Oral History of Victor Tsvetov

Interviewed by:
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Victor Tsvetov, May 14, 2012

Rosemary Remacle: Today we are here interviewing Victor Tsvetov. And I'm Rosemary Remacle with the Computer History Museum in Silicon Valley. And Victor, let's start. First of all, would you please give us some background about yourself? Where were you born? What was your family? How did you go to school? How did you decide to be an engineer? All of those things.

Victor Tsvetov: <laughs>

Remacle: A scientist.

Tsvetov: And so I was born in 1934. And in Leningrad, of course. I'm just a Leningradian. And I finished high school with gold medal. Medal, metal. Not metal but medal.

Remacle: Um-hm.

Tsvetov: <laughs> Yeah. And entered the Electrotechnical Institute. Just that time when I entered this institute, it was in 1951. They opened a new specialty. It is called dielectrics and semiconductors. And

so actually, naturally, our output was the first, I believe, the first set of engineers who finished this specialty. And I graduated from the University with distinguished—

Remacle: Distinction.

Tsvetov: Distinction. Yeah, in distinction, merit or we call it Red Diploma.

Remacle: Um-hm.

Tsvetov: Something so. And the theme of my diploma was already the investigations about the influence of some physical parameters, on the parameters of germanium alloy transistors. And especially the influence of crystal orientation. And so it helped us to design new construction of plane transistors. Not planar but plane, you see, yeah?

Remacle: Yeah.

Tsvetov: I mean germanium alloy transistors.

Remacle: Um-hm.

Tsvetov: And somewhere, a couple of years after my journeying to Svetlana [Semiconductor] company, we designed and produced, then began to produce, transistors which has cut off frequency 5, 10 and 20 megacycles.

Remacle: Um-hm.

Tsvetov: It was, I believe, in 1958, yeah, I think so.

Remacle: You joined Svetlana in 1958 or ’55?

Tsvetov: No, no, no, no. Well, I made diploma in 1956. And graduated from the institute in the beginning of 1957. And a couple of years ago I <inaudible>—

Remacle: <Inaudible>.

Tsvetov: <Inaudible>, of course, yeah.

Remacle: <Inaudible>.

Tsvetov: Yeah. We designed new transistors and, of course, it was our great, I would think, great achievement. Because we began the activity connected with semiconductors in the beginning of 1956. So Svetlana company was the first company who began to produce mass production of germanium alloy transistors. And the design of these transistors was fulfilled in Moscow in semiconductor devices institute, which was organized in 1953. And really it was the first plane transistor, not point but plane transistor.

Remacle: Yeah, not a point contact.

Tsvetov: No, no. Well, actually, they designed with point contact, but they didn't produce it in mass production. So Svetlana was oriented as the first company of the Soviet Union, which organized the production of these transistors. They had numbers P1, P2 and P3, see.

Remacle: The beginning.

Tsvetov: <laughs> It's just beginning.

Remacle: Can I go back and ask you if in 1951, the Electro Technical Institute had just started a coursework in—

Tsvetov: '53.

Remacle: '53?

Tsvetov: Yeah, right.

Remacle: But they had just started the coursework in semiconductors.

Tsvetov: Yeah.

Remacle: What made it interesting to you since that was a whole new field? Why were you interested in that?

Tsvetov: Well, the thing is that when I finished high school, my interests were attracted to physics. And especially to physics of materials. And just this time was the beginning of investigation of transistors and it just coincide with my interest. It is the reason why.

Remacle: Um-hm.

Tsvetov: By the way, for some months, I trained in the Physico-Technical Institute, which was, of course, which existed from the '20s.

Remacle: Um-hm.

Tsvetov: And <inaudible> Ioffe was the leader of this institute, and they engaged in semiconductors for many, many years. And for instance, it's known, well-known, that for instance, very valuable article about p-n junctions and theory of p-n junctions was fulfilled before the Second World War. In 1938 or '9, something. So Dr. Daviolov was author, and I think that Americans know about his work.

Remacle: Oh, yes.

Tsvetov: And in any case, when you ask people from Physico-Technical Institute, you will have the same information. And so it was the reason. But <laughs> I intend to stay in the Physico-Technical Institute, because, well, my interest was investigation, maybe theoretical investigation. But it was very rough intention to involve some good people, pupil. <laughs> Some young engineers to industry. And so I moved to Svetlana instead of Physico-Technical Institute, and for the first time maybe it was even against my desire. But now I'm already more than 55 years in Svetlana, and I don't worry about this <inaudible>. <laughs>

Remacle: So talk a little bit about how did you find out and from whom did you find out that you were going to go to Svetlana instead of staying at the institute? In other words, how did the government manage that?

Tsvetov: I see. Well, you know that it was decision of government to organize the mass production of a germanium alloy transistor at Svetlana. And so Svetlana needed young scientists and young designers to make the practical investigations and active work. And so they decided, I mean government decided, to organize a lab, Svetlana.

Remacle: Svetlana.

Tsvetov: Which should design new types of transistors. And so, they selected the chief of lab and he tried to gather a good team to do it.

Remacle: So something like Shockley did at—

Tsvetov: Right.

Remacle: —Bell Labs?

Tsvetov: Right. Yeah. Unfortunately, that chief of lab was not… <laughs>

Remacle: He wasn't Shockley?

Tsvetov: Even close to Shockley.

<laughter>

Tsvetov: But he did.

Remacle: Okay.

Tsvetov: Well. And it is a reason why I am here.

Remacle: Um-hm, okay. And what was your first job here? Did you work in the lab doing research? And how did the research get translated into mass production?

Tsvetov: Yeah. Well, actually, my main interest was in technology. And so from the very beginning, I tried to concentrate my activity on development of technology processes. And even in my diploma, you see it was already some features which belongs to technology. And there I started allowing processes, you know, the materials to alloy, into germanium <inaudible>. And we were really lucky because we designed some types of transistors, and even if to speak only about cut off frequencies, not so good. Not so bad for alloy transistors. Yeah. And it was in 1958, yeah. Well, the thing is, if you speak about common situation in the Soviet Union, it was so. At first it was organized, the institute in Moscow, for developing transistors and diodes.

Remacle: Um-hm.

Tsvetov: By the way, in some years, this institute was split for two institutes. And diodes were separated from transistors. And by the way, Dr. Nosov, he's, I believe, the best specialist in diodes from that institute. And another aim and the second step, was to organize the mass production of some semiconductor devices and include in some design bureau or lab from the very beginning, and then maybe they became as a bureau or design bureau.

Remacle: And let me—

Tsvetov: Yeah?

Remacle: —stop and ask a clarifying question. So there was this, the institute or the ministry at the top?

Tsvetov: Yeah.

Remacle: And then they had some design bureaus?

Tsvetov: Yeah.

Remacle: And then there was Svetlana where—

Tsvetov: Yeah.

Remacle: —there was interaction between Svetlana and the design bureaus?

Tsvetov: Well, actually, as a rule, design bureaus were submitted to plants.

Remacle: So they resided in the plant?

Tsvetov: Right.

Remacle: Okay.

Tsvetov: Yeah, right.

Remacle: Thank you.

Tsvetov: And, for instance, financially and even in organization manner, they were submitted to plant, to factory. But sometimes, they have just enough rights and even financial rights in order to have, for design, new devices. Yeah. Well, and fortunately, there were some centers were organized during some years, yeah. And they were organized except Leningrad. It was organized in Voronezh. It was, I believe, the second center. And then in Siberia, now Novosibizsk. And then Kiev, Minsk and Baltic Republics. And so on and so on. And so there was just a net of semiconductor power, as in production. And as well as in design. And one more thing that you know, because of our centralization, very hard centralization, we were to design only definite types of devices.

