Oral History of Robert B. Palmer

Interviewed by:
Craig Addison

Recorded: November 18, 2004

CHM Reference number: X6196.2011

Craig Addison: Thank you, Robert, for joining us.

Robert Palmer: It's a pleasure.

Addison: Can you start off by talking about how you first got into the semiconductor industry?

Palmer: Well, I majored in math and physics at Texas Tech University and got interested in solid state electronics when I was in graduate school. And got married and started to interview for jobs and was offered a job at Texas Instruments. So I began my career there and got to work in the Semiconductor Research and Development Labs at TI.

Addison: What year was that?

Palmer: That would be 1967. And I was assigned to work on an infrared silicon vidicon as my first project. And it turned out by good fortune to be successful. Then I got assigned to the MOS group which…I probably was there several weeks before I figured out what MOS stood for. At the time the semiconductor industry was primarily bipolar and Texas Instruments was the leader in bipolar technology. So MOS wasn't the ideal thing to be assigned to. It was quite a nascent technology. But I found it quite interesting and it worked out well.

Addison: Did you have any idea at TI that semiconductors would be a huge potential industry in the future?

Palmer: I felt like when I was in graduate school looking at different industries that semiconductors was a really good place to start and I felt like it had at least the possibility of lasting as long as my career lasted. And obviously that's proven to be the case.

Addison: At TI, assume we're talking about TI, did you meet or work with Jack Kilby at all?

Palmer: I had met Jack Kilby and I certainly saw him walking around the halls. He's hard to miss. [Editor's Note: Kilby, at well over 6 feet tall, is known around TI as the "humble giant."] And even at that time he was of course very highly revered at TI. There were many really good researchers there but none with the status that Jack Kilby had.

Addison: What did you learn from your period at TI?

Palmer: I learned a lot. In fact I found working to be a lot more interesting that school because you got the chance to apply your theoretical knowledge to practical devices and see how it worked out and try things. I really enjoyed working in the labs there. And I think TI was an excellent place to start your career, or for that matter, to stay and have a career. It had a very professional engineering oriented environment and people are very helpful -- always willing to share information with you if you needed some technical information you didn't possess. I'm a person that likes to seek out others for advice so it worked out really well for me.

Addison: Now can you tell me the story of why you left TI and where you went?

Palmer: Really, my first mentor was Dr. Louay Sharif, who was responsible for the processing and manufacturing of the MOS projects [at Texas Instruments]. L.J. Sevin was responsible for the design and sales of devices. And again this was really emerging technology at the time. I really enjoyed working for Louay and for that matter, L.J. and some of the other people that later formed Mostek. The principal founders of Mostek were L.J. Sevin and Louay Sharif. And they asked a few of the rest of us if we would like to join this startup and be part of the founding team. I was 29 years old and it sounded like it might be exciting and I liked the people. And even though I liked TI and felt like I'd certainly been treated very fairly at TI, I decided to take a chance and be one of the founders at Mostek.

Addison: What was the thinking behind the formation of the company? Did they think TI wasn't doing something or there was a market opportunity? What was the motivation?

Palmer: Well I really don't know what the motivation for L.J. and Louay was at that time other than I think they really did believe that MOS technology would become important. They probably had their personal reasons and I don't know what those are. But at the time, MOS really was not a factor in the integrated circuits business. It was all bipolar. And TI as the leader in bipolar certainly had every reason to continue to invest heavily in bipolar. At that time though there really wasn't any venture capital business. Certainly not in Texas. And it was not that easy to start a company.

I believe we may have been the first semiconductor spin out of TI of any size ever. That was probably in June of 1969, if memory serves correctly. Louay and L.J. had managed to find Sprague Electric as an investor in the company and they were the majority…I don't know if they owned the majority, but they certainly were the largest outside investor in Mostek when it was begun. Sprague had some manufacturing facilities in Worcester, Massachusetts that were devoted to their business. And part of the arrangement as I understood it was that Sprague would host some engineers, in this case myself and a few others, from Mostek and let us use some of their facilities as part of their investment in the company. And that was of course essential because there were no foundry facilities at that time. That was an industry that hadn't yet developed. And so we needed some way to do our own research and development and to learn how to built MOS devices, which really at that time there were a lot of technical problems still to be solved.

Addison: Does that mean you were actually employed by Sprague?

Palmer: No. I was employed by Mostek but we were guests at the Sprague Electric facility in Worcester. And it was a very good relationship actually. Sprague people, because they knew their company had made a big investment in us, were very cooperative and I would say essential to our early success.

Addison: So Robert, can you talk a little bit about the research and the manufacturing work that was going on at Sprague? What sort of things you were working on?

