goal.

**Sello:** That's certainly true--

**Resor:** So I really had three interests, technology, business and international. It all came together in the semiconductor business.

  

**Sello:** That of course is interesting from my side because in school it's academic learning is very important. You need to know math, physics and chemistry and all that but putting it all together doesn't occur in school. It occurs outside.

**Resor:** Yeah. Yeah.

**Sello:** Is that what you would perhaps recommend in some of your advice to other gray hairs in the business?

**Resor:** Well, what I tell young people is you probably won't know exactly but try things, be experimental, 'cause that's how quickly to learn so in your summer jobs between -- I also recommend it to all my kids: Get a master's degree or a Ph.D. but work a little while, so you get some sense of what the world is like. So I think figuring out what to do with your life for most people is experimental. Very few people get there by deduction.

**Sello:** It's interesting that you recommend going for a master's degree or a Ph.D. yet you yourself didn't feel the need of that.

**Resor:** Well, I didn't when I graduated but then I went back and got my master's in business. Yeah.

**Sello:** That answers the question.

**Resor:** Yeah.

**Sello:** You did feel the need of it.

**Resor:** Yeah.

**Sello:** Your early professional years-- How did that transition occur and where did it occur?

**Resor:** Well, I took the job at the David Mann Company really as a technical person so I filled more of an engineering role and I started looking at some of the manufacturing processes. Their machinery really was designed to measure aerial photographs and some really sophisticated stuff they could pull out of satellite pictures and there were some of that around and pictures taken from airplanes, and that got me a good understanding of some of their key technology and how the systems work and how their manufacturing process worked.

**Sello:** What was your title or what was your area of responsibility?

**Resor:** I was assistant to the general manager 'cause they didn't know what to do with me <laughs> and I know a guy named Jim Gallagher, who is one of the founders of semi, was instrumental in putting me in the David Mann division. Not only had I studied it for my Harvard class but the general belief at GCA was that Burt Wheeler was an excellent manager, which he was, and so it's a good person to understudy.

**Sello:** That's the first time you've mentioned Burt Wheeler and it's almost the first time I was aware of Burt Wheeler about that time. Who was he exactly and what did he start?

**Resor:** I don't know how Burt got interested in this field. I know he went to Wentworth, which is a Boston area school that's trained some people to be very good in the mechanical field. Some of them became machinists. Some became engineers and even at the Mann Company we had sort of next generation young people that we'd hire from Wentworth 'cause they were trained in mechanical design, and so that was Burt's bent but he's a very bright guy with a lot of interests, very personable. Probably one of the reasons I joined the Mann Company was I felt he had a really good set of ethics, he was interested in a quality product, and he treated people well.

**Sello:** That's very fascinating coming from you, Griff. I learned it somewhere and I don't know quite where but I learned something about the fact that find somebody you like or you can respect or get associated with and tie yourself to them as a career approach. Would you go along with that kind of point of view?

**Resor:** I think that's very good advice, yeah. Find someone that you trust that can mentor you or at least you can just follow. It doesn't have to be that formal but it's definitely helpful. I think there must have been some studies of that because I didn't figure that out for myself. Jim Gallagher figured it out for me and I benefited from that.

**Sello:** But it didn't start necessarily way back with a high school teacher or something like that. It came later to you or did it?

**Resor:** Yeah. Yeah. Yeah, that's right.

**Sello:** The reason I say that is because I remember very fondly by talking to you a particular high school chemistry teacher who changed my life I felt.

**Resor:** The school I went to was a fairly new small school and their technology courses were not strong so I didn't have that advantage.

**Sello:** You had to do on the job training so to speak.

**Resor:** Yeah.

  

**Sello:** What was your first assignment when you went to work for David Mann Company?

**Resor:** I analyzed-- The key component in their machinery was a lead screw and my first assignment was to understand that manufacturing process—

**Sello:** Please explain--

**Resor:** What's a lead screw?

**Sello:** What's a lead screw?

**Resor:** Yeah. Well, first of all it's not a lead screw, which is what a lot of people call it.

**Sello:** It spells the same.

**Resor:** Yeah, it's spelled the same way. In a precision machine you would put a glass plate or a piece of film on this stage that you could move in one axis.

<crew talk>

**Resor:** So-- Well, I have to explain the stage first so the stage carries the film and then the stage is driven by a screw that's just a very precise thread on a very nicely ground cylinder and by turning a dial out here by hand then the screw pulls the stage along, and there's- on the wheel they had little numbers for every micron or if it was in inches it'd be--I don't know--hundredths of an inch or something like that. Yeah. And it had a microscope on it so you could look at something on the film, read the dial and then you could move the dial and that would move the screw and the stage until you got to the next point. Let's say you're trying to measure the length of a runway or something or the distance between two towns. Whatever you're trying to measure on the film, the lead screw is the key to making that measurement.

**Sello:** Is that a patented kind of thing--

**Resor:** No, it was just an art form. In fact, the David Mann Company-- David Mann was an astronomer at Harvard and the only place that the U.S. could buy these tools was in Germany from Zeiss and his vision in the 30s was that the U.S. should not be dependent on the Germans for this kind of equipment, that they should have their own supply. And so he basically figured out how to make these lead screws and it was all custom homemade machinery that he had worked out this process of making these very accurate lead screws.

**Sello:** This was your first assignment to understand this. What did you have to do with it? Did you develop it or--

**Resor:** No. They had a very well-developed process. I really had to learn the process and figure out how it could it be improved. One of the problems was that training new people how to do this took a long time. It was still sort of old world apprenticeship kind of work and so as the business grew and they needed to make more lead screws they needed more skilled people to do it. So I guess really my end objective was not so much to improve the process but make it easier to train new people.

**Sello:** How did that relate to marketing or to customers of lead screws or that equipment?

**Resor:** It didn't really relate to the marketing at all. Yeah.

**Sello:** You were not in marketing--

**Resor:** Yeah.

**Sello:** --at this point.

**Resor:** That's right. Yeah, strictly internally.

**Sello:** You were strictly a scientist/engineer.

**Resor:** Yeah. So I think what happened then next was my next project-- Burt learned from that that I could understand the exotic mechanical technology. He had created a new product for the Mann Company called a pattern generator.

**Sello:** What was that--

**Resor:** It's a pattern generator and the idea of a pattern-- The customers at the time were the mapping community, which was about two thirds of the business, and the integrated circuit business but really mask shops where you've told me you began, and so they had some machinery for the mask shop and Burt had thought up a new product for the mask shop which was called the pattern generator. And it could take data for the circuit pattern and create that artwork directly by machine. The technology it would replace was drafting boards and X-acto knives. People would take a mechanical drawing, transfer it to a rubylith cut—

**Sello:** That's a plastic sheet.

**Resor:** The plastic sheet, yeah, and so this would directly generate that artwork. And so my second project was to go get rid of about 50 microns worth of error in the pattern generator.

