Shockley Labs Alumni Reminiscences

Interviewees:
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Richard Finch
Samuel Fok
Roland Haitz
Michael Heynes
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Leo Amadi: Actually, my stepfather, his nephew, worked for Beckman and I was a young fellow, probably in my early 20s, and was looking for a job and he said, "Why don't you go down to the Shockley facility and they, you know, they might be hiring people?" And so I went there and Hans Queisser interviewed me and he hired me and, at the time, I hadn't finished my education. I had gone to Stanford but had not graduated so I was working and I took this job there and that's how I got there.

Dag Spicer: And your background is physics or chemistry or something else?

Amadi: Well, it was electrical engineering and, later, I did go to Stanford and complete my master's degree after the Shockley Lab closed but I had a lot of training in mathematics and stuff for three years.

Spicer: Terrific.

Amadi: Yeah.

Spicer: There was something you wanted to tell us?

Amadi: Well, the main thing that I-- and I've worked in the industry many years now but, after awhile, I got to thinking about what was important about the second Shockley group. We've recently attended a meeting of-- what was the name of that book that they wrote on Noyce?

Spicer: *The Man Behind the Chip*?

Jacques Beaudouin: *The Man Behind the Chip*.

Amadi: Yes. And there was a lot of discussion about why the people left and how Shockley was directing a lot of the activity towards a four layer diode and whatnot so I began to think about what was the most significant thing that came out of this Shockley group?

Spicer: The second group?

Amadi: The second group. And then it occurred to me that what it was was the gaseous diffusion and...

Beaudouin: <inaudible>

Amadi: Well, Jacques, we used to-- I had been out of processing for a long time because I was in electrical engineering and looking at troubleshooting the circuits and-- but, at any rate, when we were doing-- making devices in the old Shockley lab and even after they moved out of the warehouse and went up to Stanford, in the Stanford Industrial Park, we were using a platinum box to do the barn[?] diffusion and kind of a glass crucible, quartz crucible. Now, why don't you explain that a little bit, the temperatures? Because he-- Jacques' kind of an expert in that area and I can't remember the details. It's been 50 years.

Beaudouin: Well, in the old Shockley labs, we were using platinum boxes and in the platinum boxes we had boric acid, essentially, B2 or 3, to do the P-type diffusion because there was a problem of uniformity with that process and also the platinum boxes were very expensive and, if you think of the wafers at the time, the boxes were small but some, they could not do it today, with big wafers. And the other problem was the silicon-platinum is an alloy which occurs at a relatively low temperature so if you ever touch silicon to the platinum box, it would just essentially alloy, destroy the box and, anyway, uniformity was a big issue. So, in the case of phosphorous diffusion, we were using a quartz box at the end of the tube with some phosphorous pentoxide (P2O5), and that would create-- there would be problems there because, if you got a glassy layer because of too much oxygen or humidity, then the diffusion would not take place to the concentration that you had hoped for and so you would waste-- so there were a lot of problems with freely positional diffusion with constant solid source and this is where Leo wants to explain the big step was [that] we went to gaseous sources.

Amadi: And how we got there was-- and you have to understand that the gaseous source actually spread throughout the whole world, okay? Because everybody was using this other technique and so now it's taken for granted. How this came about was really quite accidental. Shockley hired a fellow, a Dr. Hans Strauch, who I worked under for quite some time and we did some-- we did ion implantation in a glow discharge and we got P- and N-type layers and we did some mathematics and calculations of the diffusion and all that sort of stuff that's kind of interesting because it was kind of-- and difficult to do and-- but, basically, doing gaseous ion implant. But, before we did ion implant, Dr. Strauch had used di-borane and phosphene gases, one for P-type, one for N-type, that he had in Germany. Well, we didn't have that available in the United States so we had to get that from a reduction in Oakland. It took us, what, about nine months to get the gas?

Beaudouin: It took a long time.

Amadi: Long time. So we built this apparatus which, later on, Jim Gibbons took to Stanford when the lab closed and he set his graduate students on this thing. So we were using -- we got this going and we were using di-borane and phosphene and, one day, Mike Haynes came along, Dr. Mike Haynes, and he says, "Hey, how about -- let's try putting this thing through the oven and see if we can dope with this gas?" So he wrote a couple of papers about this and that's how it spread, as I understand, throughout the industry; that, now, everybody uses gaseous diffusion. And I don't know all the details now of what's being used and how it evolved but, basically…

Beaudouin: Well, basically, gaseous, gasses are still being used.

Amadi: Yeah. And, actually, I spoke to Mike last night, at dinner, and we had a Shockley dinner and I asked him about it and he says, "Yeah, as a matter of fact, I think Andy Grove had cornered him at some technical meeting and asked him about this". So I suspect we were -- I'm sure that -- we had been using this boat concept, a platinum boat and the little quartz crucible for the phosphorous for, oh, I don't know, about three years. I was at...

Beaudouin: Yeah, about three years.

Amadi: ... Shockley lab from about 1960 to 1965 when it closed and at least three years using it. So, obviously, there wasn't a gaseous technology. So, when I looked at this and I have quite a bit of background now and I looked at it and I said, you know, of everything that came out of that second Shockley group, that's probably the most important thing. Most people just look at it and say, well, it was kind of an appendage to the first group but it really wasn't, when I think about that.

Spicer: And did you notice improved yields, for example, once you switched?

Amadi: Well, the whole -- well, you got a unit-- well, you get a whole uniform...

Beaudouin: We did improve the uniformity...

Amadi: ...uniformity and, well, you could never go to these large wafers and everything and this other technology and it was very spotty diffusion. So, as I say, you know, it's something that was developed there, somewhat fortuitous, but that's the way things happen, right?

Spicer: Absolutely. Often, it's like that, the infrastructure that's developed to do something goes on -- I think Jacques and I were discussing how sometimes spin-off companies were created just to build one instrument or to control a process step.

Amadi: Exactly.

Beaudouin: Well, just like I said earlier, companies like Tylan started making gas distribution systems specifically designed with the gas sources, you know, like phosphene and di-borane. The first thing I did when I went to Stanford was to change their solid source concept to gas...

Amadi: They had all this old stuff, it was all-- that's what was in the industry. So...

Spicer: Did it come from semiconductors, this gaseous diffusion...

Amadi: Oh, yeah, the...

Beaudouin: The diffusion process in silicon came from Bell Labs originally.

Amadi: Bell Labs.

Beaudouin: Yeah. But...

Amadi: This concept of-- yeah.

Beaudouin: The source-- the concept of the gaseous source came from the Shockley Lab.

Spicer: Good. Okay.

Amadi: Yeah, that second group.

Beaudouin: Yeah.

Amadi: And, yeah, the idea-- this whole way of doing it was what was done apparently at Bell Labs and they did a lot of studies on diffusion, error function and Gaussian diffusion and the mathematics of that. But that didn't help in terms of -- basically, the gaseous diffusion allows the mass production of silicon wafers, of silicon transistors and-- as opposed to kind of a...

Spicer: And the purity, I guess.

Beaudouin: Purity, uniformity...

Amadi: Uniformity.

Beaudouin: ...and the ability to process large wafers.

Spicer: Right.

Beaudouin: You can process large wafers...

Amadi: Can you imagine putting this 12" wafer in a platinum box? <laughter>

Beaudouin: In a platinum box.