Remacle: So the devices you were to design were decided someplace in Moscow?

Tsvetov: Right. Well, actually, we can say some our proposals, but as a rule it was decided from Moscow.

Remacle: And they would also decide which design center would design which things?

Tsvetov: Yeah.

Remacle: Okay.

Tsvetov: Yeah. Well, for instance, for Svetlana, for the first years of activity, of semiconductor activity, our specialization was low power, high frequency alloy transistors. It was about four or five years of our being as a enterprise which produced semiconductors. But in design bureaus, we did two kind of deals. At first we design it, of course. And construction into enclosure, of course. And then we helped to organize the mass production of off-site devices.

Remacle: Okay. So in the U.S. we would say that was transfer from development into manufacturing. There's a well-known process in the semiconductor companies that it gets designed, but the design team works very closely with the manufacturing—

Tsvetov: Yeah.

Remacle: —and process people—

Tsvetov: I see.

Remacle: —to transfer the new design successfully into mass production. So it sounds like a very similar process?

Tsvetov: Yeah. It's just very similar. Because we were very close to production team, and so team of designers and team of production. But all the time they, I mean who manage the production, considered there to be made bad designs.

Remacle: <laughs> Same thing.

Tsvetov: And we designers—

<laughter>

Tsvetov: —told them, "Oh, it's—"

Remacle: It's your problem.

<laughter>

Tsvetov: It's a common problem, yeah?

Remacle: It's very same thing in the United States.

Tsvetov: I see. <laughs>

Remacle: Yes. Very same thing. Intel had that problem a lot. So when you were deciding which products, what kinds of products? Like processors, controllers, memories? Which products did—

Tsvetov: I see.

Remacle: —Svetlana?

Tsvetov: Well, just up to now, we discussed about only transistors. But now, you are asking me—

Remacle: I'm jumping ahead.

Tsvetov: —already jumping, yeah.

Remacle: Yeah.

Tsvetov: Well, let's wait for a while. <laughs>.

Remacle: Okay.

Tsvetov: Don't jump.

Remacle: All right.

Tsvetov: Yeah. In 1944— no, no, no, '64, '64. The people from a Moscovian institute, its name Pulsar.

Remacle: Okay.

Tsvetov: And maybe you—

Remacle: Yes, I remember.

Tsvetov: Yeah. And Tzutko was that time the director of Pulsar. And he came to Leningrad and here he recommended our company to involve in the designing of planar process. It was in 1964. You see?

Remacle: Um-hm.

Tsvetov: '64. And we agreed. By the way, Mr. Kaminski, whom picture I showed to you.

Remacle: Yes.

Tsvetov: He was the first director, very progressive. And he decided that that's good if we will be involved in this process. And so I believe that during 1964 to 1966, for these two years, we managed to develop the main technological processes of planar technology. And so oxidation, diffusion, from the very beginning, diffusion in tube. Then in implantation. You see.

Remacle: Yes.

Tsvetov: It's also Metallization. All these processes were developed. And we began to design planar transistors. Just transistors. Not integrated.

Remacle: Not ICs.

Tsvetov: Yeah. Not ICs yet.

Remacle: Yes.

Tsvetov: And so…

Remacle: So did you develop? I'm forgetting the exact dates.

Tsvetov: Yeah, yeah.

Remacle: But I know that Jean Hoerni and Bob Noyce worked closely together on planar technology, which enabled the mass production of ICs in the U.S. or with Fairchild.

Tsvetov: Yeah, yeah.

Remacle: So did you have planar technology developed about the same time frame as the U.S. or—

Tsvetov: Well, actually, I think to say honestly, it was three or four years later.

Remacle: Okay.

Tsvetov: Yeah. Because, of course, we follow the articles of Americans and oxidation and the stability of worksite.

Remacle: Yes.

Tsvetov: Two layers.

Remacle: Very important.

Tsvetov: If you remember.

Remacle: Yes.

Tsvetov: It was quite a problem.

Remacle: Yeah.

Tsvetov: Yeah. The same for us. Yeah. And I think that we already designed it somewhere in ’66. But if to speak about Noyce and his thing, it was somewhere in ’62, I believe, yeah.

Remacle: Okay.

Tsvetov: ’61, ’62. Isn’t?

Remacle: I don’t remember, but I think you’re right. Because I’m remembering Jack—

Tsvetov: Well, in any case—

Remacle: —Jack Kilby, yeah.

Tsvetov: In any case, the gap through that time was not so big, by the way.

Remacle: Between what was going on in the Soviet—

Tsvetov: Oh. Between the level of designing in United States and in the Soviet Union. I think that one of the most important problems in the Soviet Union was organizing of mass production. And so we can design rather good device, but to organize mass production, it was a problem. And the gap between design and organization of mass production. I know that in United States it may be half a year or something. But we have two or three years for, you know.

Remacle: Why was that?

Tsvetov: Why was that?

Remacle: Um-hm.

Tsvetov: If I know about it…

Remacle: You would've solved the problem?

Tsvetov: With great difficulties.

Remacle: Well, what were the biggest challenges? Maybe that's a better way to ask. What were the challenges that had to be resolved to get it into mass production? To get clean an environment where you could have reliable…

Tsvetov: Uh-huh. <laughs> That's very difficult question. Well, so the organization at first, how to organize all the process, all the processes. And then how to organize the supply, all the materials which I need. Some chemicals and gases and so on. And to be sure that quality is quite enough, such things. Of course, the organization of clean rooms and if there will be, I guess that there will be, some questions about Dr. Staros and there—

Remacle: Yes.

Tsvetov: —I think that one of the main reasons why they failed, was the lack of quality of clean room, for instance. Yeah. Well, and maybe some more reasons. If you know, I think that it's nearly tradition for Russia.

Remacle: Yeah. That's just the way it is.

Tsvetov: Yeah. It's really so. Because it takes too much time to organize mass production of something. By the way, there are some, for instance, historical examples. Well, when, for instance, something was invented in Russia, but the practical using was not in Russia, for instance. For instance, if you know of, because for instance, laser or not laser itself, but laser effect in the UHF range, yeah, was invented here. The authors were Prokhorov and Basov, they became Nobel Prize winners. But if to speak about the practical application, it's America, you know. And it's—

Remacle: Do you think that— I mean, I don't know.

Tsvetov: Yeah?

Remacle: But do you think it is the difference between having a government's central planning, centrally managed government, versus commercial companies who just could do what they wanted? Do you think that was a—

Tsvetov: Yeah. It's one of the reasons, of course. Of course. Was one of the reasons. Yeah. And so we were ready to design new transistors. And for instance, in 1967, '68, we designed and began the mass production of some type of planar transistors with fT somewhere about 500 megacycles. And collector capacity about 5 picoseconds. And time delay about 30 nanoseconds, something. So I was a main constructor, designer of this, these devices. And so it's one of my proud I would say, that—

Remacle: That you're very proud of.

Tsvetov: <laughs> Sure.

Remacle: As you should be.

Tsvetov: These were rather good transistors. And they were the first planar transistors at Svetlana. And so, of course, they were, well, simultaneously, some another institutions and bureau designed nearly the same, but we did it. And so you know that we had no already technologies from somewhere. And so we should do it by ourselves.

Remacle: So let me stop and ask a—

Tsvetov: Yeah.

Remacle: —question here, Victor. If you were working on a planar transistor and another design bureau was working on a—

Tsvetov: Yeah.

Remacle: —planar transistor—

Tsvetov: Yeah.

Remacle: —did you each one know that you were working on the same things?

Tsvetov: Moreover. Moreover. We didn't compete, as for instance, now when every company tried to hide their results. And if to speak, for instance, about the competition between Intel and AMD.

