



Oral History of Dan Worsham

Interviewed by:
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Recorded: August 10, 2007



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CHM Reference number: X6196.2011

Craig Addison: Dan, talking about the formation of Pacific Western Systems. Where did the idea come from or how did that come about?

Dan Worsham: At that time, there was a lot more semiconductor companies than there were manufacturers of good equipment to support them and so the need got more acute as the days went by and the fellow that I worked with, and some worked for me, were always frustrated...our job was to supply equipment or various support services to the main factories that were building these semiconductors. So we looked into it and decided that there were some things that we could actually contribute to ourselves and so we started doing that.

We built a lot of equipment that was not available on the marketplace for use in our own semiconductor companies that we worked for and in our case it was Fairchild and later on Siliconix. By the time we got into Siliconix, it became more of an acute issue and there were some people doing it and some people having trouble doing it so eventually we decided, my cohorts and I, that we could do a pretty good job of it and so we'd give it a try.

Addison: Who were the cohorts?

Worsham: Well the first two were Don Snow and Jack Ashley and we all worked together at Siliconix.

Addison: Did you bring anybody else in later?

Worsham: Yeah, there were other people later and one of them was Dee Dyer who was the Siliconix equipment designer and then really production man. He could build anything. So we just kept going but we had to, of course, leave the company to do that and it worked out OK. We just kept going.

Addison: Where did you get the money to start the company?

Worsham: Mostly, as near as I can recall, it came from Don and Jack and myself. So we put up our own money to do it and then we were fortunate enough to get some support from local banking concerns when we started shipping equipment and that sufficed for many, many years.

Addison: What was the very first product and why did you choose that product?

Worsham: We had a lot of experience making a probe machine and a stepping machine that would step from one semiconductor to another to another to another on a wafer with needles that would come down and make electrical contact to the device, whether it was an integrated circuit or whether it was just a transistor with two or three needles and it just kept on going.

Addison: So when you say you had experience with that, you mean at Siliconix?

Worsham: Yes, and Fairchild.

Addison: So you actually built the product?

Worsham: I saw a lot of them built. There were some built by Kulicke & Soffa from back east that were I think the first commercial models around that I saw and we thought we could improve on them tremendously.

Addison: What was wrong with the process that you saw?

Worsham: They were primitive. They were the best that people could make at the time but we thought that we could do a lot better and so we had some ideas on testing and burn-in of electronic circuits that controlled the machinery. I think the military, and certainly NASA and others, were early champions of Hi-Rel electronics and we knew about that and Don Snow was a very strong advocate of that and that was one of the major commitments that we made that really paid off. So we started burning in the equipment that we were building and once we did testing on all the components that went into it, then we burned the systems at elevated temperature for several weeks, 24 hours a day, running the machines. We found out that if we had some weak designs somewhere, it would become abundantly clear. The military, I think, had found that out a long time ago but equipment builders, I think, didn't catch on to that for quite a while and we did. I think it was a big, big help to Pacific Western and just kept getting better.

Addison: Was the military your first customer for the product?

Worsham: No. Most of them were private companies, start-up companies, little tiny guys and we could talk to them and we knew who they were and we could sell to them and they were really thankful for having high reliability equipment to work with because they really couldn't afford to have the down time and that sort of thing.

Addison: At that stage, what kind of technology was being used in terms of wafer size and linewidths?

Worsham: I'd say starting out there were still people making wafers that were like an inch in diameter and now, of course, they just kept getting larger and larger. Some of the devices that we were testing, though, were getting smaller and smaller and smaller so it was really putting a lot of pressure on us to have equipment that we could sell that would have fully automatic controls on it and it would run and run and run by itself without having to be constantly realigned or something like that, and we were able to do that.

Addison: Were they very expensive?

Worsham: Relatively not. I think probably the major cost saving that we enjoyed was brought about by the concept of power burn-in on the equipment so that we didn't get it out in the field and have it breakdown and have to send our guys out there to fix it on warranty and then also gather up a whole bunch of tickets from our customers saying they didn't like the equipment. They liked it because it would run and run and run and run and that's what they required. And so if you give them what they want, you are ahead of the game already and it really worked out.

Addison: At what stage did you introduce other probers?

Worsham: It was several years down the line. We always had an eye to new innovations or anything that we could do. We tried to talk to our customers as often as we could. I know that I traveled all over the place and I know that Don and Jack were talking to a lot of people in the field and a lot of people would come by our place of business in Mountain View and visit us and we'd give them top line shows of what we were doing and thinking so that they could get a good picture of what to expect from us and it wasn't just "send us money boys." You know, we were trying to really solve the problem and some of them were, of course, vitally important to the government.

Addison: What was the next product you introduced?