  

**Sello:** Error.

**Resor:** Yeah, error, yeah.

**Sello:** What's magic about 50 or any number like that?

**Resor:** Well, we knew the-- One of the problems in the integrated circuit is that the tolerances are very tight and particularly if you want to make the transistors and integrated circuits. An integrated circuit when I started had four transistors in it by the way. That's not a lot compared to today. Gordon Moore hadn't come up with Moore's Law yet.

**Sello:** That's right. Compared to three billion.

**Resor:** Yeah, so- but it still was a tight tolerance kind of job and this machine would create the artwork at maybe five or ten X the final size so it had to be a few microns of error and it wasn't close.

**Sello:** How do you relate to the customer? I'm trying to get your progression--

**Resor:** Well, I started to get more involved with customers then as we got those machines working and we started making-- It was a very popular mask product.

**Sello:** Were they expensive?

**Resor:** Well, the customers thought they were expensive.

**Sello:** They always do.

**Resor:** Yeah. Looking back on it, they weren't near as expensive as today's tools. Well, I started working with some people at Lincoln Labs 'cause—

**Sello:** Where is that?

**Resor:** Lincoln Laboratories is a research- federally funded research group at one of the local airfields at Hanscom Air Force Base and it's run by MIT so it's—

**Sello:** MIT is--

  

**Resor:** MIT Lincoln Labs, yeah. When Burt created this pattern generator we thought that the world had computer tools for designing the circuits but we found out nobody really had any such tools, and MIT Lincoln Laboratories people had those tools. They could create circuits on a computer so they were one of our early customers.

**Sello:** What was your function when you encountered a customer or a potential customer? How did that relate to what you were doing at the time?

**Resor:** 'Cause I knew this machine--it's a small company--I got to install pattern generators all over the world and now it's coming back to me, Harry, and that's really where I learned the customer side of the business. Nobody expects a Harvard MBA to walk in with a toolkit and install a machine in their mask shop. And you can learn a lot about the mask shop if you got that background and you're just in there working for a couple of weeks.

**Sello:** The mask being a key part of what your customer needs to have.

**Resor:** Yeah. It's where the integrated circuit starts. Well, it starts on the computer, a tool designing it, but when it starts to actually look like something real it's a mask.

**Sello:** --by the customers--

**Resor:** Yes.

**Sello:** --fight your way in or--

**Resor:** No, no. Yeah. The Mann Company had a great reputation so anybody from the Mann Company was welcome and they were interested in this tool so when I get to- you got a lot of idle time when you're out in the field and you get to talk to people so I really learned what mask shops looked like by installing pattern generators. And as I mentioned to you earlier, one of the places I installed a pattern generator was at Building 20 at Fairchild.

**Sello:** We'll get to that a little later. I'm very excited by that finding. Here you are in that never-never land I call it between the customer and the manufacturer and your objective I believe was to end up being able to charge the customer for one of your machines. Did you make commissions or a pat on the back? How did that work?

**Resor:** I did not make any commission. Yeah. No. The satisfaction for me was to see that it actually worked and that it would work 24/7. One of the things I learned working with MIT Lincoln Labs people was they would like to bring over a mag[netic] tape as the data came on—

**Sello:** Which--

  

**Resor:** On a magnetic tape. Some came on paper tape. These machines' primary input was punched holes in paper tape so- but at the Lincoln—

**Sello:** Very much like some of the early computers were run--

**Resor:** Yeah. Yeah. We were using digital equipment PDP-8'S and the primary input was paper tape.

**Sello:** PDP-8-- That's a name of one of their computers.

**Resor:** Yeah. Yeah, it was about a little box like that.

**Sello:** --developed something, PDP. I never--

**Resor:** Oh, I used to know. I don't remember.

**Sello:** It's one of their typical mini computers--

**Resor:** Right. So Lincoln Labs guys would bring over the tapes and we'd put them on the machine and the machine had to run, and I have to tell you and some days it didn't and so I tracked down what was going wrong and I learned how to make a machine very reliable so the customer could just walk up to it, load up the data and it would just perform like that.

**Sello:** If you were giving advice to a young person starting out, would you tell him to get into that area of wealth like you did, that never-never land between customers and engineers or something, however you'd say it?

**Resor:** Well, I'll tell you it depends on your interests. You have to have a broad-- You have to be a curious person I think 'cause it's not a clear path to anywhere. Right?

**Sello:** What about this--

**Resor:** But definitely I'd recommend people get into the field.

**Sello:** What about this problem of the customer's got a problem. Why doesn't it work? How do you tackle that? You're sitting there listening to him or standing and he's saying, "Your fool machine doesn't work. Why?" Where do you go from there?

  

**Resor:** Well, usually I try and find out as much as I can from what they know. Usually, the first inquiry's a manager who doesn't know a lot so-- That's not their function so you want to find somebody who's actually got the hands-on knowledge of what they were doing.

**Sello:** Who is that usually when you find--

**Resor:** Oh, that's a process engineer in this business usually.

**Sello:** That's very nice.

**Resor:** Yeah.

**Sello:** I started as a process engineer so thank you.

**Resor:** Yeah. So they're the hands-on people if you want to get close to the original data, not work with filtered data, and higher up the management chain you go the more filtered the data so—

**Sello:** What's your next step in that gray area?

**Resor:** Well, it turns out I am a pretty intuitive troubleshooter. I can figure out-- And since I've worked on the systems I have a pretty good idea of how they work so I can take the data on the symptoms and usually pretty quickly figure out- usually one or two more experiments to run to sort of sort out it's either this or that.

**Sello:** You would run them or who would do that?

**Resor:** Well, I- it depends. Usually, the customer would do it 'cause we start out trying- in those days we'd try and service it over the phone first. We were a small business. We didn't have regional offices yet. That came later so usually the first day or so was spent trying to figure it out. Also you have to know what to send and what parts to take—

**Sello:** Listening to you, you became a working engineer having not started that way.

**Resor:** Yeah.

**Sello:** With the exception of no commissions, I suppose it was a pretty good job.

**Resor:** It was interesting. It was challenging. I got to meet a lot of interesting people. Yeah.

**Sello:** Did the boss like your performance?

**Resor:** Yeah. Yeah.

**Sello:** I presume he rewarded you accordingly.

**Resor:** I got paid well. Yeah. Yeah.

**Sello:** Would you recommend that to guys to get into even if they weren't engineers to begin with, try to learn that, or should they start from a technical engineering base?

**Resor:** Well, to do what I did you have to have a pretty good understanding of the technologies involved. What I have found too, Harry, is that in this business the people who migrated towards marketing, even sales, certainly systems engineering might become a systems architect. Most of us had a physics degree and I'm not- I don't think it's so much that we had the right knowledge from the physics degree but it reflects that we had that kind of breadth of interest that we wanted to understand multiple technologies. Certainly, to understand these systems you have to work in several disciplines. It's mechanics, it's optics, it's electrical engineering, controls. It's software.

**Sello:** There's one area that I would really like to hear your experience and your advice for the future in especially and that is where does your knowledge of how to handle the human customer come from? Here's a guy with a complaint and supposedly you're going to answer that complaint. You can do the technical things but how do you communicate with him?

