Oral History of Gerald K. “Skip” Fehr

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Duane Wadsworth: We're talking with Dr. Gerald Fehr, better known as Skip Fehr. Welcome to the Computer History Museum.

Gerald F. “Skip” Fehr: Thank you.

Wadsworth: We're anxious to hear the story about packaging and assembly in the semiconductor industry. This is an area where we don’t have oral histories for the Computer History Museum, and it's very, very important. Let’s start with the beginning, Skip. Where were you born and where did you grow up?

Fehr: I was born in a small town in Iowa on a farm. And I grew up there through high school. Went to the same grade school on through high school the whole way. And then, I went to Iowa State, Ames, and took ceramic engineering with an industrial engineering minor. I graduated the first time there in 1959.

Wadsworth: How did you happen to choose a major like ceramic engineering?

Fehr: It really was the only study that was materials engineering. That looked to me like one of the fields that was growing. Quite truthfully, when I checked at Iowa State, it was the school that got—as I graduated, the most money.

Wadsworth: Really?

Fehr: Yeah, engineering.

Wadsworth: They didn't have a materials engineering curriculum?

Fehr: Not at that time. They have since changed the name to materials engineering.

Wadsworth: Now, ceramic engineering is a wide field, everything from toilet bowls to ceramic semiconductor packages.

Fehr: Yes. That's true. And, of course, I chose to go the more technical side. But it also included a lot of metallurgy, some plastic studies, and so on. So it actually was fairly broad in materials. And like I say, later on, they actually changed their name to material science and engineering.

Wadsworth: Oh, they did? So it's not called ceramics anymore. Did your parents have any thoughts about your choice of a major in college?

Fehr: No. They just wanted me to go. On the farm, I'd had so many allergies that it was a problem.

Wadsworth: Did your father make a living as a farmer?

Fehr: Oh, yes. My brothers did too.

Wadsworth: How many acres did he have?

Fehr: At that time, it was about a little over half section, 320 up to around 400 or 500 something.

Wadsworth: What did he grow?

Fehr: Corn and soybeans. Same thing today.

Wadsworth: Big change and so forth. Who did you look up to when you were a kid growing up?

Fehr: You know, I didn't have a real hero when I was growing up. Later on, in college, of course, a major professor became one but not until then.

Wadsworth: Were you influenced by guidance counselors in high school or your parents?

Fehr: No. I decided that I wanted to go to college. And it really came down to between either a medical degree or engineering. And I chose engineering.

Wadsworth: Did you have siblings or anyone that preceded you in the field?

Fehr: No. My brother had started off to school, in medical school. And he decided he didn't want to do that. He went back to farming. I think he'd been through his first autopsy and that did it. So I went to college. And, of course, that first year of school, engineering was basically the same. So you could take everything, you know, the basic math, the basic physics, chemistry and so on. And then, move on. In your sophomore year you really had to select. But by that time, I was with materials.

Wadsworth: After your Bachelor's Degree, you decided to go on further?

Fehr: Yeah, I went to the Air Force first. I'd taken ROTC at school so I went to the Air Force. Kennedy had helped me out to a few extra months. So when I got ready to get out, it was getting close to school starting again. I called back to Iowa State. The major professor there was willing to let me get there, a week or two late and get in. And he had a good Army assistantship that paid. So I went back to Iowa State.

Wadsworth: How long were you in the Army?

Fehr: It was supposed to be three years and I made it about three years and six months.

Wadsworth: And where did you serve?

Fehr: I served down at Edwards Air Force Base as a research and development officer, a really nice duty. There's a lot of stories that came out of there. But that's probably not part of this interview.

Wadsworth: Well, no, that's interesting. Because it certainly wasn't—so many people feel our military service was wasted. You could've been in the infantry.

Fehr: That's true.

Wadsworth: What branch were you in?

Fehr: I was in the Air Force. One of the major programs we had, we were developing the ejection seat for Mach 2 airplanes. And so, they instrumented the bears and kicked them out at Mach 2.

Wadsworth: Now, in those days, most people had a long reserve obligation past their active duty. Did you have that?

Fehr: No, I did not. They asked me if I wanted to sign up. But I did not.

Wadsworth: So you got out of the Army and back at Iowa State?

Fehr: Yes.

Wadsworth: And for a master's in . . . ?

Fehr: Master's just—you know, the intent was to go through all the way right for the PhD. The master's took me about a year and a half. But that was because I was going on through for the PhD. But I ended up with a PhD in just three years.

Wadsworth: Gee, that's fast, isn't it?

Fehr: Very quick.

Wadsworth: How big was the PhD program?

Fehr: Well, engineering at Iowa State's big. But in the material science department, we probably had about 20 or 30 students in the graduate study class.

Wadsworth: There you are with a newly minted PhD and the military behind you. Were you married then?

Fehr: Yes. Had two kids already by that time.

Wadsworth: Wow. So that implies that it was necessary to put a slice of bread on the table somewhere; right?

Fehr: Yes. Yes, that's true. The thing that helped me the most was my major professor had an Army contract. And I got to work on that. And so it gave me a nice stipend. But I had no choice in selecting the project. You know, the project was whatever the Army was willing to pay for.

Wadsworth: And what year was this now that you got your PhD?

Fehr: I graduated with a PhD in 1966.

Wadsworth: And I've forgotten what the economic situation was in the country then for jobs.

Fehr: Actually, quite good. We were fortunate in that sense. I had probably three or four job offers at the time. I had a choice between Texas Instruments, where I went. And then, Ford Motor was offering in the

glass division. They were floating glass for the windshields and things of that sort, the windows. And I chose between them and finally chose Texas Instruments, the electronics side.

Wadsworth: Did you know much about TI at the time?