Tsvetov: We did not compete. And moreover, we helped to each other. And we don't think that it's something strange. It's natural, we considered. And so we helped to each other. For instance, I had the chance to go to Kiev, to Minsk, and I knew, of course, all the specialties in the companies and we exchanged our experience. They don't hide something from me. And he showed me their lines, their technology. And even just documents, technological documents. <laughs>

Remacle: Again, I'm using my experience and knowledge of the U.S. semiconductor world as a reference point here, but I know that in the very early years, in the late '50s and into the '60s, a lot of the designers had to create their own design tools and help create the manufacturing—

Tsvetov: Yeah.

Remacle: —equipment, because nobody made it. Nobody made a diffusion furnace.

Tsvetov: I see.

Remacle: Nobody made an ion implanter—

Tsvetov: Uh-huh.

Remacle: —or wafer stepper.

Tsvetov: Uh-huh.

Remacle: So how did that part of your business work? How did all of the semiconductor process and manufacturing equipment and tools get developed?

Tsvetov: I see. Well, they were organized some special institutes and enterprises to design equipment, technological equipment. And as a rule, the technical rules of, and parameters of, this equipment, they were generated by leading institutes. And then this special institute or factory designed it and began to produce. And the first customers were, of course, the people from that institute who ordered it.

Remacle: Um-hm.

Tsvetov: Yeah? And then it was spread for all the enterprises, which needed in it. Nearly the same if to speak about materials. We have some special institutes for designing some materials. And so for instance, not only silicon as a main material or germanium, but some gases and liquids and it also was designed there, developed, or not designed, but developed. And then everybody may use it.

Remacle: Okay.

Tsvetov: But of course, we felt the lack of the amount of this agreement. And so, by the way, so such equipment was spread also by ministry. And so I should go to ministry and ask, “Would you sell us these and these?”

Remacle: So you had to—

Tsvetov: Yeah?

Remacle: —do a little bit of negotiating?

Tsvetov: Well, <laughs> it was necessary. <laughs> I remember in the very beginning of my activity, I remember my commission to one small town near Moscow Elektrostal.

Remacle: Um-hm.

Tsvetov: They produced a special sort of steel, which held high temperatures for furnaces, for alloying.

Tsvetov: I tried to <laughs> have couple of sheets of, you know. <laughs>

Remacle: Again—

Tsvetov: Even so, yeah.

Remacle: —the stories sound very much like things that happened in the early years in the United States too.

Tsvetov: Really?

Remacle: I see.

Tsvetov: Yeah.

Remacle: <laughs> And so I am not a liar in any case. <laughs>

Tsvetov: No. No. I wouldn't challenge you at all.

Remacle: All right. So then slowly it sounds like, as a group within Svetlana, you began to build confidence in both your design and your manufacturing ability. At what point would you say, at what date and time would you say, that you had a fully operational production line, mass production line that was working?

Tsvetov: Well, of course it was some figures, for instance, of yield, which is necessary to achieve.

Remacle: Yeah.

Tsvetov: And after that we might say, "Go ahead," and we say to them, "Goodbye," and we came to make another design, yeah.

Remacle: So you set a yield goal and when that was met then.

Tsvetov: Right, right, yeah.

Remacle: And so when— I'm asking a question, so slightly higher level. You said it took two to three years longer in Soviet Union to get mass production of semiconductor devices.

Tsvetov: Yeah.

Remacle: —semiconductor—

Tsvetov: Yeah, right.

Remacle: —or transistors.

Tsvetov: Yeah, yeah.

Remacle: At what point, what date approximately, had you solved all the manufacturing and process problems and you did have a functioning mass production capability?

Tsvetov: Well, it depends on the complexity of the device, I believe. Because if it were a just new technology, it took rather big time. For instance, if you speak already about ICs, that it took us about three years to achieve the two layers of metallization. The second layer of metallization was quite a problem for us.

Remacle: And why?

Tsvetov: Why?

Remacle: Yeah, what were the technical problems you had to solve?

Tsvetov: I think it's the quality of silicon oxide. Because we should, to supply with such conditions of growing— thermal growing of...

Remacle: The crystals.

Tsvetov: Silicon oxide. In order to— the next layer, because it was interlayer, I mean, the silicon oxide. And for the second metallization, they just melt through. It was a problem. Because there are many in the

CO2. And of course, it should be good quality of clean rooms, for instance. Because if you have a particle, it's...

Remacle: It's not a good yield.

Tsvetov: Yeah, right. Killer, it's a killer.

Remacle: I asked you a question earlier that you said you would answer now. So let me ask the question again. I read someplace in doing some research that the soviets were slow to adopt silicon as the primary material for making semiconductors, or the primary semiconductor material. And stayed with germanium much longer than their American counterparts.

Tsvetov: Yeah, yeah.

Remacle: Why was that?

Tsvetov: Well, it was because of the low quality of silicon.

Remacle: Why was that?

Tsvetov: Why was that? You know, that we had no, to that time, special plans to grow high-quality of silicon. And we had no possibility to buy it abroad. And so we knew that, for instance, German ingots were excellent, but we had no possibility to buy it. And so we were waiting for our native silicon ingots. And at last, we have got it. But if you speak about the quality, I mean, dislocations, stacks, you know, when you treat by chemicals, and very many this fault. And then _____ and so I think that is the main reason. We were ready. Technologies of semiconductor devices. But people who developed silicon, they were not ready. And besides they were from another ministries. Maybe it's also a reason. <laughs> But I think that most of your questions merge to the main question, I believe. You know, that we were isolated society. And so everything we should do by ourselves. Beginning from materials, chemicals, gasses, clean rooms, technological processes, and equipment. I mean, not only technological, but even metric equipment. And so it took much effort to reach it. And so it's difficult to say who was the last, who was the first. But all the line of this process from the very beginning, I mean, raw materials, up to the ready-made devices, it's a long way. And so everything would be, should be made properly.

Remacle: I want to ask you a non-technical question. Kind of more of a personal question, a psychological question.

Tsvetov: Yeah?

Remacle: How did it feel as an ambitious, smart, young physicist, semiconductor developer, to be isolated from counterparts, and you knew that they were working on things that were very interesting and valuable to you? How did you deal with that personally?

Tsvetov: You know, maybe you will be surprised. But it doesn't trouble me. Well, it's the same— it's such a condition.

Remacle: That's the way it is.

Tsvetov: And such the rules of game. And so why to discuss the rules of game? I should do good device. Well, unfortunately, I cannot buy, for instance, the metric equipment of HP, Hewlett Packard, but oh, well, we shall try to do it by ourselves.

Remacle: So it made it interesting.

Tsvetov: Well, of course, if I had a possibility to buy something from abroad, I would be glad, of course. But if not, well, let's try to do the same by another manner, or with another, you see. And so we had excellent new design bureaus. For instance, in Minsk, it was the highest level of, for instance, steppers. I was there, somewhere in the beginning of '80s, and they constructed the shop, which was located eight meters below the level of ground.

Remacle: Wow.

Tsvetov: Why? Not to have vibrations. You see? And they have bought some instruments from Switzerland. It was not semiconductor equipment, but some instruments to make semiconductor equipment. Yeah. And they keep, for instance, temperature, plus/minus .5 degree.

Remacle: Whoo! Very controlled.

Tsvetov: Very controlled. And the base was made of stone, because the low linear—

Remacle: Expansion?

Tsvetov: Expansion, yeah. The coefficient of expansion. Well, and it was indeed all these things. And so they made such good step and stop repeaters that they would compete with Japanese and American. For instance, it's one of the examples. And maybe another very interesting example that one Institute of Moscow he designed ion implanters. And also they create the set, just the set, for different voltage for different dose, you know, for different technological processes. And it was also, I think, the level, technical level, was very close to level of other countries.