Palmer: Well, the principle thing I was trying to develop was a process suitable for building MOS integrated circuits, which was not an area that Sprague would have been working in. Sprague was known for their work in hybrid semiconductors and in capacitors in particular. And we didn't really, when we left

TI, have a process. Obviously we had to develop our own intellectual property and really start from scratch. The biggest problem we needed to solve at that time was MOS devices at the time were primarily P-channel devices. And the rest of the electronic world was TTL or TTL compatible. And MOS devices were not inherently voltage compatible with all the other electronics. And so we really needed to figure out some way to make MOS devices that would be voltage compatible with the TTL circuitry that was pervasive. That was the problem we were trying to solve. And you were looking at a number of possibilities including silicon nitride, dielectrics, or silicon gate technology, which was again in the very early development stages.

I was actually on a trip up to Sprague Electric's research facilities in North Adams, Massachusetts. I wanted to learn something about tantalum oxide. It's a high dielectric constant material that I thought might give us a lower threshold voltage by using that material. When I was up there I looked at that process and realized it was not compatible with other semiconductor processing. But while I was there I ran into a couple of researchers that were doing work on precision resistors for hybrid circuits. And they were using a hand-built ion implantation system. I was curious about that. I had never seen an ion implantation system. And was asking them what they were doing and how did they know what the dose was that they were using to make these resistors. The researchers were Dr. Ken Manchester and Dr. John Macdougall. And they were again very open and eager to share what they were doing with me. It turned out that the way they measured the dose was by measuring the threshold voltage shift in a crude MOS device. Of course immediately I recognized that's the problem I'm trying to solve and these fellows are using it as a detector. So I got very excited. And I remember calling L.J. -- because I was the only one of the founding group up in Massachusetts, everybody else was here in Dallas -- and calling L.J. Sevin and saying, "L.J. You won't believe what these guys are doing up here." And that was really the start of using ion implantation technology to develop commercial integrated circuits.

Addison: Now where did these guys get the technology from? Where was its origins?

Palmer: Well they had built it from scratch. The machine that they had was completely fabricated at Sprague or at other machine shops. And they were both quite competent researchers. John Macdougall had been looking at ion implantation for quite a long time and he worked for Ken Manchester, as I recall. And again the problem they were trying to solve was how to make precision resistors and hybrid circuits on ceramic substrates. And they had done some really good work there. They had published some papers. And of course there were some original papers out there talking about ion implantation technology. Some work had been done at Stanford. Hughes Electronics had done some work, had some patents. But nobody had ever, to my knowledge at least, fabricated production quality integrated circuits with this technology. And we had to develop something compatible with the existing p-channel processes. At the time I think most MOS devices, if not all of them in production, were p-channel. And we had to develop a way of doing it that was compatible, that was reliable. Early on it was not known if you could implant, in this case, say, boron ions through an oxide and not destroy the gate oxide or create instabilities or reliability issues of all kinds. And so it was a lot of just fundamental engineering that had to be done.

Early on, by the way, the ion implanters…you didn't have any way to integrate the dose. Today, ion implanters of course… they're quite precise and even 10 years after this early work they were quite precise. But at that time you sort of had to guess at the dose -- the number of ions you were putting in the silicon. We had techniques for doing that but they were not very sophisticated. They worked, though.

Addison: Now can you talk about how the ion implantation technology was kind of transferred into Mostek, into your manufacturing processes?

Palmer: Well, what happened was, I used to drive up in my car with a handful of wafers to North Adams…that's a pretty good drive, especially in the winter. I'd work with John McDougal usually. We'd sit up there in the lab at night and scan these wafers with the dose. Then I'd have to go all the way back down to Worcester and finish the fabrication of the devices there. Take the measurements. Find out what we'd done -- whether anything was useful. Start another lot. It was a really quite tedious way to do things. Eventually we decided, "Look. We need to build a machine down in Worcester." And we need to build something that's a little more production oriented rather than research oriented like the one in North Adams, Mass, where we could do [only] three wafers at time. That is, you'd load only three wafers in the vacuum chamber and pump the thing down. Everything was done by hand. You moved the wafer in position by hand. It was not automated at all. I think most of the design was between John Macdougall and Ken Manchester. I had some modest input probably. But basically [we got] a machine designed and built. I think that first machine was very inexpensive. Certainly by today's standards. We had the machine parts fabricated. And a company in Austin, Texas I think, an early ion implantation company fabricated it for us. We assembled it in Worcester. By the spring of 1970 we were doing the first tests to see if in fact we could get a beam. And if we could separate the boron from the other ions and if we could actually implant wafers. I don't remember how many we could do. Although I could look in my notebooks and see but it was a big step forward. We probably could do a dozen or something at a time. Ken Manchester, I think, was very helpful in the mechanization area of that machine.