Fehr: Only as one of the larger integrated circuit houses.

Wadsworth: Did you go down there and interview? Or did they interview in Iowa?

Fehr: Well, they interviewed at Iowa State. And they did that four times a year, which was a little bit surprising. But they had found that the work ethic was good. If you graduated out of Iowa State, you had to move. So that question's already solved. And so that they had good luck. And they'd had a lot of people out of Iowa State already, which they liked.

Wadsworth: Oh, really? From the program that you were in?

Fehr: Yes.

Wadsworth: What did your professors think of your choice of Texas Instruments?

Fehr: Well, it was funny at the time. When I got my first job, my major professor called and asked me what my starting salary was. And at that time, he said, "Do you know you're making more than I am?" And I thought, "Boy, that's a surprise." Because he had been out in the industry and of course had done a lot and made a lot more. But when he went back to school to teach, he took a real cut in pay.

Wadsworth: Wow. You know, one forgets what the starting salaries are. I mean, they seem low compared to what . . . ?

Fehr: Starting salary at the end of '66 was $15,000. Not much.

Wadsworth: Of course, that was a lot more money than $15,000 is now.

Fehr: Yeah, a lot more money than now.

Wadsworth: And did you enjoy living in Texas?

Fehr: Yes, I did. I lived, actually, Farmer's Branch, a little town just outside of Dallas.

Wadsworth: Wet or dry?

Fehr: It was dry as far as liquor? It was a state where you took your own bottle in with you and paid a cover charge if you wanted to drink with your dinner.

Wadsworth: And what was your first job title at Texas Instruments?

Fehr: I was a development engineer in the packaging part. We were making packages actually inside Texas Instruments that we sent mainly to the integrated circuit division. And they put the die in and so on.

Wadsworth: How big was the packaging department?

Fehr: Oh, I think we had around 1,200 people.

Wadsworth: In the packaging department?

Fehr: In the packaging department. It was big. We were making two million of the TO5, TO18 type of packages a day.

Wadsworth: What did you know about glass to metal sealing? Because these were matched seals and compression seals, versus ceramic packaging.

Fehr: Yes. Well, in the study, we got some glass, of course. When we went down there, it was fairly easy to establish that, you know, the real requirement for the Kovar type of headers was the oxide coating. And once you got the oxide coating thickness just correct, then the glass sealing went through the furnace, made good contact. And the yields were, I don't know, 99.999 percent.

Wadsworth: So the seal is actually to the oxide, not to the metal; right?

Fehr: Yes.

Wadsworth: I see. In those days, other companies were making their own packaging, too. But, of course, that did not last. But during your stay at Texas Instruments, they continued to make their own packaging?

Fehr: Yes, we did.

Wadsworth: Were you able to keep track of what was happening on the outside with vendors supplying these packages, too?

Fehr: Yes. In fact, Kyocera—we were making our own ceramic packages and Kyocera wanted in. And I had gotten approved and we'd actually started up our own ceramic manufacturing line with the pressed ceramics and the whole bit. And then, suddenly, the prices from Kyocera dropped. And I got called into Bucy's office, who was the head of it, said, "You know, we're going to kill your project here." But he said it was okay, because he said the drop in prices from Kyocera at the time was going to more than pay for what we spent setting up our ceramic business. But then, we continued to make the glass seals and some other products.

Wadsworth: So it's an economic situation. It wasn't a technical issue, at all?

Fehr: That's right, when we got stopped. That's right.

Wadsworth: And how many years did you stay at TI?

Fehr: About three.

Wadsworth: And then, what happened?

Fehr: Well, then, I got a call one night from Andy Grove, from Intel. They were starting up. They were looking for somebody to run their packaging group. And actually we were having a party at the house at the time. So we talked probably 45 minutes on the phone. He invited both my wife and I out for an interview. We went. I interviewed with Bob Noyce, Gordon Moore, and Andy Grove, and got hired.

Wadsworth: How did he happen to single you out? I mean, there's 1,200 folks in your packaging department there. Why did you stand out so?

Fehr: Well, I think the—I had given a couple of talks. And one of the vendors came in. And Andy wasn't particularly interested in buying from the vendor. But he was saying he was looking for somebody. And the guy said, "Oh, the person you want is Skip Fehr." And he gave him my name and number. And gave him, I think, a copy of the talk. And so that's how it got started.

Wadsworth: Do you remember what the talk was?

Fehr: No. <laughs> It's been too many years.

Wadsworth: So you came out here to Silicon Valley and interviewed?

Fehr: Yes.

Wadsworth: What did your wife think about the possibility of moving to California?

Fehr: Well, she had mixed emotions. She liked the Texas house. But I interviewed that morning. We went to lunch, came back. I stepped into the restroom, came back out, and he offered me the job. And it's kind of history from there. I was employee number 32.

Wadsworth: Oh, employee number 32.

Fehr: At Intel. I had given TI—I had gone back and gave TI a month's notice. And they took it. Otherwise, I would've been, like, employee number 15 if I gotten out here earlier.

Wadsworth: Thirty-two isn't bad. And was this a newly created position at Intel?

Fehr: Yes. Intel was just starting up. That was 1968. And so I was in charge of the packaging, assembly, and final test.

Wadsworth: The whole *enchilada.*

Fehr: Yeah, both, manufacturing and engineering.

Wadsworth: And to whom did you report?

Fehr: Andy Grove.

Wadsworth: Directly to Andy Grove?

Fehr: Interesting.

Wadsworth: Well, we'll get into that a little later. What did you see in the beginning as the biggest differences between the TI way and the Intel way?