Amadi: Because the wafers were what the-- they were the size of a nickel, right?

Beaudouin: Yeah.

Amadi: About the size of a nickel.

Beaudouin: Three-quarters of an inch or even less at the beginning.

Amadi: And that's why-- probably why the transistors were so expensive.

Beaudouin: Well, yes, they...

Amadi: You know?

Beaudouin: You could only make a few. They were large by today's standards and you could not make too many of them...

Amadi: And that, as I recall, that phosphorous, what was that quartz thing that-- see, it was heated separately at the end of the furnace tube, right? When you said...

Beaudouin: Yes, you had a source that was of a different temperature than the wafer and those temperatures were critical so...

Amadi: And it was a much lower temperature.

Beaudouin: Yeah, much lower. It was 240C versus 1200.

Amadi: Okay. And so then the nitrogen gas would flow across. But that thing had to be cleaned, it's subject to contamination and, I mean, you couldn't -- there's no way you could...

Beaudouin: <inaudible>

Amadi: Yeah, I mean, you don't get these super clean circuits. You'd have all kinds of impurities. You'd never be able to get to a really high density...

Beaudouin: Things became a lot easier with gaseous sources, there's no question.

Spicer: Well, that's great. That's a good perspective. No one else has mentioned that before. Thank you.

Amadi: Well...

Spicer: Is there anything else?

Amadi: No, that's about it and-- because I've been retired and I read Scientific American and I think about various things and look, you know, different possibilities and it just occurred to me and my old mentor, Hans Strauch, I don't-- I think he eventually left. They felt that that work wasn't important and then...

Beaudouin: Well, he went back to Germany.

Amadi: He went back to Germany...

Beaudouin: He wanted to go back to his homeland.

Amadi: ...to Germany. Yeah. But -- so I thought -- I started thinking about it and I said, you know, this is what's crucial but people don't recognize it. Maybe I'm wrong, I don't know.

Beaudouin: No, no, that's...

Spicer: That's certainly possible. <laughter>

Amadi: Okay. So that should be a little-- add a little bit of spice to the history, right? It's not too mundane.

Spicer: No, no. That's...

[audio off then on]

Beaudouin: I joined the company in January of 1960. I came to see Shockley and asked him to sign my book and then we talked and, after talking for awhile, he gave me a puzzle to solve on his desk. I remember this vividly, and we talked about mathematical puzzles and things like this and he told me he'd like to speak to -- he would like me to speak to some of his senior staff members and, after talking to them for awhile, they said, "Well, we'll let you know" and then, of course, they -- it was in 1960 and I don't know if you remember. In 1960, the winter Olympics were in Squaw Valley, California and I'm an avid skier and my goal was to go and spend a fair amount of time in Squaw Valley but they called me on Thursday, I remember, just before the downhill and they said, "No, we'd like you to start right away." So that was it.

Spicer: You missed your Olympics.

Beaudouin: I missed the downhill and went weekends but-- but it was a fabulous experience, to not only meet William Shockley but to work for him.

Spicer: Now, your background is in chemistry or...

Beaudouin: Chemistry, yes.

Spicer: Okay. And tell us some of the things you worked on.

Beaudouin: Well, I learned a lot about physics, of course. I had some physics courses but some of the things I worked on… the very first thing I worked on is the four layer diode, of course, which is what caused a few problems prior to me coming to Shockley and we had-- there were a lot of problems to be solved, the uniformity of switching voltages and things like this and that's what we worked on. Diffusions and increasing the yields, a number of things like this.

Spicer: In the early days of a discipline, there's very little of what we often call in the history of technology disciplinary closure, which means many of the parameters or principles of a discipline that are later taken for granted are, in fact, very much in flux at this time.

Beaudouin: Oh, yes, definitely, yes.

Spicer: I wonder if you could tell us a bit about some of the -- you mentioned earlier when we were chatting about how [work at] Shockley [Labs] was almost like black magic in the way you had to deal with some of the parameters that kept changing and process control… it was very difficult.

Beaudouin: Oh, definitely, the -- we take the silicon wafer processing for granted now, although there are still some problems and some things to, well, we have to pay a lot of attention to, you know, contamination and so forth. In those days, we had to pay a lot more attention and we had to understand and we didn't understand everything about silicon and the problems with contamination from the ambient influences and sodium contamination, which is one of the things which probably prevented people from making good MOS devices at the beginning. We had to learn. There was a lot to learn and there was also an equipment issue. When I joined Shockley, you could not go out and buy a piece of equipment to do a certain thing. I'll give you one example. We used thermal compression bonding, you know, and, today, you can go and buy fancy machines and some of them are totally automated and will put the little wires on the circuit like a sewing machine and stitch them, so to speak. And, in those days, it was strictly manual and we built our very own machines, our own equipment. This is something that we had to learn how to build … this equipment. I remember, on the thermal compression bonder, you used a little glass tip, very -- you know, through which the wire will go and we had to make those tips. Nobody made them. And I remember learning how to blow glass and turn the glass tubing and draw on it to a fine point and things like this. So this was a -- so those were the things we had to contend with and, with diffusion, we built our own, what we called “the jungle,” which is a gas distribution system in back of the furnace. We built all this ourselves. So that was -- we built everything. The furnaces we purchased were not designed for our type of work so we had to modify them.

Spicer: I think, correct me if I'm wrong, but, in later years, people would actually form companies, sometimes on the basis of just one piece of equipment.

Beaudouin: Exactly. Well...

Spicer: **…**like an oven…

Beaudouin: Thermco is a good example, if you know Thermco. They build furnaces. They built furnaces that were designed for the type of work we were doing, later on, of course. I forget the year they began. But they also built a gas distribution system and that sort of thing and Tylan was another one of them and K&S, if you know the company, Kulicke & Soffa. I remember they started building [a] thermal compression bonder and I remember buying one of them and thinking it was marvelous that I could just go ahead and buy one rather than build one because our interest was to make the devices, not to build equipment to make the devices. So that made life easy.

Spicer: Now, just before we wrap up, you brought a few little devices with you today?

Beaudouin: Yes, I brought a crystal or a portion of a crystal and those were the size of crystals we had in those days, which translated into a wafer, which was roughly 15 mm in size and this was the size of the wafer that we used in 1960 versus the wafer which is now 300 mm in diameter, which is about this big, and, for those who are not metric, it's...

Spicer: 12"?

Beaudouin: 12". Yeah. So...

Spicer: Did you grow your own crystals?

Beaudouin: We grew our own crystals, yes. We grew -- well, we eventually hired somebody who specialized in crystal growing so we could do the work that we needed to do, which was to study diffusion and study the problems with device making but Shockley Transistor, yes, they grew their own crystals.

Spicer: Was that Czochralski refining...?

Beaudouin: It was Czochralski.

Spicer: **"**CZ"

Beaudouin: CZ, yes. CZ and we -- yes, we grew our own crystals and, of course, the crystals of those days were not quite as good and we had to learn how to grow good crystals, which have not only purity but low in dislocation and things like this. And this [holding up object] is a typical Shockley diode in the glass package, which is a four-layer diode, and this was the product that was sold, that Shockley sold. Yeah. One of the packages, yes.

Spicer: Was that device in production?