Worsham: Well, I think we got into making some test equipment and Don Snow was backing that and supervising it, directing it. And I think that we made some very good equipment. Some of it was small box stuff and it was made to the same specs as the prober with the burn-in requirements and things. We kind of limped along there for a while and I think probably it was our inability to get enough money going to do a decent job of sales and marketing [that] really slowed us down on that.

So for a while we took kind of reevaluation of where we were and then by that time I think we were operating out of Nevada and we had a couple of factories up there and we kept working on that and then I got acquainted with some other people in the semiconductor business that we were in, some CVD equipment and that worked out fairly well for a long time. I got acquainted with a fellow that started out. I got to know him at Fairchild and then he came to work for us at Pacific Western and that was Charlie Ellenberger. He developed and we both worked on some deposition equipment, some of which held up very well and was really good. I don't think that we had as rollicking success as Applied Materials did with their equipment but it was simple. It was very low cost equipment and we were growing oxide films and nitride films on the wafers. We never got into diffusion furnaces and there were a whole bunch of people doing diffusion furnaces and so that's about where that went.

Addison: So the CVD equipment was basically developed in-house?

Worsham: Yes. The first one that we made was a film machine. I probably made the head and nozzle for it and it was for growing oxides and passivation layers on wafers. I don't know if any of those are still in business or not. I haven't seen any for a long time but that was 30 years ago.

Addison: How long were you in the CVD market?

Worsham: I don't know now. Probably 15, 20 years, something like that. But it was the low end of it. It wasn't the high end stuff that Applied Materials was doing.

Addison: I just wanted to go back to the test equipment. Did that part of the business do well for the company?

Worsham: Yeah, it did fairly well but, like I said, I think we were just short on money to do a really first-class job of competing with the big fellows like Applied Materials. I think our equipment was fine. I think it was probably half the price for the same or equivalent products but to convince somebody of that takes a lot of effort.

Addison: You also were involved with epi reactors I believe?

Worsham: Well, some reactors. I'm really not the guy to talk to about that. It would be one of our other employees and that was probably mostly Charlie Ellenbergers' stuff.

Addison: When I interviewed Mike McNeilly [Applied's founder] a couple of years ago, he said that Pacific Western Systems was strong competition and he was concerned that you were coming along and being a tough competitor. Did you see it that way?

Worsham: Yeah, I did, but they had a whole lot of cash for this kind of thing and they had a very sophisticated sales and rep arrangement out there in the field and it made it really tough for us to compete with them.

Addison: You never took your company public?

Worsham: No, we never did have that idea in mind.

Addison: Was that a deliberate decision?

Worsham: Yeah, I think it was. We would have liked to have done it but we just didn't have the wherewithal to do that.

Addison: So the funding all through the years came from bank loans and cash flow?

Worsham: That's right.

Addison: At the high point, for example, what size of sales was the company doing roughly?

Worsham: Oh, probably \$20 million a year.

Addison: There's a question that Harry Sello, who is a friend of yours, wanted to ask. What was the essential difference between your probers and those of Electroglas?

Worsham: I think the difference largely was ours were a lot lighter and they were more precise and capable of running and running and running and they were very reliable. The power burn-in of the electronics and the mechanics really did a lot for our equipment and it did a lot for our equipment designers. Then they learned a lot better how to make stuff that would really last and last and that took a big bite out of the expense of making equipment installations in the field and then having us send a crew of people out there to work on it for weeks or months to get it up and running and that was quite common in those days. We really capitalized on that. We started that right away and we just broadened it as we continued to produce.

Addison: So your military background, did that influence you to want to build these very reliable devices?

Worsham: Yeah, of course. Also I might say I spent a couple of years in the Navy Reserve until I got out of high school and I think I graduated in high school in late June and the Korean War broke out a week or so later, two weeks later, something like that, and so I'd had a couple of brothers in the military and my grandfather was in the Union Army. Anyway, we went to a semi-war status on that and I could see I wanted to transfer since I was in the Navy already. Technically I went to my commander and he gave me a transfer to the Marine Corps and that worked out fine. Just a short three months, four months later, something like that, I was in combat in Korea. Then eventually...this is just a personal little vignette off to the side...I wasn't anticipating talking about this. But anyway, what happened was I finally got wounded very seriously and lost my leg in Korea so they flew me back here eventually and I spent several months over in Oak Knoll Naval Hospital over here getting several operations to heal up wounds and things and then got out and essentially went back to my hometown and went to work down there.