Fehr: I think the biggest difference was in their management style. TI had a system at that time, it made you a better manager than you really were. And I give that kind of to Bucy, who was the head of that division at that time. You know, the rest of Intel really were Fairchild people, who didn't have quite that discipline that came out of TI. So I, you know, continued to use that discipline, although I didn't push it at Intel.

Wadsworth: What did you do to build your department?

Fehr: Well, we started, when I got there, they had purchased one die attach machine and one wire bonder and one scriber, in the old days. And they had one technician. And so at that time, we built everything. We went into plastic packages. We went into the CERDIP [ceramic dual in-line] packages and into the side braze. You know, mainly, Intel at first was a memory house. And so almost all the product was DIPs, Dual Inline Packages.

Wadsworth: But, of course, the difference there also was you now were dependent on outside suppliers?

Fehr: Yes. That's true.

Wadsworth: And that must've been a little change . . .

Fehr: A little different.

Wadsworth: . . . for you, too. And now, was this at the Intel location on Middlefield Road?

Fehr: Yes, it was.

Wadsworth: That was the first Intel building.

Fehr: First place.

Wadsworth: Who was the first person you hired?

Fehr: You know, I don't remember. I hired a couple of engineers. And also, then, we started off with some operators. We had a tech. It turned out the office was right beside the Fairchild hiring office. And so sometimes <laughs> we'd get people over there that just got in the wrong door. And if we liked them, we hired them.

Wadsworth: Of course, you also were steps away from a famous bar called Wagon Wheel?

Fehr: Yes. That's true.

Wadsworth: Did you hire over there?

Fehr: I did not. I went to the Wagon Wheel one night with somebody. And I was sitting there in a booth and listening to the business that was going on in the next booth. And, you know, hey, there's all kinds of company secrets being talked, at least in my opinion, right in the very open. So, obviously, these two gentlemen had too much to drink and they were a little open. But I guess that was the Wagon Wheel.

Wadsworth: I think it was. And the museum is fortunate enough to—when the Wagon Wheel eventually closed—chip out one of the wagon wheels that was embedded in the building. And we have some other memorabilia, including a piece of the bar. And unfortunately, we didn't get a barstool, where I think many livers were left <laughs> from the people. Those were interesting times. In the museum here, we have an exhibit of IBM: Thomas J. Watson Jr., who was the President of IBM and some of his interesting management styles. But he was adamant about no drinking and what people. And it's an interesting contrast compared to what happened with the semiconductor industry, which used to be noted for very heavy drinking.

Fehr: Yes. At least part of what I saw. But, you know, I was not a real fan of the Wagon Wheel after my first visit.

Wadsworth: So you did catch the Intel part with the memory packaging?

Fehr: Yes. We did both the MOS and, at that time, some bipolar. The bipolar was later killed. They didn't think the memory part of bipolar would be big enough to keep it. To emphasize the engineering effort, they just put it all on the MOS side.

Wadsworth: But this is before the 4004 and the beginning of the microprocessor; right?

Fehr: Yes. I was there when—actually, Gordon Moore's the one that hired Ted Hoff to get into the microprocessor and so on. And, you know, I don't think Ted and Andy were ever favorites of each other. Because Andy, you know, believed in the memory at that time. But then, Gordon was the one that persisted. And, of course, for the two groups we only had one big computer for all of our various studies and all the development work for the programming and also, for our own reports. And they'd come in. And they'd just turn on that computer and start it up. And they took all the time. We just couldn't get our reports out. So we finally, after negotiation, said they wouldn't turn it on until at least 10:00 in the morning. And so they started coming in later and staying later.

Wadsworth: Did you find Andy Grove a demanding boss to work for?

Fehr: Andy was a different kind of boss. One, he was super intelligent. No question about that. You'd get into discussions of how you wanted to do something. And he kind of believed it ought to be his way. And that was of course what you'd end up doing; you'd go to some bar at night. And you'd argue this until, like, 2:00 in the morning sometimes. I finally, one night, said, "Andy, you're the boss. We'll do it your way. Let's just agree to disagree." And I'm his chapter in that book about agree to disagree. So I'm almost positive <laughs> of that.

Wadsworth: It sounds like that the job at Intel was not a 9:00 to 5:00 job then?

Fehr: Oh, no, no, no, no. I was there probably 7:30 in the morning until 7:00 at night, usually.

Wadsworth: When did the offshore assembly start to come into Intel?

Fehr: Oh, it was fairly early. I joined in late '68. By 1970, I'd established a plant down in Mexico. Now, when I say "established" it, we went into a company that was doing assembly work. And we hired the equivalent of 100 operators and supervisors and a few things, just in our own room. They were their employees. But we paid them and we guaranteed that we'd take—we'd pay for all hundred, whether or not we sent product down to be built. And so I had that done. And then in 1971, I think, we set up the Intel plant in Malaysia.

Wadsworth: '71? That was the large plant?

Fehr: Yes, at first, I went over to help set it up. We had hired a gentleman to get the building up and going. He kept saying it was on schedule, it was on schedule. It turns out that wasn't quite true. But when it was on schedule, at a certain point, I hired, I think it was the Boeing 707 at that time. We had loaded up all the equipment and we flew it over. When I got over there, there wasn't any air conditioning. There weren't any walls in the building. Literally, there was a water buffalo walking through the plant. Because this one kid would—this little boy, I don't, if he weighed 60 pounds, I don't know. And this water buffalo must've been 2500 pounds. You know, he was leading him back and forth every day.

Wadsworth: They weren't DI water buffalos?

Fehr: <laughs> No, they were not. So we got the walls in and got some temporary air conditioning and moved it up and got it going.

Wadsworth: For the benefit of those people reading this, there's two parts, simplistically, in the semiconductor industry. One called the “front end”, which is the fabrication of the chips through wafer fab. And the “back end”, which is assembly and test and so forth. And _____ doesn't often meet there.