Beaudouin: This device was in production. We, of course, built a number of different other, different devices. We built also three terminal devices, which is a four-layer diode with a third terminal, which is a thyristor in effect. And we also built little photosensitive four-layer diodes that would switch with light, yeah, which is fairly understood now but, at the time, that was fairly advanced, to have a light switch, essentially, electronic solid state, pure electronic light switch and this was one of the -- this one happens to be built by me so I'm proud of it. So that's it.

Spicer: Is there anything else you'd like to say?

Beaudouin: Well, was a -- that's okay. It was a wonderful era, experience. I learned, of course, as all of us did, learned a lot from Shockley and he was an inspiration. He was certainly an extremely bright physicist, amazingly so and I also had -- I was a sailor--a skier and a sailor--and he had a boat so I got many opportunities to sail with him and he was a very technical sailor, also. <laughter> So it was a good experience. It was the best time -- there were some good times -- and I worked with wonderful people, also, very-- that inspired me and we inspired each other.

Spicer: Yeah. It was really the perfect storm, I think, in terms of...

Beaudouin: Yes. Yes. It was unbelievable.

Spicer: Thanks very much.

Beaudouin: You're welcome. You're welcome. Thank you.

[audio off then on]

Richard Finch: I went by Dick at that time so...

Spicer: Okay.

Finch: You might want to put, in parentheses, Dick or something that people recognize easier.

Spicer: Okay. We're here with Richard Finch, who went by nickname Dick Finch when he was working at Shockley Labs and welcome.

Finch: Thank you.

Spicer: Tell us, first, how you came to Shockley Labs. Were you recruited or...?

Finch: Well, I think that -- everybody had a different story and I think that's always been fun to hear everybody's different stories. Mine was absolute luck and happenstance or a spiritual person might have said, "Led by God". I had graduated with a degree in chemistry from Brigham Young University but a bachelor's degree in chemistry is not that much and I couldn't find a job but I had had a great job in the summer working for a printing company, a lithography company, and the lithography process of making plates is identical to what we now use for making integrated circuits. So, anyhow, I was working in San Francisco and, one time, I just had a bug to go down to Redwood City and I bought a duplex in the middle of the night, sight unseen, in the dark, and moved my wife down there and was working swing shift and went to look for a second job and went to an employment agency and they sent me to Shockley Labs and I interviewed with Dr. Adolf Goetzberger and they hired me. It was -- and, but, from the minute I walked into that unimpressive Quonset hut, I was just excited. Just, it was so -- I don't know what it was, you know, I'd seen all this kind of equipment before in my labs and things but, to see something actually being done, you know, not an experiment but learning something, it was very exciting for me and I was awed and felt inadequate so I took a lot of additional classes. Shockley, for all his faults, did like to teach and encouraged his senior staff to teach so we had wonderful teachers and [were] learning a lot of stuff. And so I was in the second wave, of course, not with the original eight, and it was in September 1959 when I joined. That was just a lot of fun.

Spicer: What kind of things did you work on?

Finch: Well, as Hans Queisser referred to the other day, Shockley would -- or somebody would -- ask for an experiment at four in the afternoon and want some data the next day. These experiments usually involved making a particular device with a different set of junctions or something like that so we did a lot of what we would call processing work. We would input impurities into the silicon at high temperature, we would separate it, usually by etching, and it was very caustic chemicals, and then taking some, you know, doing some tests on it. Did a lot of that. Towards the later part, I focused more on a new process called epitaxial growth, which was depositing silicon on silicon, one atom at a time, and it gave you a lot of flexibility in how you could do that. And, in doing that, my boss, Hans Queisser at the time, and I published the first paper which identified some crystal defects caused by that type of process, which was instrumental. It was key -- and that was -- last night, I was talking at a dinner and I said, "This was the exciting time in my life," I meant professionally. By professionally, it was extremely exciting because of the things we were learning and you were learning things that you didn't know. I mean, you look back on it, gee, it was a trivial little step but it was a step into the unknown sometimes in learning control. And then it was -- there was personal growth. We were all young, all just out of school, essentially, and so a lot of personal growth going on, just learning a lot about how to work as a team and to respect your team members and all of those things, of course, stood us in very good stead as we went on about our careers after that operation failed.

Spicer: Now, any pioneering company, of course, has a lot of unknowns in the device, you know, aside from the managerial and other unknowns, just the device or the technology that they're working on. One thing the other people who have come in have emphasized is how often they had to make their own equipment, basically all the time, and how tricky it was to nail down device parameters. To me, it seems, because the field was so pioneering, it's almost like building a boat while you're sailing it.

Finch: That's a good example. But the equipment side of it is interesting. We did always build our own equipment. That was just given. And, even in my next job, we would-- we made our own little bonders and things. It wasn't until, oh, I guess, the '70s almost that some of the major equipment companies began to develop and make equipment for everybody. Each person developed their own. And there were certain hazards. I remember doing some glass blowing in quartz, which is high temperature, and you have a very dark mask and focusing the beam on my finger instead of on the glass. <laughter> It looked a lot worse than it was. And, another time, we were-- for epitaxial growth, we used the same kind of transmitter that a radio station would use at 50,000 watts and, when I was building something and I grabbed the 50,000 watt output <laughter> and, fortunately, it was a very low current and [I] survived all these things. But that was one of the hazards of dealing with all the different chemicals and different pieces of equipment.

Spicer: But nobody got hurt.

Finch: Well, not major, no. Certainly, nobody died. No. But everything we dealt with was toxic.

Spicer: Yeah.

Finch: I mean, every single thing was toxic. We used silicon tetrachloride, [which,] when exposed to air, [decomposes] into silicone dioxide, hydrochloric acid and [water] vapor so you'd break a bottle and you'd be breathing this stuff until you could clean it up and we were perhaps not as cautious as we should have been. The environment was different and we didn't have air packs and things.

Spicer: For gasses especially.

Finch: Yeah. And we used phosphene gas, which was, of course, horrible and lot of phosphorous compounds. There was -- but in all small quantities and we were careful.

Spicer: So you were working on -- tell us a bit more about the problems you were kind of solving.

Finch: Well, we solved a lot of problems related to eptaxial growth, first, in terms of how to eliminate defects, how to grow perfect crystals, then how to do it in quantity and volume. And other projects, we were working on some power transistors. We had a contract from [the] Jet Propulsion Laboratory [at Caltech] to build power transistors, which they would use to take the output of solar cells and make it AC if they needed to or whatever. So we did different kind of metals on those. And we discovered a failure mechanism that would give you a thermal runaway. It would start to get hot and it would get hotter there and it would just – a transistor would fail and we found out how to eliminate that by putting little resistors in series with the emitter. It was pretty good stuff. I mean, not that we commercially capitalized on that but, subsequently other people did who made -- a lot of materials technology. We learned how impurities were distributed. We did early work on ion implantation, which is now a standard technique. We did, you know, 5,000 volts in a bell jar and could see that the concentration of the impurity you were dealing with was higher, a micron and a half, under the surface, than it was at the surface and, oh, what causes that? Well, I guess it goes through interstitially or something. So those were just kind of great things to...

Spicer: Yeah, it sounds like the field was just wide open.

Finch: It was. You just, you know, if somebody thought of something, you did it and you, you know, published on it. One thing that Adolf Goetzberger and I published was we found, if we put mechanical weight on a P-N junction, the characteristic changed. <laughter> Sort of a peizoelectric or peizoresistive effect. That never got used for anything but it was there. <laughter>

Spicer: Some kind of effect.