**Resor:** That's a very good question. I don't know exactly where I learned how to deal with people, and of course you run into all kinds. My favorite story was a guy named Maurice Bach at TI, ran their mask shop—

**Sello:** Say that again.

**Resor:** Maurice Bach.[ph?]

**Sello:** Bach?

**Resor:** Yeah. I don't know how you spell it. He was known as the Mad Dutchman and so I was prepared but he called me in one day and he said, "What do you mean my engineers can't open that machine up?" And I said, "Well, it doesn't say that. It just says if they do the warranty's void," and he says, "Well, that's what I said. Why can't I open that machine up?" and I said, "Because there's a lot of delicate stuff in there that's real easy to screw it up and you really want somebody from our company to come down and do it and so it's your choice." He says, "It's my machine. I own it. Why can't I do whatever I want with it?" I said, "Well, you're correct but I wouldn't advise it," and in the end he didn't open it up.

**Sello:** He didn't open it up.

**Resor:** Yeah. So my dad was an insurance salesman and he was good with people and I also spent nine years at a Quaker camp in Vermont.

**Sello:** At a Quaker camp?

**Resor:** Yeah.

**Sello:** Did that help your human relationships?

**Resor:** It's definitely helped me do business in Japan. I've had this discussion with another guy. The Quaker method is consensus based decision making. It's not the command and control and it's a very good way of discerning what's really needed to be done and getting the whole group on board, and I find that a lot of Japanese management's similar. And you sit through a lot of long staff meetings so when you get to Japan you get to sit through a lot of meetings.

**Sello:** How does that affect your personality? Are you impatient, patient--

**Resor:** I'd say patient, yeah.

**Sello:** Do you think that's an essential quality for a salesperson or a customer-related person in this area?

**Resor:** Yeah. Yeah, and I- you can't put your ego in front of the customer and I've learned over time you're- if you're selling something to a customer your job is to be of service to the customer.

**Sello:** You can't tell them such things like "You don't know what you're talking about."?

**Resor:** Well, I've made that mistake but yeah. <laughs> Yeah. Well, actually it- was training a young Japanese engineer and I- he wanted me to explain-- I forget exactly what it was but basically a pipeline kind of control system, and his background was in washing machine controls with microswitch controllers so I just- I—

**Sello:** Washing machine controls.

**Resor:** Yeah. I made a mistake of telling him that he didn't have the training to understand the answer to the question he'd asked. I should never have said that.

  

**Sello:** What happened?

**Resor:** Well, typical Japanese fashion the meeting was broken up quietly and people went out and settled him down and then came back the next day and told me I'd made a mistake.

**Sello:** Did you see he was offended?

**Resor:** Oh, yeah. Yeah. I'd worked with Japanese long enough to know I'd done the wrong thing.

**Sello:** How did you get around that obstacle with that guy?

**Resor:** I'm not sure I ever really did patch that over. That was not the right thing to say even though I still believe it was the truth.

**Sello:** Did you--

**Resor:** Caused him to lose face and I shouldn't have done that.

**Sello:** Did you learn from that experience how to handle American or European customers as well or was that different?

**Resor:** Well, what I've learned is to pay attention to sort of the style of the customer that I'm working with and then adjust so that-- Some people you can't be subtle; you got to be blunt.

**Sello:** That kind of goes against what you did what that Japanese engineer. You were pretty blunt.

**Resor:** Right. Right. That was a mistake. Blunt in Japan still doesn't go. Yeah.

**Sello:** It might have worked someplace else.

**Resor:** Korea I think you can be a little more direct.

**Sello:** Maybe in Germany you could be more blunt.

**Resor:** Right. Yeah.

**Sello:** Where did David Mann and that technology go after wafer steppers or--

  

**Resor:** Well, wafer steppers came after pattern generators.

**Sello:** After pattern--

**Resor:** Yeah. We were at that point still serving those two markets, mapping and the mask shop, and I had put the Hewlett-Packard interferometers onto the stage. We did a new model- new design for the mask stepper that you created for the masks and we've showed it out here at the Hall of Flowers.

**Sello:** Did you invent that thing or was it--

**Resor:** This was an improved mask stepper.

**Sello:** Or modification.

**Resor:** Yeah. So it was more evolutionary. It was designed to make masks for if I remember right five or six-inch wafers. I forget which.

**Sello:** In going through these various new things, was there some training on the job involved? Was that formal or did you have to like a sponge learn it on your own or how did that work?

**Resor:** I'd say I had to learn it on my own. Yeah. I had to figure out how the interferometer worked, how to put it on the machine.

**Sello:** Wasn't there anybody at this company who you could go to?

**Resor:** Well, Hewlett-Packard was helpful. They had an applications engineer.

**Sello:** They were a customer.

**Resor:** They were a supplier.

**Sello:** They were a supplier. I see.

**Resor:** Well, and they were a customer. You're right but in this case they were a supplier.

**Sello:** You could learn from them?

**Resor:** Yeah. Yeah.

**Sello:** I've heard a lot from my end of this kind of business that you learn information from customers, from one customer what another customer is doing so you're in a funny land of danger of revealing business or technical secrets. Is that a problem?

**Resor:** Well, that's definitely a challenge, yeah. You can't cross-pollinate technology that belongs to one company to the other. That's one of the- one of your customers' big fears as an equipment supplier so you learn to be very partitioned in your mind and remember where you learn things and who you can talk to about what.

**Sello:** Which secrets you keep or you don't keep.

**Resor:** Yeah. Well, you basically keep a different file of secrets for each customer.

**Sello:** Would you say the customer plays a role in the development of this kind of equipment?

**Resor:** Yeah. In fact, I think there's a key point we should touch on. When I first got into the equipment business a lot of companies were building their own machinery. You've told me that Fairchild was building a stepper. TI was building a stepper for wafers. IBM had their own pattern generator. We talked early—

**Sello:** <inaudible>

**Resor:** Yeah. We talked earlier about a guy named Art Lasch. Before that IBM was building their own resist processing tools and one of the things I saw growing up in this industry that I think's important for other industries. It's that when we started serving each of these companies and we started to exceed really the capability of the internal team what we learned from all those different customers which we didn't have to cross-pollinate but we had to bring home was we learned how to build a machine that would do all the jobs and do it reliably. The in-house guys never--at especiall IBM--never got to look at what TI was doing or Fairchild was doing or NEC was doing.

**Sello:** --information problems.

**Resor:** They're in their own little silo so one of the big advantages of having the equipment company be part of the infrastructure as opposed to part of the captive integrated company is the- I think you get better equipment because we're certainly challenged to design equipment that meets everybody's needs and does it reliably, and we learned from 20, 30 customers what's needed, not from one customer.

**Sello:** Interesting point. Is any of this taught anyplace, not even in the great and famous Harvard Business School or something like this?

  

**Resor:** Well, they did a case on my company at one point but I don't- not that I'm aware of. I don't think it's taught. I'm not even sure it's studied. I teach my clients. Now I've been consulting for about 13 years and one of the things I do for them is try and help them understand what advantages they have, what they need to be doing with customers, and how to design their machinery so it's better.