Fehr: That's true.

Wadsworth: Would you comment on the early issues of—oh, I've heard expressions like “the prima donnas in fab looked down on the packaging and test” and so forth.

Fehr: Well, that was basically true. Andy, in all fairness to him, that was one of the things he did try to keep going as smoothly as possible. I can remember one time we were having glass on the pads. And they just weren't taking it out well enough in fab. And we set up a couple of tests to prove that. And Andy supported that very well. I mean, we had to give good products. Suddenly, our yields jumped a couple of percent and, you know, all of the yields went up. But in the sense of management style, that is probably my biggest disappointment in the industry. And the industry's very good to me. Don't get me wrong. I enjoy that. But the back end, the assembly test, I think it was considered to be anybody could do that job. And so oftentimes, our plant managers would come out of production control. They'd come out of almost anywhere, a couple of engineers they wanted to promote out of wafer fab came over there. These people knew absolutely nothing about assembly. And so it became our task a little bit to make sure that they didn't get in trouble. Because if they did, the company got in trouble. And that you just couldn't do. You know, you had to keep that going.

Wadsworth: What kind of packaging issues did you have, such as space, size and so forth? You know, you were forced to package something that was done on a wafer and cut into a particular size chip. And what about thermal issues? Did you have purple plague issues? Or what were your biggest challenges in the early days at Intel?

Fehr: Okay. Purple plague was basically understood by that time. We never saw that problem.

Wadsworth: Could you define exactly what purple plague was?

Fehr: Well, purple plague was if you had an aluminum pads on the wafer, and most of them are aluminum, 100 percent essentially. And you put gold on it. And you got it up to a certain temperature, the gold would—or actually the aluminum would migrate into the gold. And pretty soon you had no aluminum left on the wafer pad. And you just had an electrical open. So what we ended up doing, of course, was using the ultrasonic aluminum wedges. And put aluminum on aluminum. And it was okay. Now, if you put the aluminum onto the gold on the package side then, you had thick aluminum, you know, a mil or two thick. And it was more than enough. It'd go into the gold, reach saturation and you just never saw the problem on the package side. So it was always on the die side. But you understood that. But you just kept those problems from happening. But the other problems we would have mainly, at Intel and some of the rest of them, at LSI Logic later on, was the growth in lead count. Intel didn't ever grow too much in that. We went up to the 40-lead and maybe a little bit more. But when I was there, about 40-lead was the biggest we had.

Wadsworth: The thermal issues, it would seem to me that your ceramics background, of course, handled some of the thermal issues better than glass to metal seals, obviously. Would you comment on that?

Fehr: Yes. The ceramic actually was a pretty good conductor of heat. Not as good as some of the other things. And we would put maybe some copper bases and a few things in there to help, if we really had a hot package. But most of the time, I could get ceramic to handle it pretty well. There were some products that we just couldn't put in plastic because we couldn't dump out the heat as we needed to. But most of the time, at that point, ceramic did reasonable.

Wadsworth: How did you interface with the suppliers of these packages, technologically? And you were looking for innovations to come from them at your suggestion? Or how did that work?

Fehr: Well, on the package design, we did all of those ourselves and then gave them the design. Because we wanted to make sure that electrically the package would do what we needed it to do, particularly as the devices got faster and faster. We started to have to have certain ground pads and certain ground leads and low inductance and things of that sort. But other than that, we would talk to

Kyocera. Most of our ceramic packages came from Kyocera. And, you know, we changed some materials and designs, but most of the time, we had them do their own development. But they were very cooperative, one of the better companies I've worked with. We worked a lot on the plastic side with Sumitomo, and they were very good for us on that side. And of course lead frames, there were many sources of lead frames. If you could use the stamped lead frames, they were cheaper. But we used a lot of etched because we had higher lead counts than normal.

Wadsworth: Intel had a policy of copy exactly for their plants. This policy has been criticized by some as not really fostering great innovation. If something was locked in that it would be very difficult for something new to get evaluated, even evaluated at Intel. Do you have any thoughts on that policy?

Fehr: You know, in my days there, I didn't see that. Andy was always pretty good open on that. He was my supervisor so he was always pretty good about if there was any innovation that we thought we could use. We ran into a couple of things where we had to. One of the new die that came out, one of the new processes, just wouldn't take the temperature of the glass die attach. And so we had to go into what was essentially an epoxy type of die attach. To get that approved we had to do a few things. So during my days at Intel, I just didn't see that problem. And maybe I was far enough up, you know, working direct for Andy that if it was there, it didn't come across as an issue.

Wadsworth: Now, in the meantime, did your department grow?

Fehr: Oh, yes. Yeah, we had the—well, at one time, if you counted every operator and staff, we would've had, like, 5,000–6,000 people reporting in. But, you know, not all operators were in our plant sometimes. We were doing a lot of work outside, too, you know, at subcontractors.

Wadsworth: Did you continue to travel a lot to Mexico and to Malaysia?

Fehr: Yes. We finally closed the Mexico plant, just when the Malaysian plant got up. But I would be overseas between our own Malaysian plant and then, of course, into the Far East plants. We had some work being done in Singapore, some in Hong Kong. I would be out at least a month every quarter.

Wadsworth: Did you spend a lot of time in Japan with the Japanese suppliers?

Fehr: Not to that extent. I went there, would make some trips sometimes when we were looking for something special, either going into Kyocera or looking for some molds or some wire bonders, equipment etc. Then, I'd make a trip. But usually that was a stint of a few days at each place and that was it.

Wadsworth: What project or accomplishment were you most proud of at Intel that has the Skip Fehr stamp on it?