It worked out for a while but I could see I was really in need of an education if I wanted to get more money and so I went back to school there in the junior college system and spent three years there in junior college and then transferred up here to Stanford and spent three more years there and ran out of money. I was just about to graduate. Anyway, I got out of there and talked to my professor at Stanford and told him I was short of money and really was hurting and he said, "I want you to go talk to this fellow down in South Palo Alto," and I did and it turned out to be [Dean] Knapic, the crystal grower, and he was a very genuine, warm individual and he showed me through his factory and what he was doing. I was pretty familiar with crystals and crystal work and it worked out that he gave me a recommendation to go talk to Bob Hall who was foreman of preproduction at Fairchild R&D, which was just a couple of miles where Knapic had his shop. So I went and talked to Bob Hall and he interviewed me and then I ended up working for Bob Brown who was a physicist working for Fairchild...Brown worked for Dr. Harry Sello, and so I got to know all those people pretty fast.

Addison: Just going back to Dean Knapic, could you talk about what sort of equipment he was building?

Worsham: I don't know if he built those crystal growers or not. He might have. He didn't waste any time. He showed me them and let me look at them and put on the real dark glasses and looked down in there and I could see the crystals growing. It's white hot in there. But they were small crystal growers, probably about that big around, and maybe 6, 7 feet tall, something like that. They were putting a seed in a melted pot and turning it around and pulling it out and they would pull out a crystal. I knew how to make crystals.

Addison: How did you know how to make crystals?

Worsham: I'd moved up [to the Bay area] but I'd come through college down south and, of course, I'd taken chemistry and things so I knew how crystals were made. Some of them are made in a cold process like salt crystals. Some of them are made in hot processing and down there sugar is a big thing in Santa Maria because the Union Sugar Company was at that time one of the major employers and they were just taking sugar beets in there and boiling them down and getting the crystals out.

Addison: What was your first job at Fairchild?

Worsham: It was working as an engineer for Bob Brown, an equipment guy. He was the lead active engineer, I thought, in the pre-production section which was a transition from R&D through pre-production

to a certain production level that could be considered serious production. Then the whole thing, personnel and all, would be transferred to manufacturing and the engineers in pre-production would be re-routed back to R&D to pick up a new program and bring it to fruition.

Addison: At that time Fairchild was building all its equipment. Was there any equipment that you could buy off-the-shelf or it was all built?

Worsham: I think some people like Kulicke & Soffa back east were making some equipment but most of the equipment that Fairchild had, even though it might have been available somewhere, it was very formative, primitive and not very reliable... and so most of the equipment was built in-house.

Addison: Did you have any hands-on involvement in building some of this equipment?

Worsham: Some of it, yeah. Lots of the jigs and fixtures and stuff. I did some work on mask aligning and mechanical mask aligning rather than optical and it worked out real well and I thought was a very big success at Fairchild for a long time.

Addison: Did you work with any of the Fairchild founders?

Worsham: Oh yeah. Sure, I knew all of those guys. Jay Last was a real nice fellow and a very sharp guy. Of course I knew Gordon Moore very well and he was a very warm, outgoing, very, very sharp Ph.D. I got to know Bob Noyce slightly and before I left Fairchild we knew each other fairly well. He was really a sharp man.

I think probably because of our Navy backgrounds I was naturally drawn to Harry Sello. We could work together real well and I think it paid off for me a lot because I'd get to do work that was of a learning nature and it led me to have a better overall feeling for what was going on. It was just a happy time for work and exploration. I never got around to really thanking Dean Knapic for giving me the recommendation.

Addison: Dan, when you joined Fairchild in 1959, that was the year that the integrated circuit was conceived. Do you have any recollections of that being announced?

Worsham: Sure. Inside it was announced. We all knew about it. Of course there were several iterations to start with and when it got to the point where they wanted to have some movement of the integrated circuits from R&D to pre-production or to get it out of R&D and get into production...I was fortunate enough to have the job of doing the tooling on any of that integrated circuit equipment. Now that doesn't mean I did everything. It just means that out of pre-production I was designated to follow up on that.

And then shortly thereafter it moved right on into production in Mountain View and about that time...we moved all of pre-production out of R&D to the Mountain View building. The next thing you know, a lot of things started happening. Harry Sello got transferred to Italy to do a job with SGS in Italy and, gee, he was my chief mentor so I was at a loss for about an hour or two and somebody gave me a job and so it just grew. We were under so much pressure at that time to produce things and to improve the equipment that it was really an enjoyable place to work. The environment was good and it just went forward.

Addison: I've heard stories that there was a wall between Fairchild R&D and production and a lot of things developed in R&D didn't get into production. Do you see it that way?