**Sello:** You have to teach your user things about how to design what he's using.

**Resor:** Yeah.

**Sello:** You have no problem with that.

**Resor:** I don't. Should I?

**Sello:** <inaudible>

**Resor:** Yeah. One of the other things I started learning maybe from the mask business but really once we got into wafer steppers-- A lot of wafers were originally manufactured by sort of shadow printings called contact printing and proximity printing. It was a one-to-one process so the mask geometries were the same size they're going to be on the wafer. Perkin-Elmer converted people to projection and it turns out for projection we really wanted different photoresist. We needed a positive photoresist and we needed one that would work in oxygen, in air, 'cause all our systems were in the air, and contact printing was a negative resist that—

**Sello:** Explain a sentence or two about contact printing. Isn't that just developing a photograph of your own?

**Resor:** Yeah. Yeah. You have a mask which has a picture of one of the layers of the circuit.

**Sello:** The mask is the picture.

**Resor:** The mask is the picture and then you put it on top of the wafer which has got a photographic sensitive film on it called resist and the contact printer has a light bulb and a shutter. When you open the shutter the light transfers the image into the film and then you shut the shutter—

**Sello:** --little--

**Resor:** --take the mask away- actually you take the wafer away, and you develop that image and then you can create what you need to create on that layer. You might etch away some metal or you might make a hole, whatever needs to be done on that layer.

  

**Sello:** As a side issue I think but related to that in an area that you've gotten in which I think is fascinating is the light that you use to expose has to go through a lens.

**Resor:** Yeah. So—

**Sello:** What's the function of the lens and what's good and bad about it?

**Resor:** Well, what's good about it that we came to realize with wafer steppers is it only has a certain amount of information processing capability. It's got a limited resolution. From the customer's point of view, that was always a problem but what we found right away was a lot of defects that are on masks which would print in contact printing can't be transmitted by the lens, and so wafer yields went up from 20% to today they're in the high 90s and the lens made that possible because it filters out a lot of defects that are on the masks.

**Sello:** I shouldn't blame my bad printing of photographs on the lens of the camera.

**Resor:** No. You could. Yeah. Yeah. The lens-- So the bad news was particularly the early lenses they weren't very good and they not only didn't transmit the defects; they sort of screwed up the stuff you did want, and so when I got to the David Mann Company we were using microscope objectives from Bausch and Lomb and were high-grading them. Basically, they would let us buy a whole bunch, sort through, find the best ones and return the other stuff, but as the volume grew that's no good way to run a supply chain and their process wasn't in that good control so there'd be some batches that were no lenses we could use. So then the Mann Company turned to Nikon and I don't know this for sure, Harry, but I think the Nikon lenses were 35 millimeter camera lenses. Nobody was talking about custom designed lenses yet and the Nikon lenses were much better and they weren't designed for a microscope; they were designed for a bigger field.

**Sello:** Let's shift because of that interest to an area which was very critical in your experience time and my experience time and that is the area of competition from Japan. In your area, which was the background of David Mann cameras as you explained, lenses were needed and more equipment of that sort was needed. Could you say a few words about competition from Japan who were trying to make the same equipment to sell to your customers?

**Resor:** Well, at the point that the David Mann Company started using Nikon lenses Japan wasn't competing yet.

**Sello:** That was before--

**Resor:** That predates that. I think they probably got interested as a result of building the lenses for David Mann, and you first asked me earlier to explain a little bit about some of the lenses. One of the problems-- And I think this is important. We didn't learn everything at once. Right. You're on a learning curve and as you change applications you get a new steep learning curve. Nikon built us a lens and they used to have six of them in one machine so it's important that they behave pretty much the same way, all six of them.

**Sello:** They'd be matched so--

**Resor:** Yeah, they'd be matched, exactly, and so we discovered that if we changed the focus a very few microns we could change the size of the image significantly, way out of tolerance, and that's when we realized that we need a lens that's what today they call telecentric. The primary rays are all perpendicular to the wafer surface.

**Sello:** Say that word again so we get--

**Resor:** Telecentric.

**Sello:** Telecentric.

**Resor:** Yeah, and so the modern lenses, the imaging side, all the primary rays are normal to the surface and that allows you to go up and down a little bit in the depth of focus and because the rays are perpendicular-- Well, it's- if it's at an angle and you go up and down you can see it's going to move.

**Sello:** And you--

**Resor:** Yeah, and so it needs to be perpendicular so as the wafer goes up and down the image doesn't move. What I don't know is the people who were managing the relationship-- And we had a very good relationship with Nikon.

**Sello:** With Nikon?

**Resor:** With Nikon through a distributor in New York but also right back to the factory. Why we didn't take that problem back to them and say, "This lens is not acceptable;--excuse me--we need some kind of different design—" Burt and Howard Lovering went to Zeiss and Zeiss—

**Sello:** That is the German manufacturer.

**Resor:** In Oberkochen, Germany. At this point East and West Germany are still split so Yane[ph?] is off limits and got another lens. Maybe Zeiss already had talked to somebody about the telecentric lens. That might make sense. Anyway, Zeiss was interested. They created a lens that had this property of being telecentric and it was a much better lens for making masks. That left Nikon with no business.

  

**Sello:** How did they learn that it had to be telecentric?

**Resor:** I don't know that part of the story. I learned it from this experience. Yeah.

**Sello:** But they learned it.

**Resor:** Yeah. So then Nikon was interested in building machinery and they fixed their problem with the lens design of course, and about the same time the nation of Japan took an interest in getting into integrated circuits and they had a VLSI program in the late seventies this is and they sponsored a lot of research and they put Nikon into the stepper business and they put- and Canon chose the proximity printer business.

**Sello:** Let's say quickly for the observer VLSI means very large silicon integration.

**Resor:** I thought it was very large-scale integration but yes.

**Sello:** There is the equipment side--

**Resor:** Yeah. Yeah, and they used to say in Japan that integrated circuits are going to be the rice of industry and- the rice of industry.

**Sello:** Jerry Sanders, the founder of AMD, once said that Silicon is the oil of our industry so the Japanese naturally had to follow with something else--

**Resor:** Well, and if you understand the Japanese diet rice is the key staple and it's- everybody has it. Everybody's dependent on it so their image was their industry was going to be totally dependent on this. They didn't want to be importing—

**Sello:** Didn't this compete with your business directly?

**Resor:** Oh, yeah.

**Sello:** Did you lose business as a result of it?

**Resor:** We didn't seem to lose business in the mask segment but by now we'd started moving into the wafer segment and we definitely lost a market share over the years.

**Sello:** Of wafer steppers?

  

**Resor:** Wafer steppers, yeah.

**Sello:** Because they were in it directly.

**Resor:** So by '84, '85 Nikon is a factor in the wafer stepper business and taking market share in Japan first. The rest of the world—

**Sello:** Were they good at it?

**Resor:** They were good at it. They had a learning curve. The early machines didn't work 24/7 but they're persistent and they had good supportive customers.

**Sello:** That brings us into a lot of areas but that brings us into the area of how the semiconductor people and their needs for equipment related to the competition from Japan and in this was born the organization called Sematech.