Fehr: I would think setting up the Malaysian plant because I actually went over there for six months. And, like I say, we went from no walls in the building with the water buffalo there to that sixth month we shipped 100,000 parts each of the Sidebraze, the CERDIP and the plastic parts.

Wadsworth: Did you choose the manager of the plant?

Fehr: Yes we did. Actually, for a while there we actually brought over an American, took over an American and so Bob Wallace was the guy that replaced me. The rest of the managers were nationals. There was only the one U.S. person. We had a very good crew. It was excellent that way. Before I left to start up their plant there Bob Noyce called me and said, “Hey, I need this much product in this amount of time.” And so I said, “There’s no way to do that and train the people” which is what you were supposed to do over there. So I hired qualified or already trained people out of National and some of the other places and that of course caused a little bit of an uproar. They came to see me, they went to see Bob Noyce and Bob had already told me, he said, “They will call me, but you’ll never hear from me. I’ll tell you, yes they’re going to come see me and I’m going to say ‘yes, I’ll take care of this and that’.” So by the time we get done the plant will be up and you’ll have your own training crew going and you’ll be alright which was true.

Wadsworth: Well Noyce apparently was noted for not wanting to be confrontational. So Andy Grove didn’t handle those things and it would have eventually ended up at Noyce.

Fehr: Yes on this point I don’t know why I got this word from Bob but he called me just before I went over to Malaysia and said, “I need this amount of product in this amount of time and you have to get there.” And that’s when I had the discussion about “You know, I can’t do that and train my operators at the same time” because his time level was six months and you know, it’s going to take two to three months. We had to start from scratch training people and so I hired a lot of experienced operators. The government came up and complained to me giving me a hard time and I finally said, “Well I got to tell them I can’t hire them anymore.” He said, “No, no, you can’t do that. You know, they’re free to move wherever they want to.” And we, at the end of that meeting, agreed I can steal 30 a month and went on from there and that’s about what I needed for another three months.

Wadsworth: Were there any or many situations where limitations on your assembly operation hindered serious shipment issues?

Fehr: I don’t think so. Technically we were capable of doing almost anything anybody else could do. I think the first few months starting the Malaysian plant production was probably a little tight because we

really relied on that Malaysian plant. It’s grown much, much larger now. I know when it first—I got my schedule of what I had to ship and I was shipping that amount and I told my production control guy, “Hold back on some product shipments and just go a little bit above the schedule so I would have a little cushion for the next month. Well about the third month of that, Gordon, I guess is the one that chartered the shipments vs. schedule and caught on. He said to ship the rest of the parts, which we did.

Wadsworth: I was going to ask you if you interfaced much with Gordon Moore and you said you didn’t.

Fehr: Not too much. He was—Gordon was really, at Intel, I think, the person that had the foresight of what new products to get into and that’s where he kind of stayed. Andy ran all of the operations and of course Bob Noyce could get in to see anybody so he was always a great sales tool for everything.

Wadsworth: It’s a very interesting trio.

Fehr: Yes it really was. They worked extremely well together. I don’t think either Bob Noyce or Gordon Moore ever had to fire anybody. Andy always did that job.

Wadsworth: You, in your early days, when you were in Iowa, Fairchild wasn’t a job prospect at all maybe before TI or anything?

Fehr: You know, when I got out of school, TI was the one that came in and interviewed. Actually, I did interview essentially twice because they came every quarter.

Wadsworth: How about Motorola, did they interview?

Fehr: No they did not. General Electric did multiple interviews each year as did other companies but I didn’t see Motorola.

Wadsworth: A lot of people seem to forget that there was a semiconductor industry in the East Coast. You ask someone in Silicon Valley about Transitron and you get a blank stare. It’s very, very interesting. Because Intel is such a high profile company and you were so important in early parts, let me ask you a point on the saying that you can’t build something unless you can test it, so test was under you too and that’s a completely different thing from die attach, wire bonding and so forth. How did you handle that responsibility?

Fehr: I had final test. The wafer fab people had wafer Sort. So as far as the technology of the testers themselves, the Wafer Sort manager actually ran more of that than I did. Now the part that I got into was

the speed testing because you didn’t speed test on Wafer Sort. But for most of the product, the design group, when it came out with the product, had to make sure that their product was testable. And so they came out with the programs to test it. They knew how fast they could run some of the products. Now CMOS never got quite that fast but some of the bipolar product that first started out, actually would run a little bit faster than the testers would and so you had a problem that you started just lowering the voltage and saying, “If it still runs that fast at this voltage it will run faster at its correct voltage…

Wadsworth: But you had to get involved mechanically with things like handlers of the parts in and out of the testers?

Fehr: Oh yes. All the handlers and of course I learned pretty quick on even the testers themselves that if this tester wasn’t running correctly, if it started getting too many failures or something was wrong I could go in and change boards on the testers.

Wadsworth: Really? Did you depend a lot on your tester vendors?

Fehr: Yes. Most of the vendors would supply us testers and they would come in and maintain them on a routine basis but we had our test crew. I had a couple test engineers reporting to me.

Wadsworth: Now TI made some of their own equipment, wire bonders, they made testers and all of those things in the early days but Intel seems to have been totally dependent on outside vendors for equipment.

Fehr: Yes. We never got into building equipment at Intel at least on the assembly side. Now we would go back to the supplier and say we want certain modifications on the hardware and things of that sort and get it done. So we did that but the basic wire bonder itself was always a K&S or a Shinkawa or a vendor-supplied thing. It’s the same on the die attach equipment and the saws. We went to sawing very quickly. Scribers were going out and laser scribing was throwing so much dust all over the die <laughs> and they would short out even they were a good die to start with.