Remacle: What information, even though you were in a closed society, and people on the other side of the US, the Europeans, were protecting their information, also. So it was kind of two edges.

Tsvetov: Well...

Remacle: How much information did you get through like journals, or conference notes and things like that.

Tsvetov: In any case, at first, we had read magazines. And all the technical magazines, we used and maybe it is the reason why most of soviet designers knew English in the level of technical terms. And so I can compete only in this region. Yeah, because we have read the— even up to now, I get the electronic version, e-version, of four American magazines. I try to find what's happened now in integrated circuits. I don't know why, because I'm not designing new devices already.

Remacle: You are retired.

Tsvetov: Yeah, I'm retired. But it's interesting for me up to now. And so it was the main source of knowledge, I mean, the first one. You know, of course, some people came to different conferences, but most of them were high bureaucrats, but not...

Remacle: Not technical.

Tsvetov: Not people who designed really.

Remacle: So these were soviet bureaucrats that went to conferences in maybe Europe or someplace else.

Tsvetov: Yeah, you are right, yeah. Well, of course, not only bureaucrats. Of course, we also visited conferences. For instance, as for me, I was at conference in Boston. If you speak about America, United

States, then couple of conferences in England, and in what else, Japan, yeah, Japan. And so it was. But you know.

Remacle: In what timeframe did you go to those conferences? In what years were those conferences?

Tsvetov: Well, it was from— I think from 1968 or '69, something from this time, up to '82, I would say.

Remacle: How difficult was it in those years to get permission to go to these conferences?

Tsvetov: You know, if our authorities decided to give a place for a conference, and they selected person, it was not a problem.

Remacle: But if you, as an individual person working in Svetlana, if you had said, "I want to go to a conference in the UK," and somebody upstairs had not said, "Victor, we want you to go," it would not be possible for you to go to a conference just because you wanted to go?

Tsvetov: Well, of course, it depended not on my desire. But if I'm recommended to do it. But I was among these recommended people, because I knew a little bit English, and I was rather experienced already, and so some marks, maybe. Well, and so I was abroad about 15 times. I was, for instance, five times in Hungary, as I told you already. Then five times in Germany. Japan, once. England, once. Two times in the United States. What else? Italy, once. Maybe a _____ or something. But in any case...

<overlapping conversation>

Remacle: You traveled outside of _____.

Tsvetov: But I'll just say now a funny thing. I was forbidden to go abroad as a tourist. <laughs>

Remacle: You could travel as an engineer/scientist.

Tsvetov: Right, right.

Remacle: But you could not get permission to go—

Tsvetov: Right. I know why, but it's not for, you know. <laughs>

Remacle: Well, now I want to know why!

Tsvetov: <laughs> Well, actually, it's— I believe that it's possible to speak now about it. If we go abroad as— in commission, we were guaranteed by our Minister, you see? He guaranteed that we are good people.

Remacle: Good communist citizens.

Tsvetov: So on and so on. But if you are going as a tourist, nobody guarantees anything, you so. And now I begin to go as a tourist. I was already in Turkey, and Egypt, and so on and so on.

Remacle: Well, isn't that a nice thing to be able to do? That's a good thing.

Tsvetov: Yeah.

Remacle: So talk a little bit more about what you did at Svetlana. You talked about the transistors. Now what other products did you work on?

Tsvetov: Well, somewhere in the, I think, in 1970, we began to produce integrated circuits. And you know, that we had experience to this time in planar technology. And in producing bipolar transistors.

Remacle: Okay.

Tsvetov: And so first devices we began to produce was based on bipolar transistors. I should say here that our customers would like to have just copies of, for instance, American semiconductor devices. And I think that made for us bad service. Because they insisted everything should be just copy of American devices. We tried to design somethings which were original. It's not for originally. But it was our reasonable ways of destination of results and so on. But our customers were very rigid.

Remacle: This is the military, the government?

Tsvetov: Yeah, yeah, and military at first, of course. And they, for instance, they were ordered to create such and such apparatus. And so they tried to dictate to us to make just copy.

Remacle: I read someplace that it became government policy for about ten years in the '70s/'80s timeframe, that rather than invest in new designs inside the soviet union, the policy from someplace above was to do copies, to backward engineer American and European parts.

Tsvetov: It was one of the most serious reasons why we were behind all the time. Because you know, if you repeat to make the copy, you have no possibility to be ahead.

Remacle: That's right, you have to wait till the original gets done and then copy it.

Tsvetov: Yeah, right. For instance, if you speak about our company, you ask me about what Svetlana did after that. Well, we copied some integrated circuits from the set of TI-54/74, for instance. It's very famous series. And I believe that about ten bureaus copied three, five, six of this series. Series was about '70, I don't know, very big. And then we also copied Motorola 10,000, of course, this series. And some others. I don't remember already. But we did it of course and maybe not so worse we did it. But it was only copying. And at this time, we tried to reveal our activity and independence something. And we proposed to ministry to design series of electronic devices and multiplexers. Well, we did not copy, for instance, electronic devices or semi-tronics, or hardy semiconductors. We just copied only the functional.

Remacle: Not the full design.

Tsvetov: Yeah, right. It was our original design. And the result after many years of being in this field, we at first we became the first in the Soviet Union— the second. We developed radiation stable special for cosmos for rockets, and so devices. And now, it's the only series which continues to produce at Svetlana, but it's to speak about another which was copied. Well, now, copies are cheaper rather than to produce it here. But these integrated some circuits were. Up to now, they give the profit to Svetlana. And so...

Remacle: What are the applications?

Tsvetov: We have very positive— so pardon?

Remacle: What are the applications for those analogs?

Tsvetov: Applications? Oh, very many, many applications. It's just switch any signals. And so it's any application.

Remacle: What does Svetlana sell them? What application do they sell them into? What do their customers use those analog circuits for?

Tsvetov: Well, we have many customers. And you know, applications just different. Because it's not specific function. It's just switching analog signal.

Remacle: Yes.

Tsvetov: And so even up to now, we have hundreds, maybe even more than hundreds of customers.

Remacle: Did Svetlana feel like they competed with some of the big analog producers in the United States like Analog Devices, or TI?

Tsvetov: Well, I can speak to you with pride that our analog switches, they correspond to Siliconix. I know that now there is no this company. That National Semiconductors, also, is not a company now. Well, Analog Devices, I owner of this company, I consider that it's one of the best. Something so, I think.

Remacle: They are for Analog Devices, certainly.

Tsvetov: Yeah, and so we had some. Just now I cannot to say you what types definitely. But believe me that some our devices were just analogs, I mean, functional analog of such. Well, so the set of our devices is about maybe 25 or even more types. They different on switching rate, the number of channels, and on resistance and so on, you see, such kind of things. Well, it's just positive example that if you have some rights to design what you consider that is quite right. It's a...

Remacle: It's another personal, psychological question. How did it feel to you as, again, a smart capable designer to be told, "Copy only. Don't be creative." How did that feel?

Tsvetov: It's very difficult situation. Moreover, if I shall tell you about my activity in bureau, which was leaded by Staros, and I was his— not predecessor, how to—

Remacle: Successor?

Tsvetov: Successor, yeah. I was his successor. We just had very difficult situation when we developed set of minicomputers. You know...

Remacle: Are these the UM-1, and UM-2?

Tsvetov: No, no. It was minicomputers before me. Yeah, I speak about microprocessors, some series. And they were developed for special technological using. Running of technological processes. And we developed set of commands with key of Institute of Cybernetics. And with a couple of academicians from Kiev. And we spread our production through some hundreds of customers. And we involved another plant to produce our production. And everything was excellent. We were ready to very high level of, you know, of our activity. But ministry decided that we will use only one system of commands. Set of commands. And so CISC [Complex Instruction Set Computer], I mean, you know, yeah, CISC was from company DEC.