**Resor:** Yes. Yeah.

**Sello:** What was your understanding of how this all worked relative to equipment?

**Resor:** Well, at first I was very skeptical 'cause it looked like another layer of bureaucracy in the marketplace.

**Sello:** Sematech.

**Resor:** Sematech, yeah.

**Sello:** Sematech-- How do we parse that? Semiconductor technology or--

**Resor:** I don't know, Harry. Yeah. Yeah.

**Sello:** I know "Sem" is for semiconductor, "tech" is for technology, so Sematech is the word.

**Resor:** Yeah. Well, I think the original concept was that the equipment users would get together and do a road map and decide what they would need and that was going to help the U.S. infrastructure.

**Sello:** This was the organization that I feel obligated to say was organized and led by Dr. Robert Noyce of Fairchild Semiconductor and Intel.

  

**Resor:** Yeah.

**Sello:** Thank you, Griff.

**Resor:** Yeah.

**Sello:** Go ahead, please.

**Resor:** Yeah. So when I've come to learn over the years is that that road mapping process really worked well and it allowed a lot of people, particularly government agencies and universities, to focus their energies on the identified challenges. And I think the fact that for so many years now, 30, 40 years, we've been able to make Moore's Law happen over and over and over is that that road mapping process that Sematech pioneered--I think they pioneered it--really does work.

**Sello:** In your business of equipment, it kept American equipment manufacturers alive--

**Resor:** Some. Yeah, that was- I think that was more of a hope than a reality. I would tell you part of the GCA story was we went from building one machine a month to one a day. We went from 300 people to 3000 in three years and we ran out of management. We lost the process so part of the story isn't just that Japan got organized and made a very deliberate effort and used their home market to get them launched but at the same time our effort wasn't firing on all cylinders. We didn't do a good job building the tools so we were disappointing our customers. I think it would have turned out differently perhaps even at Sematech. By that time I had left GCA, started my own company, but Sematech tried to rescue that GCA and it didn't- in the end it didn't work.

**Sello:** To your knowledge, did they rescue any other of the equipment manufacturing people?

**Resor:** I don't really know. Yeah. What I can see is how it's benefited the whole industry over time.

**Sello:** It did return--

**Resor:** They went international after--what?--about eight or ten years?

**Sello:** I see, but in your recollection it did return some business back to manufacturers in the United States that weren't there before?

**Resor:** Well, certainly the suppliers that still were well respected by their customers and worked with Sematech continued to have good business but they really had- really have to-- That became an international business so you can't just focus on winning in the U.S. so even the equipment suppliers had to do well in Japan and Korea and Taiwan, Europe or you lose out to somebody in those territories that does a better job.

**Sello:** Initially, it did something but it still depended on successful competition among all companies.

**Resor:** Yeah. So maybe that's why I've changed my mind on my view of Sematech. It isn't that they saved the U.S. industry. What they've done is they've maybe made the integrated circuit industry really happen. They've made Moore's Law happen year after year after year and that's what we've learned is that the markets are elastic. If you can build a transistor cheaper and cheaper and cheaper, they show up everywhere. Think about how many computers there are in our lives these days.

**Sello:** In your experience, how did computers play a role in the work you were doing or responsible for?

**Resor:** Well, one of the things I'm thankful for-- You were kind of asking me how did I acquire the knowledge to do what I do. I didn't learn anything about computers in college.

**Sello:** Not even Yale?

**Resor:** No. They didn't have even one to run payroll. I don't know how they did payroll. It wasn't my province but-- So the pattern generator project that I told you about was controlled with a digital equipment computer and I learned to program and I learned how a computer runs a machine, and so I basically grew up with computers as a machine- a form of machine control and an interface.

**Sello:** Any particular computer come to mind or--

**Resor:** Well, it was all Digital Equipment [DEC] computers.

**Sello:** You mentioned--

**Resor:** Ken Olsen?

**Sello:** Yes, Ken Olsen and the PDP-8.

**Resor:** Right.

**Sello:** Did that play a role in any of your work?

**Resor:** Oh, yeah. That's where I learned how to work with computers.

  

**Sello:** We won't go into--

**Resor:** But again, a good point you made earlier is I had to teach myself.

**Sello:** That was a significant--

**Resor:** Yes. It's a myth that your education's finished when you graduate from college.

**Sello:** That is a very profound statement.

**Resor:** Yeah. You got to—

**Sello:** Would you recommend if you were the tutor of somebody starting in your kind of business to take off and take a refresher course or take some sort of a break away from what he was doing if he could afford it and go and take a course in computer technology and come back to work?

**Resor:** I—

**Sello:** How would you handle it?

**Resor:** I think you-- Yeah. You have to keep adding to your knowledge base I think in any field and how you do it kind of depends on where you're at geographically particularly with the internet these days. I don't know that you have to stop work and go back. Certainly I didn't. Everything I did I just did evenings. You know I'm now working in the light emitting diodes field so I had a quiet month in my consulting a year ago in November. One of my clients recommended a book on LED physics and I bought it and I read it.

**Sello:** Did you have to read books on semiconductor technology?

**Resor:** Some, yeah. I've had to read books on Japanese culture.

**Sello:** That's interesting.

**Resor:** Yeah. So one of the things I would do is every time I flew to Japan, which was three or four times a year for many, many years, I would read one serious book on Japanese culture and then I would read one on-- I forget the name of it but it's a baseball Japanese style basically. It's a fun book but also on Japanese culture.

**Sello:** Did you participate in going to Japanese ballgames or--

**Resor:** I watch them on TV. Yeah.

**Sello:** Not while you were in Japan.

**Resor:** Oh, no. When I'm in Japan. Yeah. I don't think they're available on cable here but when the Boston Red Sox hired a famous Japanese pitcher a few years ago I was actually in Tokyo for the first game in Boston and it was broadcast in the middle of the night in Japan so that everybody could watch their star pitcher pitch for Boston.

**Sello:** They really were rabid about it I presume.

**Resor:** Oh, yeah, yeah. Yeah. So you've hit on a key point and that's that particularly to stay up in the technology field but the same- I know the same is true for my tax attorney. Right? You've just got to keep up to date.

**Sello:** So you get a better tax return? Is that--

**Resor:** If you have a tax expert who's not keeping up to date, you better get a new one. Right?

**Sello:** Out of all this very fascinating conversation, you've written a little bit about this. Let me repeat. What advice would you give to young scientists or engineers or red-hot students or whatever as to how they could contribute to what we all need is innovation, new developments, growing? I'm not saying your own son but somebody. If you go to a class, what would you lead them through? I've bridged that--

**Resor:** Yeah. That's a good question. Well, I think it starts-- My view is that an economy is really we're selling our skills and contribution to our fellow people, men and women, and if you're going to make a successful business out of it you have to do something that people value for a little more than it costs you to deliver it. That's really the trick.