Wadsworth: Things seemed to go full circle. We have a very nice Tempress scriber in the museum collection. The industry went from the diamond scribing to the sawing to the laser and apparently diamond scribing is back again. Is that true?

Fehr: I understand it is, particularly for some of the real thin wafers, where it starts to work well. When we were assembling, most of our wafers were 10 mils thick and scribing didn’t work real well. It left little cracks going in and out and also it was more operator-dependent on how good the operator was. I had

some operators good enough that they actually had their fingers on top of the scriber controlling the pressure.. But that you can’t teach, it’s just something that somebody does that for months and years.

Wadsworth: Wasn’t that true with hand scrubbing that the operator was so important?

Fehr: Oh the old die attach days. Yes, when we did manual die attach. The guy with the tweezers would manually scrub in the die. How good they were and how fast they were was variable. There seemed to be two grades of operators, one that could do what I thought was a reasonable job but there would be a few that would stand out that could do twice as many for some reason.

Wadsworth: Did you have any comments on your decision to keep part of the assembly operations still in Mountain View/Santa Clara.

Fehr: Yes.

Wadsworth: The comparison of the Asian operators versus the American domestic operators here.

Fehr: Actually I thought they were both, when they were at the top, really very equivalent. We did all the new products first in the US and so that—they always got the largest die, they always got any new issues we had to work out. But of course they’re right there so you could work with them and get that worked out before we sent anything overseas and, of course, any real brand new products that we didn’t want out very far as far as just the intelligence of it, they stayed here for quite some time just to make sure.

Wadsworth: And you said you were working with thicker die so was this really before the back grinding era of the very super thin die?

Fehr: Yes, at Intel at that time it was. Now, of course, now you’re down to 2-mil thick and require a few things to solve some other problems.

Wadsworth: So you did not get involved with wafer back grinding?

Fehr: Not at Intel.

Wadsworth: How many years were you at Intel before you decided to leave?

Fehr: I guess around eight or nine. I was getting kind of burned out. It turned out that Noyce when we first got started had a dinner one night and mentioned that 60 percent of you gentlemen are going to be divorced before we get through this. I didn’t think he knew he was one of them but he was very correct. And the other 40 percent had problems and I was one of the 40 percent so it was time to leave. So I went on to a couple of other things that worked out quite well for me and then of course back into LSI Logic which also was a startup.

Wadsworth: That’s right; you were involved with a couple of other companies. Do you care to itemize those?

Fehr: Well one of them was actually Burroughs when it was still in existence down in Escondido. That was very nice duty. That was truly the first time I had an eight to five job type of thing. It was a small crew. We built product for the big computer houses, for Burroughs itself of course. And some of those big computers didn’t take a lot of a certain amount of product and so the very specialized stuff, we built for of them and that was it. And there we had some real thermal issues. We had some molybdenum heat sinks so we really could throw off watts.

Wadsworth: Did they have a wafer fab, Burroughs?

Fehr: Yes.

Wadsworth: In San Diego?

Fehr: Yes in Rancho Bernardo but yes.

Wadsworth: Did you move down there?

Fehr: Yes. I lived in Escondido which is about five or six miles away from Rancho Bernardo.

Wadsworth: And how long were you at Burroughs?

Fehr: About three years and then one day we went to some company dinner that they were giving and the VP announced to us, reminded us all that they were a computer house, not a semiconductor house. About half of us kind of looked at each and said well that’s the writing on the wall. So we started looking around and I got a call from Jack Higbee who was a good friend joined LSI Logic, which was just starting up and he called down and made an offer. And of course it was an easy jump.

Wadsworth: Was the family happy to be back in the Bay area?

Fehr: You know, it was funny, when I moved down to Escondido none of the kids wanted to go. When I came back, neither one of them came back with me. Both of them stayed in Escondido. My wife was glad to be back. I was kind of glad to be back. My sons had became associated with a lot of friends down there and they just wanted to stay.

Wadsworth: The product line is different, was LSI Gate Array high-lead count package…

Fehr: Yes. Yes that showed up in a lot of different ways. We were one of the first houses I know that were up at 256 leads and that was when we were first going. That was a big lead count. We had one of the customer designers come in and he stood there. He went out, we put him a chair in the middle of the assembly floor and he stayed there for at least four hours watching to make sure we could really build that product. When it became known we could build it, he went back in and signed the design contract. There were several examples of that.

Wadsworth: Because of the high-lead count were these strictly done on automatic wire bonders, there was no hand bonding.

Fehr: They’re automatic in the sense that once you started the machine it would go. When you first started you would have to align it and then when you get it aligned then it would wire bond the rest of it automatically. Because we were doing a lot of ceramic at that point with the ultrasonic bonders, they were never too fast. You had to do the alignments. We set up with three wire bonders around an operator each in a laminar flow hood and she could just start one then the next one then the next one then come back around and get it going. So it really wasn’t too labor intensive although it would take over a minute to wire bond each part.

Wadsworth: Even though the product line was different at LSI Logic, it sounds like you may have inherited the same vendors.

Fehr: A lot of the vendors were the same, yes. And of course here with LSI we got more heat, more thermal problems than we did at Intel.

Wadsworth: And how about test on that one, final test?

Fehr: Didn’t have final test on that. They separated that out. Well I did have it at first, excuse me, then finally, later on, they finally put all of test back together with wafer sorting.

Wadsworth: And were you the number one package assembly at LSI Logic when you went there?

Fehr: Yes, yeah. I had all the operations for assembly and test at that first to start and then later on test got moved.

Wadsworth: Of course that was a new company then too, is that correct?

Fehr: Yes I was employee #10 up there.

Wadsworth: The number’s going down.

Fehr: Yes. <laughs>

Wadsworth: And to whom did you report over there when you went?