Remacle: DEC.

Tsvetov: Digital— yeah. You call it DEC?

Remacle: DEC, DEC.

Tsvetov: DEC, I see. Not "deek."

Remacle: No, not "deek," DEC.

Tsvetov: DEC, yeah. In Russian we say DEC. Yeah, Digital Equipment Company.

Remacle: Yeah, that's a different word.

Tsvetov: Not another set of commands. You know, we developed our system of commands before the decision was already made. And so we have no possibility to combine with somebody. Yeah, but the leaders of our ministry. They decided that all our achievements for five years closed.

Remacle: So how did that feel?

Tsvetov: Well, we published a book. I'm one of the authors, about this set of microcomputers. And it was from the microcomputer of four chip— four chip— up to one chip computer. One chip computer. And in 1979, we had the same parameters with Texas Instruments 9940. Maybe you just now write it. 9940. Yeah, you know, that in 1979, we were on the same level. It was 16-bits— one chip microprocessor. But it has another set of commands. You know?

Remacle: So it won't go.

Tsvetov: It's main pain of my life, of all my life. Because we did our activity about six years from 1973 up to 1979. And everything was just stopped. And we sent our proposals to a worth by state premium of Soviet Union. And everything was clear. But one angry man who was responsible for this activity, he made in such a way that, you know...

Remacle: It didn't go over.

Tsvetov: No. No premium. Yeah, but the end of this story is that it should be called bulldozer <Russian>.

Translator: An excavating machine?

Remacle: Oh, a bulldozer.

Tsvetov: Yeah, in order to— well, of course, in the world, the system of comment of Intel was...

Remacle: The standard.

Tsvetov: The standard. And so all the things which made, for instance, <Russian> and Zelonograd [ph?], they submit to this decision. It was waste. It was everything was trash.

Remacle: Who was the angry man, and why was he angry?

Tsvetov: I don't say! <laughs> But you can calculate.

Remacle: I was going to say, I think I can go back. But why was he angry? Had Staros.

Tsvetov: No, no, it's not Staros, of course. Staros was dead, unfortunately, through that time. Well, the things that— idea was positive in certain. He considered that you see there is a set of commands of Intel, of Motorola, and so on. We have no such possibility to help so many sets of commands. And so we select DEC. And so everybody should do DEC. But he failed, because DEC also was not the right, yeah. But it is real dramatic.

Remacle: Yeah, I can see where definitely would be. So let's go back and talk about Staros and Berg. This is a good place to do that?

Tsvetov: Well, the thing is that the story of Staros and Berg is very well known. And there are different positions to their activity and their influence on the microelectronics in the Soviet Union. I shall speak only according to the facts, which I took part personally. Because I know opinions, I know different just extreme opinions from one and from another side. But what I was participant, the first one, somewhere in 1959 or 1960, between this, I don't the exit, Staros, who was at that time already the Chief of Design Bureau.

Remacle: The one here in Leningrad?

Tsvetov: Here, right, yeah. He decided to collect all the people from different branches of electronics, to say something special and important, and to try to organize the common job, common billing. And so it happens in such a way that I was delegated to this meeting to start us from Svetlana, because the invitation was sent to Svetlana as well. And so I saw Dr. Staros for the first time. I didn't who was he, but well, it's some kind of meeting. I was sent— well, I risen. And I've heard they wrote microelectronics for the first time.

Remacle: Oh, interesting.

Tsvetov: Well, maybe— maybe I was so ignorant that everybody already knew this, word— but I don't think so, because just now we know that Dr. Kilby invented integrated circuits in 1950s, 1959. And it was somewhere between 1959 and 1960. And so I think it's—

Remacle: It's new language.

Tsvetov: Of honor of, of honor of Staros, that he paid our attention on this new phenomena, and new field of activity. And so he asked us to take part in his efforts to— today— to make some new and maybe first devices of microelectronics. Well, I think it's very positive.

Remacle: Did you have any idea that he was not Russian when you met him?

Tsvetov: Well, no more than he is a foreigner. No more. Because it was in high secret, and so now everybody can speak about it and the— you know. Well. And I think it's very positive and I was a participant. It means that it's— it has no maybe or not maybe. <laughs> I am real man who was there on that meeting, yeah. Well, it's the second— the first one. The second.. in 1973. In 1973 there occurred the situation when authorities, I mean, Moscovian authorities and political authorities of Leningrad, decided of rid of Staros, made rid of Staros. Am I right?

W: To get rid of.

Tsvetov: Thank you.

Remacle: He what?

W: To get rid of.

Tsvetov: Yeah, yeah. To get rid of. Well, the reason.. I don't know, but I saw <speaks in Russian>.

W: Just yeah, just a copy of.

Tsvetov: <speaks in Russian>

W: Is it the right.. just the project of a paper.

Remacle: Oh, it's—

M: Draft.

Remacle: Draft.

W: Draft.

Tsvetov: Okay. Draft. I saw by these eyes, I saw—

Remacle: Those blue eyes.

<laughter>

Tsvetov: Yeah. I saw the draft of letter to Khrushchev. The thing is that Khrushchev visited Leningrad and bureau of Staros and offered to him helps because he was very interested in the results of Staros' activity.

Remacle: But Khrushchev himself was not a technical person.

Tsvetov: Yeah, yeah. But Staros organized very— you know, very <laughs> in very good manner. Well, Shokin also was present, and some ministers I believe were here, and Khrushchev told to Staros that if somebody will stopped his activity, to write a letter just to Khrushchev. And this draft I saw, it was the letter which Staros wrote to Khrushchev. I saw it. I remember. And the thing is is just a— just a novel or a movie, I don't know. It came to Kremlin and it was in October on 1964.

Remacle: Not a good year for Khrushchev.

Tsvetov: Then Khrushchev was knocked down, you see. And this letter was moved to whom?

Remacle: Shokin .

Tsvetov: Shokin . You know, who was claimed as a man who just stopped his activity, you see? Yeah.

Remacle: So Staros in that letter to Khrushchev said Shokin is causing me problems.

Tsvetov: Oh. He was not so.. so stupid. He of course wrote it without names. But everybody knows. And so Shokin also knows. How do you think if somebody wrote a letter against you, how do you refer to such person.

Remacle: I would be unhappy with them.

Tsvetov: Yeah. Well. And so it means that for instance political authorities of Leningrad, they were angry at Staros. Well, he is a foreigner, he takes in his bureau many Jews, it's— but he was— he has rights to accept every people whom he wants, you see. And they don't like it that he doesn't submit to party authorities and so on. And from the— from the Moscow also such a <laughs> reaction of Shokin, this also was very, very difficult. Well, it was the beginning of end of Staros. It's the second point I know, just by myself. The third one, the third one. There was a discrepancy between the design of the first calculator, you've seen it some hours ago. Some—

Remacle: Hours.

Tsvetov: Yeah. Hours ago in museum of Svetlana. And the level of technology, it's very delicate thing to coincide and to fit design and technology. I believe that you know about it no less than me. Well. And so

they designed excellent device, but they could not reproduce it technologically, because of lack of clean room, because of maybe some rather not clean chemicals or another things, or maybe technological processes were not so good as it's necessary. But of course minister required that you need to produce hundreds, hundreds thousands, thousands and so on, and they had no possibility. And it was a chance to check the, you know, all the things. And he sent, I mean, Minister Shokin, he sent to Leningrad commission, special commission. It was in June 1973, and the level of commission was very high. The leader of commission was deputy minister. And then some.. some chiefs of departments of ministry also.

Remacle: So they were very powerful men.