**Sello:** Do you mean extra hours that you spend or--

**Resor:** No. So you need to look at- you need to identify a group of people you want to serve. We call them customers usually but- and then you need to figure out what it is that your skills or your group's skills can do better than other people can do that those people want. So part of my advice would be pick a group of people that you like working with that you'd like to serve in some way and then figure out how to do a good job of serving them and you'll be rewarded, and that's basically the venture capital game, people with bright ideas, a new idea—

**Sello:** There's a gap here that strikes me due to my own lack of experience, Griff, and I'd like you to address it if you can and that gap has to do with where do you learn this kind of stuff? Is this on-the-job training or is this off-job, trade school, university-type training or your own reading? How do you acquire these kind of things--

**Resor:** Well, for me it's been on-the-job training or sort of during the job, while you're flying to someplace or flying back. You got to find that moment. It's not always convenient to do it but you have to keep learning and I think it helps to be curious about what's going on.

**Sello:** The Harvard Business School has always sponsored kind of an on-the-job exposure for which they give you college credits toward advanced degrees. Is this a good way of doing it or do you have to get out and work in industry to do all of this?

**Resor:** Well, I think you could do both. I don't think you could just do the academic study but definitely some of the advanced study programs that Harvard offers for people who are in business and maybe didn't go to a business school earlier in their life. It's definitely helped me in marketing to have had that background. You just need to know how to read a financial statement. That's—

**Sello:** Economists learn how to read financial statements.

**Resor:** Yeah, but most managers don't.

**Sello:** Very interesting.

**Resor:** And part of what I learned-- A guy named Doug Marsh went off to ASML. ASML eventually took over—

**Sello:** What's ASML?

**Resor:** Well, it's a Dutch company or it was. They built wafer steppers.

**Sello:** Competitive wafer steppers?

**Resor:** They are the most advanced supplier of wafer steppers in the world today. They have taken significant market share from Nikon and Canon and they were in the game way back when. They figured out how to understand in the wafer stepper business which of the features in the machine were really worth the most amount of money to the customer, and so then they focused their R&D on it turns out to be the lens. Now if you'd asked any of us, we would have said, "Oh, yeah, the lens is important" but they figured out more nitty-gritty that if they could build a little bit better lens before everybody else then their customer could shrink the chip before anybody else. And when you could shrink the trip- chip--excuse me--you get three things. It's faster, if it's designed right use less power, and you get more on a wafer so it's cheaper so you got a better product for less money if you're the chip maker. And so ASML over the years has worked closely with their customers to figure out where really is the money and I think—

  

**Sello:** <inaudible>

**Resor:** For their customers. Yeah. Then you have to bring that back in and—

<crew talk>

**Sello:** Getting the product out so they do a lot of this kind of engineering. Is this sort of thing done in equipment making as well?

<crew talk>

**Sello:** You've explained that knowing what the competitor is doing is very vital. That's true from my experience in integrated circuits, yours in equipment, but some of it comes from trying to do what we call backwards engineering; that is you analyze what your competitor has done and then go back and try to incorporate improvements that you've noticed into your equipment, engineering it in, not necessarily copying but engineering it in. That's done in integrated circuits. Has this happened in equipment like wafer steppers or--

**Resor:** Yeah. I think it happens in all of these businesses. It may even happen in the honey and jam business for all I know but that's not my business. I know the equipment business for silicon processing. Yeah. I would tell you when I started up my own company in '85 and took the litho process into flat panels—

**Sello:** It should be lithography process.

**Resor:** --lithography process into flat panel displays I had to do reverse engineering on the flat panel process in order to figure out how to design a machine- an effective machine to move that business forward, and so I very- I'd find any technical paper. I'd go to the conferences, understand—

**Sello:** --and look at their equipment.

**Resor:** No, no. Looking at the displays.

**Sello:** The displays--

**Resor:** Yeah. What I want to work out is what really needs to be controlled in the display circuit because a lithography tool is really providing control. People think it's pictures but it's really control of the picture.

  

**Sello:** That's in the LED business. Relate that please to our main subject of integrated circuit manufacturing equipment. Did you ever buy somebody's equipment and analyze it?

**Resor:** Sematech did that but I had already left GCA at that point.

**Sello:** Sematech did this.

**Resor:** Yeah, and of course I know it goes on in Asia.

**Sello:** That's interesting. What went on in Sematech specifically that is an example of this?

**Resor:** Well, this is secondhand information, Harry, but my understanding is—

**Sello:** I'm not trying to derogate anything but--

**Resor:** My understanding is somebody bought I think a Nikon wafer stepper and took it apart to figure out what was good and what was- where were they vulnerable and that kind of thing.

**Sello:** And then tried to learn from it and--

**Resor:** Yeah. Yeah.

**Sello:** --not necessarily copy but try to learn--

**Resor:** I would say these businesses moved too fast, that particularly machinery business you can't just copy. You'll be behind the eight ball by then. Yeah. So it was more to understand where were- are they strong, where are we weak, that kind of thing; how can we improve the U.S. made product, and so then Sematech made a big investment in Tropel as a supplier of lenses.

**Sello:** --lenses.

**Resor:** Yeah. Yeah. They were one of two makers of custom lenses in the country. They're now owned by Corning.

**Sello:** What was Sematech's role in that particular--

**Resor:** They made a big investment. I don't know. It was all Sematech money but there was a big investment made.

  

**Sello:** It was money invested--

**Resor:** Well, also technology.

**Sello:** Technology.

**Resor:** The money paid for basically closing the loop on the process some lens design software, but they had a pretty good handle on that. The real weak link was in the manufacturing process and they- so they built- added metrology. One of the things when you make a big lens that you depend on is that the properties- the optical properties of that blank that you start with are basically the same all over to say one part in a million.

**Sello:** Homogeneous.

**Resor:** Yeah, homogeneous index of refraction, but they didn't really have a machine to measure that and so they built one of those. It's homemade and what- they find out the glass isn't uniform. Some is, some isn't, so you can pick and choose and you can feed that back to the glass supplier.

**Sello:** Actually--

**Resor:** And that kind of thing was done.

**Sello:** They did a good thing because information that they learned about glass they passed along to U.S. local manufacturers perhaps that could use that kind of thing because it was developed at Sematech.

**Resor:** Right. Right. Well, and they also invested in interferometers to check the surfaces and different- improved metrology for assembling the lenses so when I came back as a customer ten years later the lenses performed as designed whereas before that it was kind of hit and miss.

**Sello:** The company called Tropel, T-r-o-p-e-l--

**Resor:** Yes. Yeah.

**Sello:** --could learn this because they were members of Sematech Association and--

**Resor:** I assume they were a member. I don't know that they were a member of Sematech. I think that's the chip guys. Right?

  

**Sello:** --published material on this.

**Resor:** They were part of a Sematech program, yeah, definitely benefited, yeah.

**Sello:** Let's skip so we do cover aspects that we haven't talked about. I would like your opinion on how you felt about some of the advances that were being touted in mask making that--

**Resor:** Advances like x-ray lithography?

**Sello:** X-ray lithography, yeah. I sort of hesitate because I'm frightened of it. Who uses x-rays--

**Resor:** Well, there's probably two topics we should cover, x-ray lithography and e-beam or—

**Sello:** Please, let's do that. You lead.

**Resor:** --charged particle 'cause the ion guys always feel left out when you say "e-beam." Right? Yeah. So early on x-ray-- I had this conversation with Hank Smith at MIT Lincoln Laboratories before he became a professor at MIT and sort of has the original patents on x-ray lithography and I think this is in the late sixties. I forget when exactly. The idea was as things shrank and we needed to print smaller and smaller features we would have to change the wave length and to go from-- At that time we were at 436 nanometers, which is a g-line of mercury.