Fehr: A gentleman by the name of Jack Higbee. He had been at Fairchild. He had worked for Wilf Corrigan at Fairchild and thus was on the ground floor at LSI Logic.

Wadsworth: Now these were the days, maybe not at TI but certainly at Intel and I gather LSI Logic where engineers went there for x-number of dollars salary but weren’t there stock options for most employees at your level and so forth?

Fehr: Oh yes. In fact at Intel the stock options went all the way down to the operators. Everyone got stock options. So that stock was very valuable because that’s part of what helped me out a lot. And LSI Logic too had them all the way down so they’ve made a big point of that.

Wadsworth: In those days when you considered a job offer, how much importance would you sign to the options versus the salary?

Fehr: When considering a start-up company, knowing the people at the top more important than the company. The stock option was more important than the salary. You were going to make more money than you did with the salary. At other companies that’s not true. If you take a look at it and say I don’t believe those guys are that fantastic. They’re not a Noyce, they’re not a Moore then you want to get your salary.

Wadsworth: What year did you go to LSI?

Fehr: I think it must have been around 1990.

Wadsworth: 1990?

Fehr: There 10 years. Oh no, it must have been earlier than that, earlier than that. I’ve forgotten.

Wadsworth: You must have seen a different management attitude over there than you did even at Intel let alone TI.

Fehr: Yes, no question of that. And it was not bad, I mean it was good. When it first got going, of course it was very small again also. If you needed equipment you could go in and get it approved over lunch and that’s because everybody was there. As it got bigger, of course, they had to start putting in all the same procedures that everybody else did as they grew. A different style of management from Intel. Intel hired young managers and let them grow with the job. At LSI, they hired experienced people and let the job grow up to them so a much easier deal. And of course the divorce rate was much lower too.

Wadsworth: You obviously have demonstrated flexibility as far as adjusting to do different management styles, different geographic locations, and different technical challenges. What were the technical challenges that were different at LSI than Intel that you had the most trouble adjusting to?

Fehr: Well I don’t think technically that there was too much of an issue for me We had a higher lead count and had to start working with more thermal issues and, of course, the electrical design became more and more important because the devices kept getting faster and faster. So I hired a really good young PhD too that did all my electrical designs in the fact to make sure that the induction was low that the capacitance was low that you could get it so the part would work. We had one experience where we were building a product and I think it was AMD that wanted to build the same product and somehow, they got a few of my packages (should not have but nevertheless did). Their device would work at speed in my packages. They would not work at speed of their own packages. So I got this offer they would pay for all of my tooling back if I would just allow them into the tooling and I went into the president at that time and presented the offer. He said no. “I’ll pay another $500,000 to keep them out for another three months. And so we didn’t do it.

Wadsworth: Now the volumes were much lower at LSI Logic?

Fehr: Yes, no question of that.

Wadsworth: And what about subcontract assemblers for them?

Fehr: We did some of that. Went Anam but didn’t travel as much on this. We tended to put out the older product. We also put out more plastic. We had a small plastic line there but didn’t run it real heavy. We limited size. CERDIP tended to go out. The side braze and the high lead count stuff we tended to keep in house.

Wadsworth: For any particular reason?

Fehr: Oh, just it was more difficult to do, more difficult to control and also it was the newer packages and newer devices and so they wanted to just kind of keep that under wraps as long as they could.

Wadsworth: All industry comes down to people one way or another. Do you have any interesting character stories about the various characters you run into in your semiconductor career?

Fehr: Well, Andy probably was the most interesting at that point. Like I say, I’m his chapter of the book about agree to disagree and he really didn’t start to use that until we agreed on that one late night. I don’t think he enjoyed the late night drinking bouts to get people to agree with him either. He was, like I said, super intelligent. If you disagreed with him and he didn’t like you, you were probably gone, didn’t last long at Intel. At the rest of the companies, nobody really stood out too much. When we started IPAC, I was one of the three at the start. I enjoyed working with the president and the other vice president there, we had three of us. Batinovich, Victor Batinovich was President. I don’t know if you know him or not.

Wadsworth: Sure, of course I do.

Fehr: Yeah, well he was the president. He was an interesting guy to work with. He had a win/loss type of personality, so I did most of the negotiating at the company because you had to let both sides make some money on this type of thing.

Wadsworth: Back to Andy Grove, other people have made the comment that as rough and tumble as some of the things were at Intel in those days but when it came down to it, Andy Grove was fair and that goes along way with a lot of people doesn’t it?

Fehr: He was fair and the other advantage, he would always listen to your side and you could always make sure that you each understood the other. He would make sure of that. And then of course that’s when it came down to once you understood each other well that he was still the boss and you remember that.

Wadsworth: That’s very interesting. If you could change or redo any of the events of your semiconductor portion of your career, what would that be?

Fehr: The only thing I really think of, I had an engineer one time. The plant manager moved the project and the engineer to the production organization. He took that engineer and in my opinion ruined him. Project failed, everything else failed and I got it back at the end of course but I should not have let that happen some way. I don’t know how I should have stopped it but it was—I felt bad for both the engineer and for the company. We lost six months. It was bad.

Wadsworth: That’s a long time. What do you think of the next—you retired and you—what do you think is the next big challenge for the semiconductor area that you were intimately involved in?

Fehr: Well I think, of course—I think the die will continue to get bigger. I think the packages itself may well somewhat disappear and we start getting so much onto the die that becomes almost like the board itself and I think we’re going to end up with much more electrical requirements. I think we’re going to see a lot more wireless stuff in the end. So that’s kind of what I see. I don’t see any real big breakthrough on a whole new package style or something of that sort.

Wadsworth: Do you see an end to Moore’s Law?