Worsham: I think that was probably not by design but maybe they hadn't made enough preparation for transferring things. I found it a little hard myself to understand how the transfers were made until I got responsible for it. Then mostly what happened was...there was a constant pressure for new products on the R&D people. Then it was a constant pressure on the R&D people to get it to a certain production [level] -- so many devices a week -- so that they could get it transferred out of R&D and get on to some new products. So they were really working those people that you mentioned earlier -- Jay Last and all those guys, really smart guys. And they all had their heart in the right place. I never had a mean or tough word out of any of those guys. They would do everything they could to help you understand what they were trying to do, what the company was trying to do. All of them really needed a lot of help.

Addison: Why don't we talk about the events that led to you leaving Fairchild and going to work for Siliconix.

Worsham: There were quite a few Fairchild employees who were leaving to join start-ups and get a piece of the action. Siliconix wasn't any different but there had been, oh I don't know, by that time probably a dozen other semiconductor companies in the [Bay] area. I'm sure once they get together over there in that new company, two or three of them or four or something like that, they were getting inquiries from their own new personnel people [about] anybody they would recommend to come over and help out. Then they'd go after you and so I'm sure that's just exactly that happened to me. By that time I had quite a bit of organizational training myself and so the personnel department from Siliconix contacted me to see if I would be interested in coming over for an interview. I had heard through the grapevine that most of these companies were offering stock options to people and that was a big thing, a big symbol to me. I needed the money badly and wasn't getting bad treatment or anything like that. I loved Fairchild and the people there but I just have to look out after my family as best I could.

And they [Siliconix] were making a semiconductor they called "field effect transistor." I don't think Fairchild had come around to doing that yet so it was something new. But when it got right down to it, it was a planer device and looked very similar. It was just geometrically a little bit different and it has some different qualities about it so I reckoned that I could handle that pretty easy and they got me back for another [interview] and I liked the job they offered me which was manufacturing manager of their silicon operation. And I felt confident that I could do it, especially since they had already hired several of the Fairchild people that were very close friends of mine and I got along very well with them and I knew that they were cooperative and competent guys. So I thought we were in pretty good territory and the only thing was left for me to do was to make it very plain where I stood on the stock option programs. I needed the money. As it turned out, I got very generous stock options and I certainly changed [jobs] right away and that was that.

Addison: As the manufacturing manager, what were you involved with? Building equipment?

Worsham: I was a little bit more aloof from it but I was approving it to be built and I could give the guys a lot of guidelines about how the manufacturing people wanted the equipment to perform. I think that was one of the problems that we had at Fairchild...there wasn't a real good line of communications there and

so we did very well at Siliconix and got them going and there were times when we had to work some long nights to get it going but everybody was cheerful and went ahead and did a good job on it and so that's how we got going over there.

Addison: By that stage were there many equipment companies that you could buy from?

Worsham: There were getting to be a few around, yeah. There were people making diffusion furnaces. I think Fairchild had made a lot of their own and I don't know if they quit doing that or what. I wasn't in that area exactly. There were a lot of lead bonders that [Fairchild] were building and by the time I got over to Siliconix, I think there was one [supplier] called Microtek doing lead bonders and die attachers. I think the guy that was doing it had been a Fairchilder at one time. I know Art Lasch was off doing something and almost everybody around in those days knew Art Lasch and he was a real nice, jovial guy and you could get along with him and he'd build almost anything. He really had a good understanding of it. I think Applied Materials was probably getting in business about that time.

We didn't have any lead bonders or die attachers that we could really brag about. We had a bunch of old used stuff. It looked like they might have bought it from Western Electric or somewhere back east because it was real old stuff. It was real clumsy so we built some real simple things and all of a sudden we were up and making production and it was really great. One thing just led to another and we built some probers and then they got off on some very complicated circuits. I think they had a circuit they brought out over there that had 40 or 50 contacts on it and there wasn't a chance that they could do it with commercial equipment at that time so we made some.

Addison: How long did you stay at Siliconix?

Worsham: I think it was close to five years. As I look at it in retrospect after all these years, it's kind of hard to remember exactly what tripped me up there as far as wanting to leave but I got to the point where I just felt that I wasn't seeing eye-to-eye to the boss and that was time for me to pack up and leave and so I took a couple of guys with me that I knew very well.

Addison: Is that when you had the idea of starting a company?

Worsham: Well, we were going to do some consulting first and not really go into a full-blown corporate thing. We just wanted to test the water and see what was out there. But anyhow, the long and the short of it was we got to a point where we thought we would take a try at it and so we actually spent...it ended up being three of us that left. Two of the guys worked for me anyway and so I spend a lot of time talking to potential customers, meaning semiconductor people, who we could sell equipment to and we got it going and we started making money. We were operating out of just an apartment over in Cupertino. It was nice and new and it had a pool, so it was a new concept in manufacturing I'll tell you. But, anyway, it was close to all three of our homes so it made it friendly in that regard.

END OF INTERVIEW