Tsvetov: Very powerful men, yeah. And we guess that something will happen, because among them was chief of department of <speaks Russian> personnel.

W: Of the staff, party staff.

Tsvetov: Of the staff, yeah. Of staff.

Remacle: Of the communist?

W: The Communist Party staff.

Tsvetov: No, no, no. Not Communist Party. <speaks in Russian>.

W: <speaks in Russian>

Tsvetov: <speaks in Russian>

W: Ministry staff.

Tsvetov: Ministry department of..

W: Employees.

Tsvetov: Employees, maybe.

Remacle: Oh, so like HR? Human Resources?

Tsvetov: Well, actually HR. Actually HR. Yeah. And it was strange but I was among these people. I did not know about it. I was also a member of this commission.

Remacle: But you didn't know about it in advance?

Tsvetov: Yeah. Well, I knew about these events, but I did not know why I included in this commission. And when the meetings began, I understood that the aim is shifting Staros from his state, you see. And to that time, I was chief of design bureau in Svetlana— just Svetlana's bureau— who designed transistors and bipolar integrated circuits. If you were to speak about Staros, that design bureau was engaged in minicomputers and MOS transistors. Well. And commission decided if these two bureaus has very close thematics, just unite them, but in one design bureau, new design bureau. It should be only one director. And they recommended me to be director. And it was a manner how to move shift out. <laughs>

Remacle: Staros.

Tsvetov: Staros. Yeah. It's— well.. of course, it was a fantastic bureau. It's very sophisticated. And so the third position I know firmly, it's that this team was very professional. And so what we do—

Remacle: This is the design bureau team?

Tsvetov: Right, yeah, yeah. And what we do during that six or maybe even more— so seven, maybe, years with them— I felt that it's the professional team very high level. And so it means that Staros managed to create very powerful team. Because I worked with them consequent years, I can speak about it, surely. Yeah.

Remacle: So what kinds of things during those seven years did the design bureau work on?

Tsvetov: Microprocessors. Microprocessors.

Remacle: CISC, RISC both?

Tsvetov: CISC. Well actually we did— by the way, I just now, I have no possibility to insist, but I think that somewhere in 1966, 1967— no, no 1976, 1977, we have some controllers which were compared with Intel, by the way.

Remacle: The 8088?

Tsvetov: Just now I don't know the numbers, but it was. It was 16 bit controllers.

Remacle: That would have been the 8000 series.

Tsvetov: Right, yeah. Right. Well, 8086 and so so. Well, and my task was to be accepted to this team, to this collective, because nearly everybody liked Staros very much. It was a rather difficult problem, because you know, I'm just, you know, from another team, and they collected two teams and how to manage, do everything. But I think that the fact that I was the leader of this team for twenty years, <laughs> it proves that I was accepted.

Remacle: What was their immediate reaction when they heard— or do you know— when they heard that Staros was gone?

Tsevtov: Media reaction?

Remacle: Immediate.

Tsevtov: I see, I see, immediate reaction. Well, immediate reaction— ah nothing. It was not such a— well, it was only a reaction from the team of him. They were angry about it, but nothing special. Well, Berg tried to go to Kremlin to go to authorities of high level, but he was accepted not there.

Remacle: He was not accepted.

Tsvetov: Not accepted, yeah. He was not accepted over there. Well, and Staros, of course, began to find another place because <laughs> he became my deputy. This is ridiculous you see— well, and he knew rather well the President of Academy of Science of the Soviet Union. Academy— Academician Keldysh. It's very high level figure. He knew him. And Kelysh organized for Staros special institute in Vladivostok, in far east.

Remacle: I was going to say, that's a long ways away.

Tsvetov: You are right. Yeah. And Staros, of course, invited his pupils to follow him. And only one— if to speak about the most powerful persons— only one, his name Firdman, you know this name.

Remacle: I've read it.

Tsvetov: Yeah. But then Firdman decided to go to the United States. And of course, I've read his book. It's a mixture of truth and lie. All the things I told you here, it's real truth. Because I was, as I told you already—

Remacle: You were there.

Tsvetov: For times. Yeah. I was a participant all this. If to speak about the role of Staros in organization of Zelenograd, Russian Silicon Valley— I know that there are two different points of view, just extreme points of view. I cannot comment on it because I did not take part in it.

Remacle: The two points of view are?

Tsvetov: Well, the first one, that Staros gave the idea, and they make preliminary project, draft, right. <laughs> Draft. Yeah. And even— well, what is the truth, that Staros was deputy of General Director of Zelenograd center.. for some time. For some time. He stayed director of design bureau, but he was also moved out because of his rarely being in Moscow, because he was in Leningrad most of the time. But Zelenograd is near Moscow. And it was the reason, formal reason. And another point of view that everything was created by Shokin, by some Moscovian people. Well, I don't pronounce my opinion nowhere in the <laughs> in no time.

Remacle: In public?

Tsvetov: Yeah. Because you see that it's quite difference between the facts, if you are a participant of them, or your opinion. It's quite different things. And so because I insist only on the facts which I was a participant, I would like to speak about some versions. But in any case, if to assemble all the— all my opinion, Staros of course, a man of good— it's a good manager, of course. And he created, I believe, western style of managing. It is of course. Because he created a team very, you know, very creative in any case, you see. Some new ideas and, you know, and the open discussion, and such kind of things. It's of course his..

Remacle: Contribution.

Tsvetov: Yeah. His contribution. Well, but his fate I believe was bad. Because he came to Vladivostok, he was there for some years, he tried to be a member of Associated Academician. And three times he

was walked out. And when he knew about the third attempt was negative, heart attack happened, and he died in Moscow, I believe it was in 1979, something, so. Well, if to speak some words about Berg—

Remacle: That was going to be my next question.

Tsvetov: Yeah. <laughs> Well, I would then say you about psychological things. You know, when Staros died, Berg was very active in describing of the activity of Staros and Berg. And I know that, of course, Staros is figure number one, but if to look at TV interviews which Berg gave, some articles, and even the novel that was written— a novel by Granin, it's our rather famous writer. Yeah. The name is *Running to Russia*. It's a name of novel. Granin. He's not—

Remacle: So it's a fictional version?

Tsvetov: Fictional. Right, yeah. Right. And so in these three types of impression of this situation, Berg was number one, and Staros, well, so-so. <laughs>

Remacle: Staros was dead. He could not.

Tsvetov: Yeah, yeah. It's just human nature, you see. <laughs> Yeah. Well, I worked with Berg nearly all these twenty years.

Remacle: He worked for you?

Tsvetov: Right. What I can say. He was not realistic, he was romantic, I would say. And his ideas was very interesting for fiction book. Something so. Yeah. Because he was, well, he was really full of ideas but they be— don't be realistic for just this period, you see. For instance, he offered to create the notebook. On LSI. But it was somewhere 1974, and the integration was not so big, in order to create. Now, it's okay. And I guess that even the failure of activity of Staros' collective team was created by Berg, because he was responsible for technology. And technology was not good enough. But he maybe considered that it's okay. And this discrepancy, I think it's one of the most popular situation when if you don't fit these two things, it's dramatic. No device will be created. Yeah. And so what I did, and what I began with, to make more powerful technology. And so I invited some technologists, I constructed clean rooms. I tried to find the best materials and so on and so on. And it means that for instance, at that year, I mean 1973, we produced two thousands of these calculators. But they did, well, five, six, in a month something so. But we did it. Yeah, because of this. And so I tried to understand the main failure— reason of failure, and of course I tried to help to people. Because at Staros team, the designers were the highest level. And so technology is ah well, they said something. But we are technologists, isn't. <laughs>

Remacle: Yeah. So what did you think when you heard the true story, or the mostly true story of Staros and Berg, that they had been defectors from the United States who had come to the Soviet Union. And that they had lived a double life. I don't know how— whether double life gets translated. But what did you think when you first heard that?