**Sello:** Light wave length.

**Resor:** Light wave length. We would have to get shorter and shorter wave lengths and if you follow the optical technology, you know that happened. We went to i-line at 365 and then at 248. Then the excimer guys created 248 with a different light bulb and then they moved to 193 and they tried to get to 157.

**Sello:** --you're using--

**Resor:** Nanometers of the wave lengths.

**Sello:** Nm's. Right?

**Resor:** Yeah, and the basic optical theory is if you've- the resolution's limited by the wave length and the other features of the optics so you- eventually you have to move the wave lengths so the early discussion was why not just go all the way to x-rays and basically be done with it. Right?

**Sello:** What would the target would be in nanometers there--

**Resor:** I forget. Today it's around 13 nanometers so- but the technology had several problems. There was no photoresist. You're an old resist guy and one of the guys at Bell Labs told me that one of the problems on these learning curves is you can't just create the resist in the chemistry lab. You have to have customers to use it like we were talking earlier about the equipment business, not one customer but a bunch of them, and so it takes years to create a batch of resist, use it, find out what worked right, what didn't, improve and drive down a learning curve. Without suppliers and customers you can't drive the learning curve. So x-ray struggled for a long time to get a decent resist but there also wasn't a strong enough source. It took a long time to print a small wafer.

**Sello:** It was very slow even if they had a good resist.

**Resor:** Yeah, which makes it not competitive economically and it also started out as a contact printing on small wafers so as wafers got bigger--I was thinking about this since we talked the other day--then the contact printing method made the mask cost really high and in the- and there has to be stencil mask, which means you need something with holes through it to transmit the x-rays, and so that really pushed the mask technology. In the meantime, we have optical steppers meeting the real needs, sucking up all the available capital, right, because it works, and they're- they were ten to one reduction, then five to one, and today four to one so the mask technology can be ten, five or four times easier 'cause the lens is going to reduce all those errors. That's another advantage of the lens I forgot to mention. All the dimensional errors get reduced by the reduction ratio. So the optical guys are driving the mask infrastructure to a whole different place than the x-ray guys need them and the x-ray guys just didn't catch on. They never hit critical mass and so they can't get the money to push the mask technology.

**Sello:** Would you say that it was limited by the slowness of development or lack of knowledge? They would be too slow even if they did work. That's what I meant.

**Resor:** Yeah, but it's not for lack of carrying your pace. What I see in these businesses-- If your idea's not- doesn't really pay off and you're out here in the noneconomic fringe, everything runs slow. You don't have enough users to drive the resist. You don't have enough interest- commercial interests to drive sources.

**Sello:** Or not enough resist--

**Resor:** Though IBM built a synchrotron, a lot of people put their x-ray machines on synchrotrons. I know from working with Sumitomo they developed a synchrotron. That was a solution to the source problem and I think the mask problem is what killed it in the end so- but then Intel resurrected it in '97.

**Sello:** How's that--

**Resor:** Intel said, "We're going to have-- We need a shorter wave length. We're going to use imaging x-ray optics, not just contact printing. It'll be a projection system" and they changed the name to EUV so it's extended ultraviolet, not x-ray because x-ray's a bad name.

**Sello:** Give me a couple of numbers. X-rays will go down to the few tens of--

**Resor:** Well, on the MIT stuff Hank worked with might even have been at two nanometers.

**Sello:** Two nanometers.

**Resor:** Yeah, 'cause it was hard x-ray.

**Sello:** And then--

**Resor:** EUVs backed up to 13.6 I think it is.

**Sello:** 13.6 - order of magnitude certainly.

**Resor:** Yeah.

<crew talk>

**Sello:** What's the wave length--

**Resor:** X-ray.

**Sello:** Yeah, of x-ray compared to the UV?

**Resor:** So I think Hank might have been working-- I forget what wave length he was working at but it might have been around two nanometers and so the- Intel said, "Let's move back up to soft x-rays but we can't call them soft x-rays 'cause it has a bad name. Nobody'll adopt it." So we call it extended ultraviolet, EUV, and that was in '97 I believe.

**Sello:** That'd be ten times the wave length.

**Resor:** Yeah. Yeah, so it'd be easier to work with.

**Sello:** Two would become twenty.

**Resor:** Yeah. Well, maybe one became thirteen but-- Yeah.

**Sello:** But it never went that way you said.

**Resor:** Well, it-- No, it's-- Actually, that's a big ongoing effort. That'll be discussed here next week in San Jose. Yeah.

**Sello:** That's right. That's in the future.

**Resor:** Yeah, and Sematech has been driving that technology now for 14 years.

**Sello:** --were all in that.

**Resor:** Yeah, and that's really what's changed my mind about Sematech. I've seen—

**Sello:** When they could do these developments.

**Resor:** Drive the whole technology development community internationally.

**Sello:** In the same way, where did the electron beams poop out or did they?

**Resor:** Well, electron beams really found their niche-- As information density went up, the opto-mechanical pattern generators took longer and longer, days and days to write a mask, and the electron beam technology could generate a good mask in a few hours at a real high resolution. So the e-beam guys, even though they've always had their target to write the wafers, ended up owning the market for the pattern generators for almost a decade and then laser scanning replaced electron beam scanning for some of the cheaper ones. So today masks are mostly made on e-beam tools and some laser tools for the less critical waves.

**Sello:** They're faster than the x-ray tools would be.

**Resor:** Well, even for x-ray you needed something to generate- you needed a pattern generator to create the first original picture.

**Sello:** But they still--

**Resor:** And that's all been done with e-beam.

**Sello:** But they couldn't reach the ultimate that x-rays could if the x-rays could reach that.

  

**Resor:** Well, today you have nanoimprint lithography, prints beautiful eight nanometer lines.

**Sello:** That's not quite ten times x-rays but it's close.

**Resor:** Yeah, and it's done with regular UV light, 365, but their masks- they're pushing the limits of mask making- e-beam mask making and again it's a 1x technology like x-ray and it's having a hard time getting adopted.

**Sello:** I think we can sort of line up on this kind of a question. That leads me to an area which bridges technology and marketing. Intel would like to have this particular extra-small geometry masks available yet Intel never went into the mask making business.

**Resor:** They have a mask shop for EUV. It's in Hillsboro.

**Sello:** They do have one.

**Resor:** Yeah.

**Sello:** They did go--

**Resor:** They went back into- or they went into the mask business.

**Sello:** When they started my ancient memory tells me that the good Dr. Moore never wanted to get into the mask making business. He wanted to get out of it and so they used local shops--

**Resor:** Yeah.

**Sello:** --even owned them. I don't know.

**Resor:** I don't think they owned them though they- of course they had- the venture group might have had a piece of it but yeah, I think Intel-- The valley had a good infrastructure of mask shops and they were state of the art customers of David W. Mann, people like Michael Mast, UltraTech. There were several others so—

**Sello:** Where you'd go and order your masks made.

**Resor:** Yeah, and you can compete and they had available capacity and they're right down the street. They were able to keep customers' secrets.