Finch: Yeah.

Spicer: Is there anything you want to leave us with?

Finch: Not particularly, other than the fact that I really feel blessed for having [had] the opportunity. It just sort of dropped in my lap. I was there at the right time, I had the right kind of background and it was just the best thing in the world that happened and it's fun to have felt that, well, it was a small part of something that was very important.

Spicer: Yes.

Finch: But each small part counts and we think of the people who have been, you know, very successful, both financially and scientifically, and yet the success of any endeavor, in this endeavor, is a collection of a lot of people, people who grew the crystals, people who learned how to slice them, people who did all kinds of different things and some of them were there short times and some longer times but each one contributed and it's a great lesson. And I would hope that young scientists, engineers today can find as much excitement in the opportunity of discovery that we did and, if they do, they're going to be happy and they'll be successful.

[audio off then on]

Samuel Fok: I was working in Cleveland, Ohio, and my wife and I got married out on the west coast in 1952. Yeah. We went to Berkeley, her folks were there, every year, [so] we had to buy an airplane ticket and fly there and come and visit home and so on. So I said, well, I almost feel like working for the airlines, so I said, I need a job in the west coast. So I sent my resume to American Chemical Society and let's just see what happens. And, lo and behold, I got a phone call. I'm working in synthetic rubber at Tyco [?] in the physical testing and so on.

Spicer: You are a chemist?

Fok: I'm a chemical engineer by training. I got my undergraduate at Ohio State in '49 and went up to Cleveland for Case Institute of technology and I got my Ph.D. in the chemical engineering I worked in the synthetic rubber program for the government, too, at that time.

Spicer: Cleveland is a big center...

Fok: Oh, yeah.

Spicer: Goodyear, I think?

Fok: I was there for around nine-- from 1949 -- I went up-- I went to Ohio State, graduated '49, then I went up there around 1950 and we were there, well, until-- then I met my future wife there in Berkeley. Well, she works at -- I know her because she went to Western Reserve School of Nursing and I tutored her for chemistry because they never had chemistry before that. That's how I know her. So we were married on the west coast and I liked the weather so much, I said, I hate shoveling snow. The snow is nice to look at, you know, like Olympics in the winter, you know, watch it on TV is fine. <laughter> But I don't want to get closer and shovel it.

Spicer: Yeah. I think a lot of people came out west for that reason.

Fok: Yeah. So that's how we moved. After our first son was born, I think in 1955, we just-- we got a phone call in the middle of the night, around -- well, dinner time or something. He said, "This is Dr. Shockley." I said, "Dr. Shockley." He said, "Have you heard about me?" I said, "Yes." I happened to go through physics, you know, and heard that you are the inventor of the transistor. He was getting a Nobel prize that year so I know him. "Oh," he said, "oh, and, by the way, I have Gordon Moore on the phone, too, and Tom Sah [who] is another Chinese. I know Tom Sah's father is a very famous physicist in China. He wrote the physics textbook and I said, "Tom is very smart..." So we had half an hour long distance conference call. Shockley used to work for Bell Labs so he got free telephone calls so -- he said, "It's cheaper for me to call you and interview you than fly you out for an interview." So-- because he Gordon knows physical chemistry by training, see? So -- and Tom is, being a Chinese and know a little bit more about what's the environment around there, how in the west coast like. In that time, they didn't have such a large population of Chinese here, very few. So, after half an hour interview, Shockley said, "You're hired. Pack up and come on out." <laughter> I said, "Fine" so we just took it easy, you know, drove all the way with a baby, I think our son was around 18 months old at that time. So it took ten days to drive across from Ohio all the way out here. So that was when I first came out. I stayed in nearby …across from Ricky's [Hyatt?] house across from there, that neighborhood. That was a wonderful neighborhood because it's a very multicultural neighborhood where Chinese, there's a Japanese family right there, there's an Italian family right there. It was just a miniature United Nations. And they're very friendly, all the couples are about our age. Most of the homes are built after the war for GIs and they all got married and all had babies about the same time. So we all have coffee every morning, in the neighborhood lawn, even the postman came and joined us for coffees. <laughter> So that's how -- we lived there about four years -- no, let's see, yeah, a couple years.

Spicer: So what kind of things did you work on at Shockley?

Fok: Well, at Shockley, I was involved with-- they had built up a crystal grower.

Spicer: Yes.

Fok: A huge machine and I think somebody had the idea, I don't know whose original idea, that, at that time, you grow crystal and you have to be pure. Don't want any unwanted impurities in the crystal. So somebody came up with the idea, well, if we make a silicon crystal-- no, not-- a silicon-- melt down a chunk of silicon and use that as a crucible, then you pour single crystal from the center, it would be very clean without any contamination from quartz. So that's how they built -- by the time, I get there, the monster, huge. <laughter>

Spicer: Is this a CZ process?

Fok: No, it's a -- it was supposed to be a grower crystal without crystal -- without quartz because they saw a lot of oxygen in the quartz [and] it's contaminating the crystal or the pure crystal silicon. So that was, I think, [my] first project. Then I got involved in modifying a front side and back side alignment [process] because Shockley a major project was to do four-layer diode and P-N-P-N like that. So I had to do a front side and back side diffusion at the same time to cut down this <inaudible> So Jean Hoerni at that time were doing diffusion calculations and Tom Sah was, well, he was working with the other people. But Gordon and my coworker, at that time, yeah, and Bob Noyce, Sheldon Roberts was there, polishing crystal and I was in other job. And then, later on, they said, well, this grown crystal, make the crucible mixing and melting the silicon in the puddle, it required some kind of heating element so you separate heating elements. <laughter>

Spicer: Sounds expensive.

Fok: Yeah. So, at that time, I think Julius Blank and Gene Kleiner was the one in charge of the building, mechanical building. Then, after-- well, I don't think we ever got the thing to fly, you know, it never took off, then comes the floating zone technique. So I was involved in growing crystals.

Spicer: Yeah, the floating zone...

Fok: Floating zone technique, yeah.

Spicer: ...refining?

Fok: Zone refining. And at that time, the crystal was probably this size, 3/8" diameter.

Spicer: Jaques brought one in and showed us.

Fok: Yeah. Those were...

Spicer: I'm sorry we're so short of time but, as we wrap up, is there anything you'd like to say about...

Fok: Well, you wanted to find out what I did at Shockley, I did crystal growing, polishing, alignment, the alignment design, photo masking, I use a black box to make the dial [sp?]and a chemical etching, using all the CP-8 and CP-4, those kind of chemicals. So being trained in chemicals generally, I had no fear of the chemistry so those are things that I helped design the first clean room there.

Spicer: So, looking back at your Shockley experience, is there anything you'd like to say when you look back at jobs you had after Shockley? Did it prepare you for...

Fok: Well, it very friendly, little -- unfortunately, I got there at a time… after six months, I got there, the whole group left, eight of them left, see, and formed Fairchild. And I felt loyalty-bound to Shockley. I said, well, he moved me all the way out here and I just don't feel right to go and so I left behind. Tom Sah and me and Harry Sello Harry Sello was hired after I was there. Yeah. And so, when the group left, we left a [?] Tom Sah and me and that's about all… and Shockley. Just a very few technical people left behind, a few technicians. So that was -- good training. I worked on the ground floor. Then, later on, I think Harry left first, joined Fairchild, then the people in production for diffusion furnace, needed some helped, called me and wondered if I wanted to move over. At that time, I think Shockley was-- Maurice Hanovan [ph?] was manager, managing for Beckman. And he told me, well, maybe this is a good time for you to leave if you want to leave. I said, well, I hate to leave without anything, you know, to settle down everything and make sure there's somebody trained to take over my job. So I left in 1960 and I went to sign up at Fairchild, they gave me badge number 1776. I think they saved that for me. <laughter> I started on Washington's birthday. I said, well, do I report to work? They said, no, you've got a holiday to start. <laughter>

Spicer: There you go.