At that time there were no, at least to my knowledge, commercially available production machines. It just hadn't been done yet. And for that matter we didn't tell the rest of the world how we achieved TTL compatible circuits for a while. It wasn't obvious. And our competitors would take our circuits apart and try to figure it out because you certainly didn't see any silicon nitride or silicon gates. Yet these things were TTL compatible. It was like magic.

We also had some really smart design people… Bob Proebsting would be one, a real pioneer with many patents. He's responsible really for the whole idea of multiplexed addresses in dynamic random access memories among many other things. But they recognized right away that if you could change the threshold voltage, you could also make depletion devices rather than just enhancement devices. So you could make depletion loads. And this would…improve the speed of the product by a factor of two or three over what was currently available. So we were the first company to use ion implantation to make both enhancement and depletion load transistors on the same circuits. And this let us do different kinds of amplifiers, more efficient circuits of all kinds. And really enabled us to do things our competitors couldn't do until they learned how.

In 1970, John Macdougall, Ken Manchester and I wrote a paper for Electronics Magazine. And we got the cover issue. I've got one around here somewhere but I wasn't able to find it. But we got the cover issue about ion implantation technology. And after that a number of people started building machines and people started adapting it. And then Dr. Chao Mai and I worked together to develop a combination of silicon gate and ion implantation technology and we got a patent for that work. And that turned out to be a pretty important patent.

Addison: Just backing up a little bit. Ken Manchester and John Macdougall. Could you just talk a little bit about those guys? What they were doing and a little bit more detail about how they fit into the picture?

Palmer: Ken and John were in the research area of Sprague Electric. And I just happened to meet them. It was a real serendipitous coincidence really. And once I expressed an interest in their work they were very eager to share the work that they were doing and talk about how that might help me. I couldn't say enough positive things about them or about Sprague in terms of helping us use technology that they had been working on for an entirely different purpose and adapt it to help us with problems we were trying to solve. So I really enjoyed working at Sprague for the three or four years I was up there before I moved back to Dallas…really Carrolton, Texas, which is a suburb of Dallas.

I moved up [to Worcester] in 1969 and moved back, I want to say, in 1972. And then we built a facility here [in Dallas]. And by then the ion implantation industry was getting going. Of course anybody that knows anything about the semiconductor industry realizes there was this tremendous symbiotic relationship between the equipment manufacturers, the design engineers and the process engineers. And we all worked together developing new tools which enabled us to do new things which enabled the development of new tools which enabled new things. And so it was just a wonderful thing to have as your career to be able to work in that area. The first circuits we worked on had a thousand transistors. That kind of thing. Today of course, one hundred million transistors and up is possible. It's just incredible what the industry has brought and all of the technological good things that have happened. And to be just part of that was very rewarding.

Addison: Can you talk more about the interaction with the equipment companies? You said you got a company in Austin to build the ion implanter for you. What kind of relationships did you have with companies outside that were building the equipment?

Palmer: Well we went around and visited all of the companies that had equipment where they could conceivably build what we wanted. I remember some of our early machines were from Varian up in Peabody, Massachusetts in addition to the one in Austin. We always worked carefully with the manufacturers because they were trying to figure out, "What is it we needed?" And we didn't know what was possible. So you kind of had to spend a lot of time over coffee or drinks and talk about what was possible and how could that be helpful and what were the real problems that needed to be solved. We were looking at a lot of different kinds of sources at that time. Gaseous sources. Solid sources. There were different ions being explored. We started with boron but quickly found after that you needed phosphorous. You had to work with some really nasty and dangerous chemicals [such as] arsenic. As I say, it was a very symbiotic relationship. In my view, progress in semiconductor industry would have been impossible without these semiconductor equipment companies that worked to make it possible. You worked with all of the companies. At that time we used contact printers. That's where the photo mask and the wafer were in physical contact. It didn't help yields a lot, but at the time we didn't know better. That was when projection aligners were just being developed. And you worked with the equipment companies to figure out how to make better equipment for lithography, and really every facet of semiconductor manufacturing. Without those companies we could not have been a leader in semiconductor technology in this country.

Addison: Now you mentioned Varian. If you went to Varian and said, “Build us an ion implanter”, who owned the technology?