**Sello:** They had EUVs?

**Resor:** Eventually when the- when it was time for the technology, yeah.

**Sello:** What's happened to these shops? Do they still exist--

**Resor:** They all got purchased by either DuPont or Toppan.

**Sello:** Toppan being a Japanese--

**Resor:** Yeah, Toppan Printing. Yeah. Well, Dai Nippon Printing's another Japanese mask maker but there was a huge period of consolidation—

**Sello:** And they were--

**Resor:** --and a lot of them got shut down. I think part of it is that the machinery that you needed to have a state of the art mask shop got more and more expensive but you're not selling a lot more masks so it got to be a tougher and tougher business model and you just needed more customers. Also the customers went international and so they need to be able to get masks copy exact. I think Intel gets credit for coining that term. So the demands now—

**Sello:** What's the term?

**Resor:** Copy exact. So when you send your data file to Taiwan and you get a mask made there, you want it to come out the same as the mask made in San Jose.

**Sello:** And somewhat as an alternate source. Is that it or--

**Resor:** Well, I'm not sure why you'd—

**Sello:** What's the objective here--

**Resor:** What I'm thinking is if a business went international then you need an international supplier base so then that led to that consolidation.

**Sello:** If Intel succeeds in its race, will that result in a mask making shop business in the states or will it be somewhere else? Do you have any idea how that might work out?

  

**Resor:** Yeah. I haven't really thought about that. There's going to be very few—

**Sello:** When Intel set up its own internal--

**Resor:** They have their own internal EUV mask shop to try and drive that technology.

**Sello:** To understand and drive that technology. They've sort of come--

**Resor:** And Sematech has a pilot line and its- and the whole lithography effort for Sematech has moved to Albany, New York.

**Sello:** Interesting.

**Resor:** Yeah.

**Sello:** Not in Silicon Valley.

**Resor:** No, and I think the state of New York had some- and IBM probably had something to do with that. Yeah. So that's a surprise to me, Harry. I really thought—

**Sello:** We might end up with this question. Will the eminent Griff Resor ever get back to the mask making and stepping business because of a trend like this?

**Resor:** I don't think so. Yeah. One of the things you've discovered is I'm curious about new things so that's- after 20 years in integrated circuits I went off and did flat panel displays and—

**Sello:** Were you--

**Resor:** It's a whole new rediscovery process and now I'm doing LEDs.

**Sello:** In the wrap up of our present discussion, we could get you back in LEDs one day but can you make sort of a half-a promise that you'll look at how computers could help you?

**Resor:** And I'm always interested in how computers can help me. Yeah. Well, one of the things we didn't talk about, one of the things I've done, is I served on the board of the American Electronics Association and headed up their public policy effort in the middle '90s. And at that time Japan was dominating the semiconductor business and I championed launching the- what was at that time DARPANET to make it into ARPANET, to make it the Internet because I saw that as a way to create a marketplace that would drive a whole new generation of computer products and graphics products and software, and it was the kind of thing that fits our financial structure. The venture capital guys can fund a hundred little software gaming companies at five million each. They don't have any money for $500 million integrated circuit plants and that works.

**Sello:** Would that bring jobs back to the States or initiate more jobs in the States that--

**Resor:** Well, I'd say for the first maybe 15 years it definitely brought jobs back to the States. You have a lot of NVIDIA. So the chips are made by a foundry in Taiwan but the design's done here in the valley. Well, what I didn't anticipate is that it would kill the advertising budgets for newspapers and it would help export the whole software industry to India so all innovations have their up sides and down sides I've learned but—

**Sello:** We'll be in touch in the future and we'll see how you fare in your LED and how they can use it in computers business. Please concentrate on that.

**Resor:** Well, a lot of your high-speed buses in your computers are LED driven so it's optics, not electrons traveling from rack to rack.

**Sello:** --which I feel if I turn you onto you won't quit. I think this is a perfectly good place to stop.

**Resor:** Well, thanks for having me in.

**Sello:** Griff Resor, thank you for a most refreshing and a most educational talk for me, and I thought I was past the day when I could learn something but talking to you I think I have a chance.

**Resor:** Maybe that's why I'm not retiring. I'm not past the day when I can learn something.

**Sello:** Remember for both of us the best is yet to come.

**Resor:** Yes.

**Sello:** Thanks, Griff.

**Resor:** Thank you.

<crew talk>

  

**Resor:** So Harry, you were asking me should people go back for a advanced management training program and I had said if you didn't get an MBA you really need to know how to understand financial statements. And so then the example I was giving was the method I think ASML has used to take—

**Sello:** What does ASML stand for?

**Resor:** I don't remember exactly how the Dutch picked that.

**Sello:** It's a Dutch name.

**Resor:** Yeah. Yeah. It was ASM, which did furnaces and stuff, so the 'L' part's lithography but I don't know what ASM stands for. Yeah. And it's originally Phillips Technology. They've had a good symbiotic relationship with National Labs and Phillips. So this group actually in Phoenix, Doug Marsh, ex-GCA guy, and a couple other guys figured out I call it quantitative marketing for the customers so the customer was Micron Technology. What is it in the DRAM manufacturing process that is worth the most money and would be something as a stepper company you could really have- you could contribute to? So it turns out that if you can shrink the DRAM ahead of your competitors you get a faster chip so it's better performance and you get- and get more chips on a wafer.

**Sello:** And you get further up on Moore's curve?

**Resor:** Yeah. You're moving down Moore's curve, creating more markets, more cost per transistor and you get down Moore's curve ahead of your competitors and in the DRAM business that's worth a lot of money. So they were able to improve the lens at the right rate to move the DRAM guys down that curve faster and they were able to charge a premium for that over their competitors and have longer delivery times, which is a curse in the equipment business. You don't want to be the longest delivery guy 'cause if the other guy's losing market share, he's going to buy the number two tool just to have a factory. So if you- to really do the marketing right you've really got to figure out what the values are and you've got to understand your customers' business model; how do they make money. And so then how do you help them make money by doing what you can do with your tool. So you could put on a better automation interface or you could make a better lens. There's a bunch of decisions you have to make every year in the equipment business, where do I put my effort, and these guys, Doug Marsh and his team, figured out where the real money was to be made for the customers by doing this quantitative marketing. So I think you have to really do this translation job between the customer requirements and your own internal strategy.

**Sello:** --was in the equipment business.

**Resor:** In the wafer stepper equipment business. Yeah. And so they dominate today. Canon's almost out of the business, probably is, they just can't say it, and Nikon is- just loses a little more market share every year and ASML dominates and it's because they've really learned how to fine tune the technology and the business together at the same time, and to do that you've got to have the business background.

**Sello:** Thank you, Griff.

END OF INTERVIEW

  