Fok: Well, I enjoyed talking with you.

Spicer: It's a very elite club.

Fok: Well, that's true because-- I wish I can do more.

Spicer: It was a marvelous place, I think.

Fok: Yeah.

Spicer: Some talented people there.

Fok: Yeah, I think they are all very nice. Too bad we lost quite a few of them. Bob Noyce is gone, Mick Green is gone. Jean Hoerni is gone.

[audio off then on]

Roland Haitz: I started there on May 31st, '61. I was recruited through a subsidiary of Clevite – Intermetal -- in Freiburg. I was interested in semiconductors. I started at the University of-- Technical University of Munich. There, I went to several summer jobs at Siemens Semiconductor in Germany and I found an ad for Intermetal that Intermetal and a subsidiary, Shockley Transistors, is looking for some physicists. I was responded to that. I refused to go to Freiburg. They made me an offer but I didn't say -- I told them, I didn't want to go to Freiburg, I wanted to go to California, to Shockley. And so Shockley came to Munich a couple months later or six weeks later. He came to Munich and I met with him there. He was the first person I ever talked to that couldn't speak German and my English -- I had six years in English in high school but I never practiced it -- and so we had a very interesting interview with pencils and papers and dictionary. You know, I knew some English but I never practiced it. And so we went through this for two or two and a half hours in the morning in a hotel in Munich and it looked like I did reasonably well, especially over -- and I showed at lunch that I don't think it's the right thing to tell here. <laughter> It had to do with how we handled Slivovitz. But it's a long story and I don't think you want to hear about all the details of that but, by the time I get over here, I got over here after Shockley make me an offer. We all said, "Oh, the man with the Slivovitz here." That's the moment Shockley made the decision to hire me. <laughter> Not about any semiconductor or mathematical equation but making a decision on something I was uncomfortable with and he hired me. <laughter>

Spicer: So what kind of problems did you work on?

Haitz: Microplasmas mainly. This was an unknown defect in semiconductors in the late '50s, early '60s. Many people had observed it and described it but it wasn't well understood and so I spent two and a half or -- two years or so trying to understand them better on some military contracts and then we got a contract to make a a ? saw out of it from-- they had a diamond lab and I think the real source behind it was not the army, it was the NSA, but they never could tell.

Spicer: Right. During this period, a lot of the parameters that we take for granted in solid state physics today were, of course, not characterized for you. Understanding dislocations, for example, and the effects of temperature or just process control, for example. I wonder if you could describe some of the environment at Shockley Labs and the way people approached solving, nailing down [a] seemingly incomprehensible number of parameters and actually being able to go ahead.

Haitz: I was never into the processing side. I was more on the device physics side, trying to study what's going on in the materials and trying to explain them. Shockley, about a month after I joined him, or maybe -- between one and two months -- he had this big accident in Half Moon Bay where, between him and his wife, they had about 60 broken bones. And he ended up-- first at Stanford and then at Sequoia Hospital, and about a week or so after this big accident, when he was there with all his broken bone problems and other problems, he wrote -- he dictated to his secretary on a tape, he dictated some theory about how to go after this problem of microplasmas and I then ended up with, on Monday morning, with the thing he dictated over the weekend to try to see if I can make experiments along those lines. And that's how I got into-- I got-- there, I developed some confidence that he had in me. Then, somewhat afterwards, there was another big problem in semiconductors called secondary breakdown. He had a hunch that a secondary breakdown in transistors was a thermal issue and then I did some general experiment and proved, beyond a shadow of a doubt, that these -- the secondary breakdown in transistors -- was a thermal issue. And, after that, I had made my mark for his and I had his confidence...

Spicer: Right. You justified his confidence.

Haitz: ...and all of these things that were said about him, that he was so difficult to work with and so demanding. I don't know if it was his accident that he had that mellowed him or because I made a few clever experiments relatively early that proved some of the things that he was all -- some of his theories that he had tried to explain some of these defects. But, after that, I had clear sailing with him.

Spicer: Can you tell us what happened? Oh, clear sailing?

Haitz: I had clear sailing with him...

Spicer: Oh, I got it. I thought you said clear failing.

Haitz: No, no. I had clear sailing with him, no trouble with, you know, being on the, you know, on the list of incompetents or whatever. <laughter> I don't think he ever had that but he had the reputation that he was very tough. But I made my point there that -- and, from then on, became good friends.

Spicer: And did you -- you stayed with Shockley until...?

Haitz: Until November '64.

Spicer: And tell us, after that?

Roland Haitz: After that, okay, I was still a bachelor and having done -- actually, I did my Ph.D. thesis in his lab. I submitted it in Munich, in Germany, so I had one Ph.D. father, I have a Nobel prize winner. As the other Ph.D. father, I have somebody who has the Stalin prize and is hero of the Soviet Union but lived in West Germany by that time.

Spicer: Oh, who was that?

Haitz: Nikolas Real [ph?] He did uranium 235 separation during the war at the Kaiser Wilhelm Institute in Berlin. After the war, they were bombed out and he lived in Magdeburg and, two months after the end of the war, in July of '45, the Russians came, "knock, knock" at 3:00 in the morning, he has one hour to pack and go over to Russia. And so they dragged him to Russia and he set up the uranium 235 separation in Russia and he was the only foreigner that was allowed to attend the first nuclear explosion in Russia. And so he ended up as my official thesis advisor because he had to represent the thesis I did here in America at the Technical University in Munich. So that's...

Spicer: Interesting.

Haitz: ...quite a pedigree.

Spicer: Yes. Could you tell us about Shockley's intuition?

Haitz: You know, he was so capable of taking complex issues and translating them into things, into words that people could understand. I mean, it goes back to the interview I had with him when I couldn't speak English much and he didn't speak German but we nevertheless got across. But he was so capable of taking -- getting rid of all the obfuscation in some of the physical problems and getting down very quickly to the point and then asking the right questions to get the answers. He was unbelievable in that regard.

Spicer: I think we'll just leave it at that.

Haitz: Okay.

Spicer: That's a great testament. Okay. Perfect. Thank you. Unless there's anything else you'd like to say?

Haitz: Afterwards, when he left, Shockley Labs and went to Stanford and started his analysis of genetic issues, he was, at that time, you know, somebody that was getting a lot of adverse publicity. He was misquoted all over the place but now, 30 years or 40 years after that, he is all proven right, that genetic issues -- that intelligent issues or IQ issues are, to a large extent, determined by genetic blueprints. He was, at that time, so attacked, especially by the left wing, but, in retrospect, what's happening today and the way scientists look today at genetic issues and intelligent issues, he is absolutely proven right and he was, at that time, one of the very few people that dared to bring this up in public, talk about it and take all the flack. That was one of the things that, at that time, he said, "What I am doing now is far more important than inventing the transistor. It's far more important for humanity than inventing the transistor and, in retrospect, I think, he is proven right, that this was an important issue, a timely issue, and I thank him for sticking his head out on that.