Palmer: Well, the technology that was used for the manufacturing of course was owned by the companies that had the patents or did the original work. And there were many of those. As I mentioned, Hughes did some original work. Sprague had some intellectual property. Mostek of course had intellectual property. The industry worked pretty well together to cross license…because everybody was building on what others had done before them, just as we were. You were pretty generous in cross-licensing with other companies. Intel and Mostek were formed within about a year of each other. And we cross-licensed on technology. AMD was another company that was formed in 1969, at that time it was a bipolar company. But there were a lot of semiconductor companies in addition to TI that had done work in this area or related areas. With equipment companies certainly the technology of how to build equipment was their property. I don’t really remember any significant issues around intellectual property. We were always able to work things out so that the industry could keep growing and move forward.

Addison: Robert, could you talk a little bit about how ion implantation helped give Mostek a competitive edge?

Palmer: Ion implantation enabled us to build circuits that others couldn’t build. In particular, the use of depletion load technology greatly improved the speed power performance of the inverters that we built. It enabled us to build amplifiers that were perhaps 10 times -- although I’d have to look to be sure, but on that order -- more efficient than were previously possible. It gave us the capability of doing a number of different structures. And our design engineers were clever enough to realize how you could apply that process technology to build different things. So we had some very successful early circuits that were just competitively better than what was out there at the time.

Addison: I understand one of the first hand-held calculators used Mostek circuits built using ion implantation.

Palmer: We did. That was a very interesting project with Hewlett Packard. The HP35. It was a scientific calculator we did in the early ‘70s. The very first four function calculator [using our chip] was for a chip for a company named Busicom. It was a Japanese company. And we fabricated that using ion implantation technology. The lead design engineer, if in fact the only design engineer, was an engineer named Dave Leonard. We had very small teams of people…and at that time you cut Rubylith. I don’t know how many in the audience would know what Rubylith is…you had to hand-craft these circuits transistor by transistor. Today of course you use sophisticated software to generate these things. But at that time that’s not the way it was done. We were fortunate to have the first four function calculator. We did some very innovative circuit technology with our random access memory line. Probably earlier on Mostek was better known for dynamic random access memories than anything.

I think I mentioned earlier Dr. Bob Proebsting came up with the idea of multiplexing addresses so that you could do 16-pin implementation of dynamic random access memories. So we had a 1024 bit, which sounds funny by today's standards, dynamic RAM that could be in a 16-pin package. Our competitors were in 22-pin packages, which obviously cost more and didn't have the same packing density on the boards. So we had an immediate advantage. And the industry wanted that advantage. This helped Mostek grow and become established as a viable supplier in the early days. None of that would have been possible without ion implantation technology.

Addison: Was TI a customer, because they had calculators as well?

Palmer: I don't think…I really don't remember if TI was a customer. Certainly early on they were not a customer. I think the first customer we ever had was Burroughs. It was a computer company. We made a shift register for them. I think it was a triple 66-bit, custom shift register. They were very hard to satisfy which was good because it helped us develop our technology and process to be stable.

It was really very fortunate when you think about being able to find the technology that was being used in one application. Realize that it was going to be important in a different application. Take advantage of that. I think since that time virtually -- within a few years – virtually all integrated circuits were manufactured using ion implantation technology in one application or another. And it's been that way since that time. So since 1970, here we are 34 years later and the technology is being widely used still and probably will continue to be used.

Addison: Robert, you mentioned that in 1970 you had a cover story in Electronics Magazine about ion implantation. Was that really when the cat was let out of the bag and the industry found out about the benefits?

Palmer: Yes, I think that was…at least the formal leak. There were leaks earlier. But I'm sure some of the equipment manufacturers were saying, "Hey. These guys are doing something." People began to suspect, I suppose, that we were using ion implantation some way. But when that article was published we were quite detailed in how we did it and what the advantages and benefits were. It was also a marketing tool for us. But I think it was important to establish credit where credit was due -- to give John Macdougall and Ken Manchester public recognition. Because up until that time frankly Mostek had gotten most of the public recognition. And it was important to me that people that really had pioneered the technology were recognized for the work they did. We just had a great little team of people up there and here in Dallas to exploit it. And like I say, it takes a lot of different people to make something like this work.

Addison: Talking of people, I understand Mostek expanded at an incredible rate in the early years. Where did all those engineers come from? Did you train them in-house or go to TI?

Palmer: There were a variety of places you could get engineers but a lot of them came right out of school. Bob Palock who was the designer on the HP35 chip, he had come to us I think from the University of Illinois. Right out of school and went to work. The first task he got was designing one of the more difficult logic chips in that family. He succeeded. He went on to have a very successful career as a circuit designer and then founded a computer company, Convex Computer.