Tsvetov: Well, the thing is that I spoke to Dr. Berg many times during these twenty years, well actually, with him, eighteen years, but is nearly. Eighteen years. And he spoke to me rather frankly. He really told that he was in the same communist group as Rosenberg. <inaudible> of Rosenberg. And by the way, he told me that Evelyn [Ethel] Rosenberg was not guilty. And he's— he's sure in it.

Remacle: But just, just—

Tsvetov: Yeah, just punished. Yeah. Well, if to speak about her husband, Rosenberg. It's really— he tried to spy something and do some of that. But if to speak about his wife, she was not guilty, and it's a tragedy. It's not dramatic, it's tragedy. He told me. And so it's also truth, I believe, because just I spoke to him. Not say he's sad that he thought, and so on. Yeah. Well, and really, Staros came to Mexico with wife of his best friend. It's really, so. And she lost there, too, her children. It's also really.

Remacle: That's what I have read.

Tsvetov: Well, it's really. Because just now I speak only about the things which Berg told me, and so it's not from books and articles. <laughs> And so it's true. But Berg was at that time when McCartney processes were, he was in France.

Remacle: So we were still talking about Staros and Berg.

Tsvetos: Yeah.

Remacle: And Berg after Staros and what he accomplished. But he stayed in the Soviet Union for quite some time and then he went back and forth between the Soviet Union and the United States. Was he respected? Was Berg respected by the Staros team that Staros put together?

Tsvetov: Well, you know, they were, I would say separate because they.. Staros— I mean, the peoples of Staros, they of course they honored him and there was rather good relations between them, but he did not influence on them and they also I think that don't influence on, you know. And so at first he has no administrative force, you know, because I was the first man. And he lived by separate life, I would say. He proposed some ideas, some of them were very romantic but not realistic. And we considered that, well,

let him be here. By the way, he has salary which was compared to the salary of minister, and nobody lower did.

Remacle: So he was paid more than you were?

Tsvetov: Pardon?

Remacle: He made more money, his salary was more than yours?

Tsvetov: Oh yeah. Yeah, yeah. <laughs>

Remacle: I wouldn't like that.

Tsvetov: Yeah, yeah. Well, I— it doesn't matter.

Remacle: So what was the impact of the foundation of Zelenograd on work in Leningrad, because up until that time, Leningrad had been one of the major centers of semiconductors.

Tsvetov: Well, I think that the decision to organize Zelenograd center, it was very very good and right decision. And even some people consider to name Zelenograd as Shokin-grad. Because—

Remacle: Shokin considered that.

Tsvetov: Yeah. Because Shokin organized Zelenograd, and he often visited the city. And by the way, maybe you know that there are— there was in the Soviet times tradition to make bust figure of—

Remacle: A statue?

Tsvetov: Yeah. A statue <coughs> who has two stars of hero of trade. And Shokin has these two stars. And as a rule it should be on the place where this hero was born. But as an exception it was erected, this statue, in Zelenograd, near the institute, I mean educational institute. And so it was organized eight or nine institutes with industrial enterprises. And besides, it was organized educational institute. And so near this institute, if you will go to Zelenograd, ask people to accompany you to show the monument of Shokin.

Remacle: So but were people in Leningrad— did they resent the fact that Zelenograd was being built or did they support it as a good idea?

Tsvetov: Well, of course, Zelenograd, support it in some manner. For instance, if to speak about the first stage of producing integrated circuits, we have the same situation as about ten years earlier, when we.. gave the first designs— that time from transistors from Pulsar, and this time, integrated circuits from Zelenograd. But then, as in that case, we produced by our own activity. And as I knew at the museum, it's our tradition to fulfill all the stages from idea and requirements of customers up to organizing of mass production. We do it by ourselves in the same company.

Remacle: And Dr. Popov said that that was unique to Svetlana. Svetlana was one of the only companies or organizations in the Soviet Union that operated that way. Is that correct?

Tsvetov: I would say that the main feature of Svetlana is that we occupy different niches from X-ray tubes, including UHF devices, including semiconductor devices, and so on. For instance, there were times when the production of semiconductor devices occupied more than half of common volume of production. But another time— in other times, there were, for instance, X-ray tubes or maybe power generating tubes, that kind of things.

Remacle: I have difficulty— and when talking to Dr. Popov, I have difficulty because I have in my head the model of an American semiconductor company, which is semiconductors only. And they make devices, and they put them in packages. They test them, and the ship them to the customers that put them in products. And it's hard for me to understand how one company could have, under one roof, the ability to do all of that, particularly manufacturing for semiconductors, and then manufacturing for systems, and so forth. It's a very complex business model. How did you manage that, or was it more like Motorola, which had a semiconductor group and then they had the mobile telephones, and they had the television sets? Was it like that?

Tsvetov: Well, I work only in semiconductors, but this multiply—

Remacle: Multiple products.

Tsvetov: Multiply, yeah, it's a headache of Popov I think.

Remacle: In other words, we say in American English, it's not my problem.

Tsvetov: Yeah, but in any case, I can say this only things, for instance, when Svetlana began to produce radio tubes in 1928, it was ready to do it because they already were experienced in vacuum technique. And so because they produced incandescent lamps, and so many processes were similar, pumping and that kind of things. When they began to produce UHF devices, they've already, according to mechanical exactness and you know very high level of exactness of mechanical details. If you speak about semiconductors, there were no companies which were ready to produce it. But Svetlana has the experience of organization of mass production, has some people and so, go ahead, go ahead. Well, if you speak about X-ray tubes, well it's rather separate by the way. It's located in another place. And only as a bureaucracy we are together. But actually they are rather separate.

Remacle: That would be similar to the Motorola situation.

Tsvetov: I see.

Remacle: You mentioned vacuum tubes of many different varieties, and we saw them in the museum, what percentage of those vacuum tubes went into computers or computing devices?

Tsvetov: Vacuum tubes in computers?

Remacle: No, tubes in general.

Tsvetov: You mean percentage of common input?

Remacle: I wouldn't phrase it that way.

<interpreter speaking Russian>

Tsvetov: I don't think that there are many because as a rule they were used in— what? In radio, radio stations, amplifiers, such kind of things.

Remacle: Okay, all right.

Tsvetov: Generators, you see, of signals.

Remacle: I'm a little bit jumping around here because I have some loose ends in my head. One of things when you and I talked on one of our Skype calls, you mentioned you wanted to be sure and talk about your experience staying in the United States.

Tsvetov: I see.

Remacle: So, why don't you talk about that, what you learned— what you did when you were here, what you learned, and—?

Tsvetov: I see. Well, I think that the first question how I managed to be in the United States. <laughs>

Remacle: How did you get there?

Tsvetov: Yeah, I'm not a spy, at first. <laughs> The thing is that I don't know why, but I graduated from state classes for foreign languages and I visited them three times a week during three years. And—

Remacle: This is while you were already working in Svetlana?

Tsvetov: Yeah, right. Yeah, well I desired to continue my education, some kind of— such kind of thing. And so, after that I had a special document that I hearing this— well, my marks were not so good as in a university, for instance, but nevertheless— and then I took part in some visits of different delegations— yeah, foreign delegations to Svetlana. And authorities knew that my knowledge of English was rather well. It's the first one. Then, I was recommended— I don't know maybe, you know that we began— I mean my generation, we began, we were young. We were rather clever. And it was just a new profession. And there were no, before us, all the academicians, and so on because we created new science, new technique and so on. And maybe I was not the worst person. And I was offered to select some American universities to send them my asking or my inquiring, yeah? Inquiring.

Remacle: Inquiry.