[audio off then on]

Michael Heynes: I came to the states from the UK, first of all to Massachusetts, working for a company called Clevite Transistor. And after about a year, year and a half after I joined Clevite, in Waltham, Mass., that company acquired the Shockley transistor operation in Palo Alto, and that was a rather exciting event, of course, for those of us who were doing research and development, which I was at the time, and after a few months I was able to arrange a transfer to work in the Shockley lab. Things were actually not going well in Waltham at that time because Clevite had been primarily successful in the germanium years of the industry, but there was a very rapid change from the use of germanium to the use of silicon as the principal material for device fabrication, and Clevite Transistor did not make that change as rapidly as they should have to stay competitive in the industry. But, I thought that in the Shockley Lab, aside from doing some very interesting things technically, there was a better chance of that operation surviving than the operation in Waltham, which was indeed the case later.

Spicer: Your background is in physics, chemistry, engineering?

Heynes: I'm a chemist, yes. A silicon chemist. A silicon process chemist, basically.

Spicer: Tell us some of the things you worked on, some of the problems you were solving.

Heynes: The first area where I worked in the Shockley operation was in epitaxial deposition of silicon, a deposition of thin layers of silicon onto an existing silicon wafer. The kind of work that I had been doing in

Waltham was of interest to Dr. Shockley, which was, of course, was very helpful with my getting the transfer to -- he had expressed interest, so it was easy to get the transfer to the Shockley operation.

Spicer: And can you tell us how many years you were there?

Heynes: About two years. Actually, I worked twice in that operation. Initially, for about a year and half from ’62 to ’64, roughly, and then I came back and worked in the operation after ITT acquired the Shockley operation. And so I worked there for another year and then eventually the operation was shut down and ITT consolidated their semiconductor operations in West Palm Beach, Florida, which I transferred to at that time.

Spicer: That sounds like a pleasant location at least?

Heynes: Not as nice as California.

Spicer: Okay. So after Shockley Labs, you stayed in the semiconductor industry?

Heynes: Oh, yes, yes. After a couple of years in West Palm Beach I came back to the Bay Area and worked at Signetics for a while, and then went on to some other companies as things rapidly changed in the industry, including a total of three start-ups, which I joined when they were still-- not as a founding member but when they were still anything from like seven to 20 people.

Spicer: What was the atmosphere at Shockley like when you were there?

Heynes: I was in the -- it was called the research lab although it was a combination of research and device development going on at the time. And it was a rather academic atmosphere, as you might expect from Dr. Shockley’s background. And there were a lot of the usual academic conversations going on and many projects being worked on, which were supported by various contracts, mostly from government and defense agencies, working on the kind of products that were going to be of importance in the defense industry in the future.

Spicer: <Inaudible>

Heynes: Not strongly so. I think he would have loved to have done that, but I think the funds were not available to work on the very long-range speculative projects. I enjoyed getting to know Dr. Shockley. He was a very social fellow, actually. I remember some Friday evenings we would go to one of the local bars and just sit around and talk and he would tell a joke or two, and on the whole I found Shockley to be a helpful man, a very good teacher when things needed to be explained, technically, were explained. And I thought he was a rather fair man. I had heard the stories of his earlier life and when he was a younger man and very competitive, I think, understandably, but I didn't see that kind of thing. He was a kind of mentor for many of us at that time.

Heynes: Yes, I felt very fortunate that things had worked out the way they did. That I was able to work there and get to know him a little bit.

[audio off then on]

Colin Knight: Well, I became aware of the transistor being invented right about 1950 while I was still a teenager, and it sparked my imagination, it brought together crystals and electronics, so I went to the Southampton University for a physics degree. I actually got to work on point contact germanium transistors for GEC in Coventry and then when I graduated, I had arranged to go to the GEC research labs in Wimberley, so I went straight there with the bachelor's degree and worked in the solid state physics group working on silicon crystals when they were still about a quarter inch in diameter. And after five years, America was recruiting English engineers so I came to the states to work for Clevite Transistor first in Waltham at the old watch factory, and then out of the plant on [Route] 128.

I came in July, 1960, and in January '61 they sent me out to Shockley Labs to do the transfer of a mesa transistor technology to bring it back to Waltham. So I was out here for maybe a month or six weeks picking up the technology and then taking it back. So I'm not one of the illustrious group; I was sort of a hanger-on to an extent, but anyway, we took the transistor technology back and converted it first from the mesa technology fairly rapidly into a planar and then into a epitaxial planar transistor. And I had several visits to the Shockley plant while it was still in the old packing factory down on San Antonio, and then later on when they were up at the place just off Central Expressway, and I was primarily involved in the transfer of technology both ways. So, that was my involvement with Shockley. And, oh, I guess one thing that's an interesting aside, is at Clevite back in Waltham, I was developing the first shots at integrated circuits at that time. I did one circuit for the Apollo Minuteman program with North American Aviation, the Autonetics division down in Anaheim, and then did another circuit for the Apollo program, and I developed a technique that considerably reduced the series collector resistance on integrated circuits and on a visit out to Autonetics, Dr. Shockley, who had just been involved in his car accident on El Camino, was very interested to hear about it. So George Wallace and I got pulled into his hospital room to tell him all about the technology, so that is definitely an oral type of thing.

Spicer: Do you have a sense for his intuition?

Knight: It was pretty good, I'd say. We got on pretty well. When I first came out here and had completed my stint of picking out the technology, he called me in and I was like, what was I, like 26 at the time? A kid, so he gave me a lecture on how important it was for Waltham to take full advantage of what was going on at the Shockley Lab. So, I definitely agreed with him. I said, also you should realize there's good work going on back at Waltham and we've got things too, that you can benefit from. For instance, I brought the first D.W. Mann Step and Repeat camera ever made from D.W. Mann out in Lincoln, Massachusetts, and it was vastly easier to make a mask using a machine that was at least automated in one direction than Shockley Labs who were using a basic ruling engine and had to set up each individual image, both in x and y, and take the backlash out of the machine, so there were -- We had a good interchange and we always got on pretty well.

Spicer: Now, you've brought some articles—

Knight: I do have a couple of rolls of film which have some of the earliest integrated circuits. I don't know how we're going to show these, but-

Spicer: We can actually scan those.

Knight: You can scan them? Okay. You're welcome to have one of these, I've got a multiple on the strip. So, this one is the first circuit I ever made for the Minuteman program. It's a seven input NAND gate it was absolutely huge, the lines were 10 mils wide and they were cut into rubylith with a razor blade and a ruler.

Spicer: Is this RTL?

Knight: This one was DTL. And everything was literally done -- I had to build my own camera, my first reduction camera to be able to handle the rubylith; there simply weren't the machines available. Eventually D.W. Mann made them, but I ended up getting an old lathe bed and building a light box and mounting a camera lens on the lathe bed and doing that. It was great times to -- you made all your own equipment. When we first started on the mesa transistor everything was done with the Buckby Meers [?] metal masks and you sprayed black wax through them and that was what you used to mask it. And we had to set up these metal masks on frames and--

Spicer: It's like silk screening almost.