Fehr: No, I’ve given up trying to predict that. Some people have predicted that, but in the end it seems to work again. It may be there’ll have to be a new change in material and a few things to make that work but I think it still seems to be going on. At some point, the computers themselves, sort of like the home computers, they’re getting so fast and can do so much now that I don’t need anything bigger, faster, anything else and I think that’s like a lot of the people. But I do think there’s products coming on mostly the wireless that you keep doing it smaller and everything you’re little Smartphone now does, will almost replace the computer.

Wadsworth: What would you tell a young person if they came to you and said that they were looking for a career and possibly considering the semiconductor industry? What would tell a young person starting out now?

Fehr: Well, you know, I have a little question to I’m doing. In the old days I used to end a lot of my talks with the fact it’s okay to have your daughter marry a packaging engineer, I’m not so sure I’d say that anymore. Most of it’s moved off shore whether it will come back or not I don’t know. But because of that I think it’s an issue. You know, I think the wafer fab, the front end, I think there’s still a good path, still think it’s going. The assembly side, it’s really dealing with some of the new technologies and dealing with offshore. But the real technical job in the US are mostly gone. Sorry to say but I think that’s true.

Wadsworth: So that would change your opinion about entering the packaging and—what about test?

Fehr: Test is very competitive and I think a lot of that is done offshore too. I think there are some people that can <inaudible> sites but I don’t see that as a real going place either.

Wadsworth: Are you saying that you think there are other opportunities within the computer realm that are more promising for a young person?

Fehr: Yeah, I would think so. I would think actually working on the basic computer itself probably is one step further that you’re probably will still going to be a lot of in the US and they may still get a lot of the product built offshore but I think a lot of the design and so on is here.

Wadsworth: Interesting. Now let’s talk about the retirement Skip Fehr. You spend some time in court rooms, I guess, as an expert witness?

Fehr: Yes. I enjoy that.

Wadsworth: How did you get involved with that?

Fehr: Actually the first case came out being—the lawyers called me and said, “Hey, we think maybe you could help us. Most of the cases get settled out of court. In particular when you do your job right you get it far enough along that if you can get it to the point that your side can actually win then the other side will negotiate pretty quickly because they realize that also. Sometimes the customers don’t want to win. I dealt with Sumitomo one time and they were being sued by their customers over the flame retardant issue. And we found enough information and got back to the lawyers and I said, “Hey, you guys could win this case.” And they said, “We don’t want to win. We just don’t want to lose too big.” Well as soon it gave that information, two weeks later the case was settled, all done. Now, I was in one for Carson against Anam and that went to the trade commission in Washington DC. That case lasted six weeks, I thought twice too long but that’s my opinion. Very interesting case. It was a matter of there was prior history of the patents that Anam had from Japan. Once we found them and got them translated and I thought that case should have been settled but they took to court anyway and of course the judge there, after six weeks he was tired of the case, but he made the right decision and said, “Hey, there’s all kinds of prior history here. That patent should never have been issued.”

Wadsworth: Do you walk both sides of the street as far as who you’re an expert witness for?

Fehr: Yes I could be on either side. I’ve got a case going now that’s probably going to get settled and this was on the plaintiff side. But I watch pretty carefully to make sure that I think we got a good shot to win. I don’t really want to get in on a case where I think we’ve got no shot to win and try to protect that because then it’s you either got to lie or you have to do something, just not me.

Wadsworth: What are you thoughts then on the litigious nature of the industry now because it was not that way in the beginning? It was just a question of being first and getting out there and people didn’t sue and now the whole—well the whole society seems litigious but what are your thoughts about that as far as it relates to the semiconductor industry?

Fehr: Well I don’t think it really helps it any. Way back when you had one of those depressions, TI their only profit came from there, the legal side. But it’s part of the life and I must admit, I enjoy it and I get paid well.

Wadsworth: You would not advise a young person to go into the law?

Fehr: Well maybe if they go in as a lawyer but not start your career as an expert witness because number one you aren’t an expert witness. You have to have these 40 years experience or something of that sort, maybe that much but you have to have that experience and you have to be an expert witness to actually—to do that job correctly.

Wadsworth: Well you’ve certainly established yourself with the credentials to handle that.

Fehr: I know, yeah. The first of the case they always try to establish credentials and everything up—the two times we into to court, both times the other side said, “No, we recognize Dr. Fehr as a expert witness, let’s not do that.” And our side is over there hoping to do it because they’re hoping to impress, that was the point so . . .

Wadsworth: Is that something new in these types of suits? I mean you hear of expert witnesses in all kinds but in the technical area?

Fehr: Yes and like I said, the lawyers I’ve talked to have said, “Whichever side, the jury or the judge, whichever technical witness—expert witness he believes, that side’s going to win.” And so it’s a big deal. I was—in those cases, I was encouraged to study, study, study to make sure I knew the patents or I knew whatever it was as well as their lawyers did so you could answer. He’d say this and you could say, “Yes, but such and such.” And of course as an expert witness, you’re the only person that’s encouraged to talk more. And so—of course that fits with me, I like to talk.

<Laughter>

Wadsworth: Well we’ve enjoyed this talk. Is there anything else you’d like to add from career to what your thoughts are about the future and . . . ?

Fehr: You know, I don’t—I've thought about the future quite a bit but I just don’t think I see it well enough to know that. I still enjoy the consulting and I’ll probably do less and less of it but continue on as long as I think I’m worthwhile to the companies.

Wadsworth: Well, you’ve certainly had an amazing career that’s contributed much to our great industry. On behalf of the Computer History Museum, we thank you for your oral history.

Fehr: I appreciate that. I enjoyed it very much, feel honored.

END OF INTERVIEW