L.J. [Sevin]…had this uncanny ability to attract and keep good people. You just really liked working for him. He was very critical to work for and at the same time he encouraged you. So he was a great guy to work for really. And I had the privilege of working with him for about 10 years. And if you looked at the people that he was able to attract and hire to help Mostek in the early days. That was the key to our success really. And that's probably true of the competitors that survived. They had teams of people that somehow as a team worked really well together.

I found out very early on that it really didn't matter how good the technology was. If you couldn't sell it, you're toast. So you had to have good sales and marketing people. We had Berry Cash who was our founding member of the company and ran marketing and sales for at least 10 years. The design team that we had, as I mentioned, included Dr. Proebsting. There was a guy named Marlin Shopbell. There was Dave Leonard. Vern McKenny. And any number of people that they either knew or recommended to come to the company or people we hired. And of course some came from competitors. Some came from some of the larger, more established semiconductor companies. They said: "Hey, this MOS thing looks like it might be interesting. Let's go and try and learn how to do that." But it was a long time before MOS became established and [became] obvious that it was going to become the leading technology.

Addison: You mentioned that DRAMs were one of the first products that Mostek did. And Intel basically started as a DRAM company I believe. The competition, was it really strong in those early days?

Palmer: Competition was fierce and has remained fierce in this industry. And what's great about that is that competition spurred tremendous innovation. At Intel of course they built their product line and their fortune on silicon gate technology. It gave you the same opportunity to have lower threshold voltage and it provided some interconnect. We used ion implantation to that end and then we married the two. And Intel had any number of innovations in circuit design and process technology and some really excellent engineers that of course have become legendary in the industry.

At Mostek, we innovated a lot of things in circuit design and [did] some process technology innovations as well. And there are many other companies that added to the semiconductor industry capability. But there was a time when Intel and Mostek were probably the leading DRAM manufacturers in this country. And then the Japanese started getting into the business. And there were a lot of intellectual property battles between Japan and the United States about technology and dumping and any number of other issues. And fortunately it was all resolved eventually -- not without some pain -- in such a way that the customers benefited. Technology continued to advance. The DRAM business became really uneconomic for a while. And new companies were started. Micron is one that comes to mind. Several of the founding members of Micron Technology actually had come from Mostek…that's where they got their early training in integrated circuit design and process technology. Texas Instruments was big in that business and were successful for many years in the DRAM business.

Ultimately though DRAMs became very commodity-like and the pricing turned out to be vicious and many companies could not earn a return on capital. And you found that you went into other areas -- in our case, static RAMs, custom circuits. In Intel's case, microprocessors and many other circuits.

Addison: I've seen some old videos made at Mostek about the quality message and get the yield up and things like that. Can you talk a little bit about how you improved the quality and increased the yield?

Palmer: Well we worked very diligently at it. For one thing, the Japanese came at the United States market with circuits that had higher reliability. And there were a number of reasons for that but one of them was that they were not pushing the lithography as hard as we were here. But there were other reasons. And that was a good wakeup call for us. And L.J. was very alert to call the top management of the company and point out that we really had to improve our overall yield and our overall quality if were going to stay in business. And we had a crash program under one of our best product engineers, who at this moment I think is still a vice president at Micron. His name is Bob Donnelly. And he took on the task of, first of all, becoming educated on quality and the new quality techniques and the way of improving quality, and getting us focused as a team on every element of reliability and quality improvement. That included working closely with design engineering, the tool manufacturers, process engineers, product engineers and really motivate the whole company to become focused on that because frankly it hadn't had the focus that was required. And we of course benefited because as we improve the quality and reliability of our products, our yields also improved which lowered our costs and enabled us to compete effectively. Which we did.

Addison: Robert, can you talk about your role at Mostek, the positions you held, your responsibilities going through your time at Mostek?

Palmer: Well I started out at Mostek as the primary process development engineer. I was really privileged to work with great people. We had been fortunate to hire a number of really smart process people from around. Like Dr. Chao Mai, who came to us from Sylvania's electronics operations. Myint Hswe, who was from Burma originally, had worked at Motorola and Texas Instruments. He came and worked on process development. We had just a number of really sharp process engineers that I was privileged to work with. I ran process research and development initially and then manufacturing. There were times in my career that I ran product engineering, all of engineering. I guess eventually I became the executive vice president for Semiconductor Operations for United Technologies which purchased Mostek in late '79. I think the deal was completed in early 1980. Then I worked for United Technologies for five years, like I say, eventually being the executive VP for the operations. So I had the opportunity to work in a lot of different roles. I think I probably enjoyed process R&D the most early in my career because as an engineer you actually get to do things and see the result right then. You run the experiment. You take the measurements. Rats! That didn't work! I've got to try something else.