Knight: Yeah, like silk screening but you had to do precision alignment and I owe a great debt of gratitude to a Scots engineer I worked with in England, who taught me all about kinematics, and that is

[that] four points do not define a plane; three points define a plane, and so all the equipment I made was always kinematic and it was always extremely precise. Anybody that tried to do it by brute force failed, but with just three points to align the mask on the frame, it worked out just fine. So the other one I have is the Apollo circuit and I have some other things from the sixties, but they were after I moved on to Computer Control [Corporation -- 3C] in Framingham, and set up an operation for them.

Spicer: Do you know Gardner Hendrie?

Knight: Gardner Hendrie? The name sounds awfully familiar. And--

Spicer: He's one of our trustees now.

Knight: Is he? Oh, of course, I met him back at the 3C reunion about four years' ago. Yeah. Yeah, I remember him. And Burge Jamison; do you know him? He was at 3C. And who else was there? There was, oh, goodness gracious, he lives over in Woodside, he went to Intel. 3C was one of the companies that first got into integrated circuits in commercial [products] and I helped set up an integrated circuit lab pilot production for them and -- Bill Jordan. Bill Jordan. He went to, he took one of the memory technologies that we'd been working with when it was 16 bits dynamic RAM, and joined Intel around that time.

Spicer: We have a DDP 116 on display…

Knight: Do you? By Jove! Oh great. Do you have any of the dot components for the Mars?

Spicer: <inaudible>

Knight: Mariner. Yeah, so -- I don't know where those are now. I guess they're all on their way beyond Mars. But they were made from pellet components and it's amazing that it ever survived as long as it did, but it kept going forever.

Spicer: Yeah, yeah, it was launched in '73, something like that?

Knight: Yeah-- it kept on going. Yeah, something like that, yeah. Any other questions?

Spicer: I was just going to say, I guess we're a little off topic; is there anything else you'd like to leave us with? Shockley?

Knight: It was a great series of-- it was a great time, they were great people; it was one of those times when the whole thing came down to just how fast you could run and it was marvelous to see how these small companies were able to outdistance any of the GEs or Sylvania's or the bigger companies that were involved. It was thrilling; I would not have missed it for the world, and I'm hoping to run into a lot of people I worked with back at Shockley in the sixties, early sixties.

Spicer: Wonderful.

[audio off then on]

Andy Ramans: Well, I had just graduated from UC Berkeley and missed -- hadn't decided what to do with my life, and I was drafted in the U.S. Army, but fortunately they rejected me so by that time it was too late to go back to school, and I started looking for a job and saw an ad about a lab technician that they were looking for at the Shockley Labs, and I'd had both chemistry, math and physics training in college, so I applied for the job and a Dr. Kurt Hubner interviewed me and hired me there. So I started working there in the fall of 1958, and I worked there for four years.

Spicer: What kind of things did you work on?

Ramans: Well, initially we did everything ourselves, basically, we were making diodes, four layer diodes, so it was a matter of processing the silicon, doing the chemical etching of silicon, of metallization and testing, and assembling and testing of silicon. And it was all new to all of us so we were kind of learning from each other and built some of the early devices and I think soon after-- I worked at the lab for two years on San Antonio Road; there were some really brilliant scientists and technologists there, and I soon realized that I'm not going to be a scientist and this isn't what I want to do with my career, so I moved-- by that time we had started a manufacturing facility in the old Beckman Spinco building on California Avenue, so I moved into the manufacturing side of the diodes that were developed, the products that were developed in the laboratory, and I worked there for a couple of years. And that's where I met Betty and not only did I start a career there, I started a -- found a life-long friend, and wife. So then I worked there for two years in the manufacturing facility; I managed most of the diffusion room and the crystal growing and the crystal preparation departments and did that for a couple of years.

Spicer: Now, Shockley Labs was a very experimental place.

Ramans: Yes.

Spicer: And almost every piece of equipment was made by the staff. How did you go from that setting into production?

Ramans: Well, by that time, this was 1959, 1960, there were a number of vendors, a number of companies, many of them local companies, that were already manufacturing various equipments, I mean, there were companies that were making diffusion furnaces, there were companies that were making evaporating equipment; there were companies that were making photolithographic equipment. So there were -- vacuum equipment. So there were equipment manufacturers that were around at that time that were copies, if you will, of some of the original equipment and those were up for, you know, purchase, so we bought most of those equipments and used them in manufacturing.

Spicer: Did you have any interesting challenges trying to make devices, improve the yield of devices?

Ramans: Well, all of that, obviously, Shockley hung his hat on the four-layer diode and it was never a commercial success and part of the reason was we were never really able to make a hard junction, high voltage, a high holding-current device with the technology at that time. The passivation wasn't very well developed, so it was always a challenge. It was always a challenge and a lot of it was just hand work, just plain hand work. And we had some unbelievable technicians, you know, people that had developed skills both in handling the wafers and handling the assembly, assembled the devices, that could do things with a pair of tweezers and, you know, under the help of a microscope, that was amazing. So, yeah, those are always interesting and challenging times.

Spicer: Almost a craft skill.

Ramans: Absolutely, yeah, absolutely. Because a lot of it -- when you talk about production, you know, this wasn't-- well, yes, it was production, but nothing compared to the volumes that we're talking about now, so right, there were a lot of basically craftsmen in those years. And to this day I believe that some of the really good technicians that had the skills and the patience made the reputations for some of the scientists and theoreticians that designed and developed these diodes or these products, I should say. The technicians made them work.

Spicer: Well, it wouldn't be the first time in science that that's happened?

Ramans: Yes, yes, absolutely. Those were interesting times, a lot of young people, yeah, people from different backgrounds, different countries, you know, there was a huge immigration wave, you know, in the early ‘50s. There were people, you know, from Northern Europe coming to the United States, so it was just an exciting time and an exciting place to work.

Spicer: There were quite a few German physicists.

Ramans: There were Germans, Kurt Hubner, the Ph.D. that I worked for, he was Swiss, and a lot of Germans; there was a lot of Germans.

Spicer: They were very strong in physics at that time.

Ramans: Yes, yes, absolutely. Yeah, absolutely. Yeah.

Spicer: So working at Shockley, how did that prepare you for later life, if at all, and did you learn-

Ramans: Sure, as I mentioned earlier, I got into manufacturing and part of the manufacturing responsibility was growing the silicon crystals and slicing them for, you know, device use, and when I left Shockley after four years I joined a company that went into the manufacturing of silicon, was one of the original silicon manufacturers-- U.S. owned silicon manufacturing companies here in the Valley, called Siltec; I worked for Bob Lorenzini, who was also one of the pioneers in developing the equipment for manufacturing silicon, and I stayed in that industry for most of my working life and most recently, I just retired from a company called Sumitomo Mitsubishi Silicon, which is the world’s second largest silicon manufacturer in the world today, so I just retired from them. And I worked [in] various senior executive management capacities for them for many years.

Spicer: Is there anything you’d like to leave us with as a thought about Shockley and the labs or the man or your experience there?

Ramans: Well, my experience of the man was always very positive, what I remember well about Bill is that he was able to relate or talk to somebody like myself who had no theoretical background but, you know, had some university training, you know, able to relate and able to explain things and took the time and the patience, you know, patience to talk to us, so that was, I think, very encouraging for somebody like myself coming out of school, and, you know, not really being sure what career path to take. But I think the most exciting thing are some of these times right here now, where we’re talking about early or fairly recent history and we have people here that can talk about it. A lot of the history that’s being written and a lot of the historical archives and museums talk about things that happened years’ ago and those people are long since passed and we don’t have that firsthand recollection or firsthand insight of those people and their experiences. So I think that’s really exciting, and I think it’s great that the Computer [History]

Museum is taking the interest and doing these archives, so I think that's a real interesting experience for me.

Spicer: It's really exciting for us, believe me. You're a pretty interesting group of people.

Ramans: Indeed they are. I worked there, started working there after the group of people that left to start Fairchild. And over these years we really maintained -- I don't know if anybody's mentioned earlier, but we've really maintained some pretty good contacts and we periodically meet. We meet in Europe, we met here, we meet in different places and not only do we have good friendships but we have good memories, I think, from the years, and the intervening years, where all of us have spent whatever our paths have taken us.

[audio off then on]

Gene Wecker: Another fellow and I were going to school in Utah; we'd been in the Navy together and we went into Utah and were going to Utah State and he had financial problems and dropped out, came out here and got a job at Shockley working for Vic Grinich. And I used to come out between quarters, etc., and I'd visit him, you know, and I met everybody there. I can remember Harry Sello's birthday party down at Ricky's [Hyatt hotel, a local Silicon Valley landmark] one night; picture looked very much like that one that was on the brochure.

Spicer: Oh yeah.

Wecker: Except people were arranged a little different. And when I got out of school—I was in-between the first wave and what we call ourselves, the second wave--

Spicer: At Shockley?

Wecker: Yeah. And I got a job with Convair Astronautics and stayed there as long as my commitment, six months. I was one of 3,000 engineers on a cost plus fixed-fee engineering basis, so they didn't care whether we worked or not as long as we weren't sitting around talking. So as soon as my moving commitment was up, I started looking in this area and I had seen that Shockley had introduced the four-layer diode so I put in an application there and got the job.

Spicer: You're a physicist or?

Wecker: Electrical engineer.

Spicer: Oh, EE?

Wecker: Yes.

Spicer: Okay. Did he interview you or how did that go?

Wecker: Very briefly. Let’s see, I was down on the -- I was a lowly engineer, not a physicist, so I did help him work on his depth finder one time for his boat, but-- anyway, I was doing applications, originally it was just applications and then I later branched out and got more people and we were doing instrumentation for production, etc., all the test equipment. But Jim Gibbons and I would get together on Tuesday and Thursday mornings -- he was consulting at Shockley-- and we would go through all the inquiries that came in from potential customers and we’d sit down and try and answer their questions: “Can you use a four-layer diode for this and how does it work?” and I would go off after Jim left with a whole stack of things I was going to build and try during the, you know, next few days before he came back in. So we did this, I don’t know, for over a year, year and a half, something like that.

Spicer: That’s a critical part, when you’re inventing new devices?

Wecker: Yeah, and it was really fun, and we were doing everything from building electronic organs, you know, to radar pulse generators for the magnetrons. I can think of one in particular that we did for Bendix that was a low altitude radar altimeter. And so there was just, you know, a world of different projects that we worked on.

Spicer: Now, the four-layer diode was basically a very high speed switch, is that right?

Wecker: Yes. One of the things that helped me get a job there was I had worked down in Las Vegas for EG&G, during one of the [atomic bomb] test series and we were working with milli-microsecond -– nanosecond pulses down there, which… I came back to school after working there for four months and, you know, we were looking at rise times of 7/10ths of a microsecond or something like this, and they thought I was -- you know, had been smoking something. And you know, that was, in the nuclear instrumentation -- so when I went to Shockley, I was one of the few people who had worked with that kind of pulse rates, so --

Spicer: A lot of Shockley, of course- people who came here before for interviews emphasize how much they had to sort of roll their own -- and all the equipment was handmade, pretty well.

Wecker: Yeah, well, all the test equipment we had to hand make.

Spicer: How do you, when you deal with something that switches in nanoseconds, or very quickly… is there actually test equipment available for you to even characterize devices that fast or that novel?

Wecker: Well, it came along pretty fast. When we were down at EG&G in Las Vegas we had traveling wave oscilloscopes which had three gigahertz bandwidth, but they were very complicated to use, etc., they weren't a bench-type unit. You know, one of the jobs I had down there during the summer was to measure the attenuation and phase shifts through the TWT [Travelling Wave Tube] structures, because they had a whole bunch of these TWT structures, oscilloscopes that were looking at the pulse, neutron pulse that came from the explosion, and it would go into one structure out into the next structure and out, etc. And we'd measure the phase shift and attenuation, and then they'd use that to calibrate and decide how much energy came out of it. It was -- that set me up good to work on four-layer diodes.

Spicer: How long did you work at Shockley?

Wecker: I started -- I think it was something like March, February or March of '59 and I left about March of '63.

Spicer: You saw some changes during that time?

Wecker: Pardon?

Spicer: You saw some changes in personnel?

Wecker: Well, the original group, first wave, left before. And there were some changes though even after I got there. I was on the leading edge of the second wave.

Spicer: What was it like to work there? Was it pretty collegial or stressful?

Wecker: No, it wasn't to me. I really enjoyed it. I was doing a lot of fun things, and Rudy Beasley was brought in just before I got there to be the operations manager; he reported to Maurice Hannifin, who was the general manager; Maurice -- Maurice, actually, was the founder or money behind Royco Instruments, Spinco Instruments, a whole bunch of these instrument makers that sprung up around here during that time period. And Beckman put him in charge of Shockley, and Maurice didn't even have a high school diploma. He [was a] very successful, self-made man and a real gentleman's gentleman. Anyway, he brought in Rudy Beasley to be the operations manager. Rudy was an old time engineer, electrical engineer, and I guess he took a liking to me because he gave me an awful lot of responsibility for somebody right out of school, you know. I got an awful lot of responsibility, and that helped. I also got into the honor's program at Stanford, which I didn't finish it at that time. I finished it later when I was at Fairchild.

Spicer: Is there anything else you'd like to say about having worked at Shockley and maybe the companies you worked with afterwards and how Shockley may have informed your--

Wecker: Well, my contact with Shockley--

Spicer: Shockley Laboratories, more than the man.

Wecker: Oh, okay. It was just a great experience, you know, we were doing leading edge work, and being an electrical engineer, I, you know -- As a matter of fact, when I went to school, they didn't even know how transistors really worked yet, you know, in the textbooks, so they -- Terman had some models in there, but they weren't really good, it wasn't until I went to school and took [Jim] Gibbons' course that I really learned how they worked, and his course was based on a lumped model approach which was very similar to the old transmission line theory that I had studied, so it was kind of easy to make that transition.

Spicer: And Shockley's book, of course, "Electrons and Holes…"

Wecker: Well, yeah --

Spicer: It was a classic.

Wecker: It's still a classic.

Spicer: Although really dense.

Wecker: Yeah, you don't do it for reading enjoyment.

Spicer: Intimidating that's for sure. Well, I think we're out of time; is there anything else you'd like to say?

Wecker: No, it's just been a very good bunch of people I worked with, we all get together periodically either in this country or in Europe and have a few days -- we try to do it every year, and the group is falling -- you know, getting less and less every year.

Spicer: Yeah, but it's great you do that. Obviously, a special company.

Wecker: Well, you know, Jacques and Andy and I are still very close and Andy's probably one of my best friends.

END OF INTERVIEW