As a manager it's not quite that rewarding. The pay is better. And so you just keep moving up if you're lucky. I enjoyed both roles. But actually hands-on engineering is hard to beat. At least for us in physics and engineering [where] you got to see stuff really come to fruition. And the early work is very exciting. I enjoyed looking back over some of my notes for this interview. I can't even read some of the notes but it's fun to look at it and think – "Wow! That really kept me up nights and was motivating and exciting". Later in management, in various positions, what would keep you up nights was different. A little less exciting and a lot more stressful.

Addison: You just talked about some things that kept you up at night. Looking back during the time that you were in manufacturing and process engineering, what were some of the really big challenges? Any stories to tell about getting problems solved?

Palmer: Well let me think about that. There were always plenty of problems to be solved. In the early days of MOS manufacturing, processes weren't that stable. And you could easily sort of temporarily lose the recipe and the yields would not meet requirements. I'm sure we lived through a number of those things. Early on one time we had a fire in our manufacturing facility. And for that matter Intel had a fire in one of their offshore assembly operations. It was very interesting because at that time I think Bob Noyce was the CEO of Intel. And L.J. called him and offered to let him assemble their products -- which were competing with our products -- in our assembly facilities until they could get their factory back up. So it was really a more collegiate environment at the time even though we were fiercely competitive in the market place. There were some great people. It's hard to think of an industry that you would have been better just by happenstance to choose to put your career into. You had the opportunity to work with really smart people and real leaders in the business. People like Bob Noyce or Charlie Sporck at National and many others. To know these people and to get to work with them. Be surrounded by really smart people and be doing something that had an undeniable, positive impact on society and on the United States economy in general. You couldn't have foreseen all of that. None of that, as I said earlier, would have been possible without the relationship that existed between the equipment manufacturers that made the advances in technology possible, and the design engineers that knew…how to exploit these technologies. It was just an incredible symbiotic and competitive industry. And for me personally it was a very exciting and rewarding career.

Addison: Now I'd like to ask a question about SEMI. SEMI was formed in 1970 and Mostek was the year before. Did you have any interaction with SEMI and the SEMICON shows?

Palmer: No. I went to the shows and enjoyed understanding what SEMI and SEMICON was all about. And that was a very important part of being a process engineer. It was a very important part of development and designing. I was one of the founding members of SEMATECH, for example. And SEMATECH was essential in my view to making it possible for the manufacturers to make a living. Early on…each of the companies would come to the tool manufacturers with some kind of different requirement. And everybody wanted something different, something special. And the [equipment] manufacturers were having a very difficult time getting a return on their investment. They couldn't please everybody and there was no consensus in the industry. And so that wasn't an untenable situation.

Even though we were fiercely competitive in the market place -- SEMATECH enabled us to work together with the manufacturers of equipment so that they had a fair chance of meeting the majority needs of the industry, and thereby being able to spread their costs over a large number of relatively standard machines so that everything became much more affordable. Much more efficient. So I saw SEMATECH as a huge part of the success of the American semiconductor industry. And I don't think we would have been as successful without it.

Well you could argue that organizations like SEMI early on were really the genesis of some of that. They showed that this is the way you could work cooperatively to enable the technology to be developed and shared among various manufacturers effectively.

Addison: While we're on the topic of SEMATECH, what sort of involvement did you have in the organization?

Palmer: As I mentioned, I was fortunate to be one of the founding members. And the real drivers behind SEMATECH like Bob Noyce, Charlie Sporck saw that we really had to have some way of dealing with the manufacturer…the tool manufacturers in a way that was helpful. And how do we explore all of the challenges that they're still exploring? As lithography continues to get to smaller and smaller dimensions, and you have ever new challenges in semiconductor manufacturing, reliability and quality, all kinds of issues. Today there are many challenges. When I started my career one of the amusing things about MOS devices as compared to bipolar is people said, "Well, they were simple." And structurally they were. You could build an MOS device with a handful of photo masks. Today if you look at a cross section of a sophisticated microprocessor, you'll have nine levels of interconnect. You'll have any number of different materials and structure. Many, many implants. It's a very complex process. And yet the yields are incredibly high. Industry has come so far. And yet the next generation requires breaking new ground every time in the physics of things and then in the tools that enable us to build the new devices. And therefore the costs keep escalating, as you know.

But SEMATECH, from my point of view, was a really important organization. It was difficult to do. There were issues about competitiveness, antitrust issues that had to be solved. There were technology issues. Just how do you get people from all of these different companies to come and work in a collaborative way when in fact they'd been competitors? But we sent scientists and engineers to work together. Fortunately with the leadership that Bob Noyce provided early on -- we forced or drafted…twisted his arm so that he would take on the first chairmanship of SEMATECH -- he just did a wonderful job of creating an atmosphere where people could come and be successful. And it was a huge loss to the industry, in my view, when he died prematurely. But SEMATECH continues to add value, in my view, to the industry and I think it was just a huge success story for us.

Addison: Speaking of Bob Noyce, everybody loves to hear stories about him. Do you have an anecdote or a personal recollection?

Palmer: Well my personal recollection…the first time I met Bob Noyce I was just privileged to be able to meet him. I just remember how soft spoken he was. And for someone with his level of accomplishment, you never met a more modest man, unless possibly Gordon Moore -- his protégé. These guys were really the best of engineering and management and yet really soft spoken, self-effacing gentlemen. And the thing I came away with thinking was—"Wow! What a great human being in addition to being obviously a leader, a pioneer in semiconductor technology."

Addison: Just moving back to Mostek and leading up to the acquisition by United Technologies, how did that happen?

Palmer: Of course L.J. Sevin would be a better source for the actual detail -- but the driving function as I recall was that Sprague Electric, which owned a large percentage of Mostek even though we were a public company, wanted to basically cash out their position and get a capital infusion for their main business. And in doing that basically we were in play.

Various companies were interested in us because of the success that we'd had and L.J. had built a company that I think in our peak probably had on the order of 8,000 employees and multi-hundred million dollars of revenue and had established ourselves as a leader in technology. Really, United Technologies, as I recall, played a “white knight” role. It was a very professionally run company and remains so in my view. They made a better offer than the competing offers and they were able to buy the company in late 1979. And I believe the transaction was completed in early 1980. And I enjoyed what I learned working with the executives at United Technologies. Harry Gray was their CEO at the time and I remember going up to Hartford, Connecticut on a quarterly basis and explaining my budget and my goals and the achievements. And believe me. It was a lot more fun to explain achievements than misses. So Harry was good at instilling a little more discipline. And they ran things in a much more financial structure than maybe we were used to. But again, for me personally it was a good learning experience. And I think the company did well. United Technologies brought additional capital and enabled us to move more heavily into photolithographic steppers than we otherwise could have. At that time we were still on projection aligners and just making a transition to using stepper technology, which enabled us to build more complex dynamic random access memories. There were a lot of technical problems to solve using that technology, not the least of which was throughput. But UTC was a good parent. We would have preferred to stay independent. But under the circumstances we weren’t in control of our own destiny. We didn’t own enough of the equity in the company.

Addison: Did you leave United Technologies before the Mostek division was sold?

Palmer: No. I stayed with United Technologies. I think I was probably the last…the longest serving original Mostek employee with UTC. I left when Mostek was sold as a division from UTC to ST Microelectronics. And of course it remains in Carrolton [Texas]. I haven’t been out there but they still have a number of engineers there and it’s been a contributor all these years to ST. But that would have been in September of 1985, if memory serves correctly. And that’s when I left the company. Then I was fortunate to go to work for Digital Equipment in their semiconductor operations.

Addison: Robert, could you talk about how you ended up going to Digital and what sort of work you did there initially?

Palmer: Well I was fortunate to be recruited to go to work for Digital Equipment and to run their semiconductor operation there. At the time I wasn’t sure I wanted to do that because I’d be moving back up to the Northeast. But I had lived up there for three years previously. I like it. There is a lot to be said for it. And Digital was a very different company. They’d been a customer of Mostek’s so I knew some of the people. But it was a very different kind of company in the way it was managed and run. And of course, a very successful company. In semiconductors I was initially responsible for the manufacturing side of that and the circuit designers. And I enjoyed it. I enjoyed the people and I enjoyed the culture at Digital. We had a relatively modest sized manufacturing facility because we were building semiconductors primarily -- well, really exclusively -- for Digital’s system products.

Addison: I imagine that Digital would have had to buy a lot of their ICs from merchant suppliers.

Palmer: Yes.

Addison: So what was the internal [semiconductor] manufacturing? What sort of advantage did that give you to manufacture internally?

Palmer: One of the most important products that Digital had in the mid 1980s when I joined the company was the MicroVax. MicroVax was…a single chip that would run the VMS software for Digital. And so this enabled us to build a very successful line of work stations and small servers…you couldn't have bought that chip externally. It had all kinds of proprietary architecture and information in it for Digital. And the engineer that managed that project…Jesse Lipcon, was employee number 1,024 at Digital, which I remember quite well because 1,024 of course is a power of two. But Jessie did a great job with that. And again he was a good systems customer.

Now I was also responsible for our external semiconductor purchases so Digital had a big appetite for semiconductors. So that gave us a lot of clout in the industry in terms of purchasing. And we only built things internally that you couldn't buy externally. It was obvious you could buy your commodity supplies and traditional integrated circuits externally much cheaper than you could design and build them inside. On the other hand, some of the things that we designed and built inside, like the Microvax chip, gave us significant advantages in the market place and with our systems products.

Addison: Were there any particular manufacturing issues that you had to deal with at Digital in semiconductor manufacturing?

Palmer: There were. Semiconductor operations are different in every company really. You learn things at a different company. You can bring that knowledge to the new company. You find that they do some things there better than you were doing them before. So there was a lot of, I think, good work being done at Digital. I enjoyed it. We had a good relationship with our suppliers and I think the company was a well-respected company. So most of the challenges I had had to do with getting the costs down. Normally in a systems company where you have much more modest volumes you need a different mindset than perhaps they had initially. So a lot of my focus was on -- "How do we become more efficient? How do we reduce costs, improve cycle times?" Things of that nature. Work better with our internal customers. But nothing spectacular. Nothing unusual when you're a semiconductor supplier.

Addison: How did you make the progression from head of the semiconductor manufacturing to the CEO of Digital Equipment?

Palmer: Well from semiconductors, which were really not a very important part of Digital Equipment Company at the time, I was successful in reducing our costs and meeting my budget and that sort of thing for a number of years. And that got somebody's attention. And they asked me to take on all of manufacturing. And manufacturing was a big challenge. We manufactured in many different countries around the world. We had far too much manufacturing capacity. What had happened is that as semiconductors enabled more and more of the computing to be done on individual chips and much smaller and tighter packing density, you really didn't need the sized factories we had because you didn't build them that way anymore. So it was my job to take that on and to figure out how to rationalize all of manufacturing.

We had about 35 plants as I recall. And we had work for a very small number of those plants if they were fully loaded. So it was a pretty difficult job, frankly. And a number of really awkward decisions had to be made in terms of which plants just had to be closed because there wasn't sufficient work. Even though the company was doing quite well there was just no work for those plants because semiconductor technology really had changed the way that you needed to build computers.

I was successful I guess in managing the manufacturing operations, reducing costs. And when it became time for Ken Olsen, who was the founder of Digital, to retire and step aside, the board did a process that involved interviewing various managers within the company, both in the systems side and manufacturing…and external candidates as well. And I was privileged really to be selected to succeed Ken, who was a legend in the industry. By that time the company was having some pretty serious difficulties. But, you know, you grow into the job. It was a real privilege and an honor to be chosen and really capped my career. I love the company. It was a great company and the people there were really wonderful to work with.

Addison: And when did you retire from Digital?

Palmer: Well, it became clear to me in the mid, probably the mid 1990s, that the personal computer business was going to continue to expand and that proprietary architectures were going to have more and more difficulty competing with architectures that were more standardized. And basically the whole cost structure of proprietary architectures was not suitable for customers' needs as the industry standard chips had more and more power and began to gain as software from Microsoft and others became more robust and capable, and as UNIX' pervasiveness began to grow and grow. It was obvious that really you just couldn't compete on small volumes against these giant volumes.

To be specific, at the time we were talking with Compaq [Computer] about a merger of the two companies, I think Digital was manufacturing about one million PCs a year. And Compaq was doing 12 times that number. So the whole economics of scale of purchasing power, everything was working against smaller manufacturers. So you either had to get out of the PC business, which is where the whole computer industry was going, or you had to find some way to get more scale. And from my point of view and my management team, the board of directors, we felt like the best opportunity was to marry the systems kind of expertise that we had and the services expertise with the high volume manufacturing of PCs that Compaq had. And I think that that was a necessary consolidation. That merger was completed in 1998 and as part of the merger, I no longer had a job. I sort of had a couple of ways to go…and the way I chose to go was to get a premium for my shareholders but it resulted in my career being over. But it certainly was a great career and no regrets about that. And that consolidation continued, by the way. As you know, Compaq and Digital and Tandem are now all part of Hewlett Packard. If you look at the total employment of Hewlett Packard today, it's substantially less than the employment of those four companies combined. So the computer industry is going to continue to consolidate in my view and that was part of that process.

Addison: Well that's it. That's all we need.

Palmer: I've enjoyed talking with you.

Addison: Thank you very much.

Palmer: Thank you.

END OF INTERVEW