Tsvetov: Inquiry, yeah. To accept me. And so, I sent each to two universities. One of them was University of Pennsylvania. And another one was USC, University of Southern California. You feel my tone of my voice when I say USC. <laughs>

Remacle: You got the best.

Tsvetov: <laughs> And, of course, I choose— I try to compare my interests and the directions of their works. And I got positive response from USC. It means step two. Step three was just organization of my moving there and asking American embassy if they agree. I was checked, probably, in American embassy. And no problem. And the fourth one was the knowledge of English. And it was a special exam in Moscow, the Second Institute for Foreign Languages. I got four. It's good. Well, and everything was okay. By the way, one of us get bad mark, but it was impossible to change something because it was nearly two days before going. And to lose the person, it was—

Remacle: It was too late.

Tsvetov: It's too late, yeah. And so, they told okay yeah. But when we flew to New York City, the only person who spoke— who spoke real English was that man because his teacher was a real American who lived in Lithuania. And so, he was from Lithuania. And so, we were checked for Oxford speech and sixteen times <laughs> but he— and he understood everything. I mean besides— well, it's just funny. Well, in any case, I remember this months I spent there with very warm feelings. And Dr. Spitzer, William Spitzer, Bill Spitzer who was my teacher, he was very clever, very intelligent. And it was very nice to work to him. And so, we worked in such— on such a thematics, investigation of local vibrations of local complexes, A3 B5 as dopants in silicon. And so, we use heavily doped silicon and look through by infrared vibrations is there any couples of these two ions. Because you know for instance for emitters [ph?] it should be very heavily doped, yeah, region. And it has practical sense.

Remacle: When was this? What year?

Tsvetov: It was between 1966 and '67. I came in the September of '66, and leaved— left in June '67. Well, and besides, I saw the American style of working because it was very— for me, it was very unusual. For instance, if I need some material, I pick up Yellow Pages, of course no Internet was there. Yeah, I list it, and I find the company I need and told them that I would like to have such material and such part. Just a moment, I'll connect— contact you with specialist. Well, we spoke about parameters, amount, the price. Okay, we shall begin. We shall begin to produce this material. No money I gave them. It was just words, no more. And so, I organized all the necessary papers. I sent it and knew that simultaneously it was already at my disposal.

Remacle: So that was very different from what you were used to?

Tsvetov: It was— for me, it was ridiculous. Well, or another thing, for instance, if we have some precise instrument— I mean spectrophotometer, for instance, of course we use it and so on. And suddenly, I saw that we had excellent spectrophotometer of PerkinElmer [ph?] Company. Yeah. And suddenly, I saw that Dr. Spitzer use very simple grating spectrometer with a very bad sensitivity. And I ask him why I use this.

Oh, the thing is it's much cheaper to use very rough instrument to know is there anything what I should investigate. Or it's a waste—

Remacle: So, it's like a first pass.

Tsvetov: Right. Right. And even much cheaper, but that instrument very precise, I use only in the cases where it is— it's also no— well, we— You know that economics for me was something, you know <laughs> And another, I can say many examples of such.

Remacle: Now, did you take your family with you?

Tsvetov: No.

Remacle: You just went by yourself?

Tsvetov: By yourself. By the way, it's interesting that many my new friends ask me this question. Why? Why you so? I didn't know what— from the beginning, I didn't know what to answer. But then, I guess. I told them. Well, for me, it's cheap because my government pays for me, but I should pay for my wife by myself, but I have no enough money. It was—

Remacle: Good answer.

Tsvetov: Good answer. Oh thank, yeah, yeah. We understand.

Remacle: We understand.

<laughter>

Tsvetov: Yeah.

Remacle: So what— if you had to summarize, what was the biggest lesson you learned in the six or seven months you were in the United States?

Tsvetov: Well, actually we received very interesting results. And these results were used by one very famous theoretic— American theoretic Dr. Maradudin. Maybe you know this work? No? Well, in theory of

local vibrations, and in any case, it's methodic methods of investigation. And I would say that the best result, for me, was the following one. It was some days before my leaving, we wrote some paper for magazine, for Applied Letters, by the way. And it was late evening, and we went to café to drink some coffee. And Dr. Spitzer ask me, "Victor, is it possible for you to stay for one year more? I like to work with you?" It's the best compliment for me for all my life.

Remacle: Really?

Tsvetov: Yeah. I told, "Well, it's impossible." Well, okay shut it. _____. But what told the very famous scientist and such a question. From that time, I avoid the complex that well I tried to say to somebody to make this and this. I thought maybe I have no possibility to do it some. But here, I decided well, I can do something by myself. And so, I have a possibility to try to, and other people toward the something.

Remacle: So, it was a big compliment and also a big boost to your personal self-confidence?

Tsvetov: Well, confidence—

<interpreter speaking Russian>

Tsvetov: Yeah, yeah, yeah, yeah. It gave me, yeah, yeah, confidence, right. Yeah.

Remacle: So what else did you do besides work when you were in the United States? Did you do any other traveling, or did you see—?

Tsvetov: Sure. Sure, much traveling. Moreover, I was followed by some special guys. <laughs>

Remacle: Did they belong to a three letter organization?

Tsvetov: <laughs> Right. Yeah, well and so I visited Arizona. And of course, I saw Grand Canyon. It's fantastic, of course. Yeah. And I tried to rule by mule.

Remacle: Oh yes, by mule.

Tsvetov: Mule, yeah, but I decided that don't rule by what— by the person who can do it better than you. <laughs>

Remacle: So you walked down the canyon?

Tsvetov: Yeah, right. Yeah, right. Well, then when I already was ready to leave Los Angeles of course, I was in San Francisco. Then I was in— on a conference in Dallas. I was sent by university.

Remacle: By USC?

Tsvetov: USC, yeah. But I thought I should save money. And I select night flight. It's two times cheaper. But then I was said, why you do so? Well, it's too expensive. So, well it's should be paid. Then, I eat some kind of I don't know <laughs> hot dog, something.

Remacle: Snack food.

Tsvetov: Snack food, yeah. And then, I was asked when I returned, "Well, where are your receipts to pay for?" I went I don't— of course not. You could do it. It was also new practice for me, see?

Remacle: That is very common.

Tsvetov: And at last, I was in New Orleans. Unfortunately, I was with pity that New Orleans was destroyed during this—

Remacle: Katrina.

Tsvetov: It's dramatic. I remember it's so nice city. And it was— for me, it was very pity.

Remacle: So, when you came back to the Soviet Union after you've been in the United States for six months and working in different circumstances, did it change how you operated here, at all, either technically or managerially?

Tsvetov: Well, in any case, I think that I've got experience, just experience of living. And maybe, I treat with people somewhere in another way to hear their desires, their proposals, and to make them more— more free, such kind of things. I think that this one. And so, it's also— for me, it's very important that people whom I work, for instance, during twenty years I'm in this bureau when I substitute Dr. Staros. They were very grateful for me because I think that I tried to treat them very— in very good manner, I would say.

Remacle: Very fair?

Tsvetov: Yeah. Well, and I think the beginning of it was in the United States. Of course, I saw very much of good principles which should be accepted by our society. Of course, not everything is ideal. It's— of course. Yeah. But much of it—

Remacle: There's a couple of things I would like to loop back on. There were some major breakthroughs. We talked about planar process, which was a major. We talked about integrated transistor, integrated circuit transition. What about CMOS and microprocessor, how did the transition to those— and VLSI, that's another one— LSI, VLSI? Talk about those transitions, or those— because those were major changes in the semiconductor industry.

Tsvetov: Well, of course, this changes. We passed. And of course, we used CMOS and VLSI, as well. But in the beginning— well, nearly in the middle of '80s when Gorbachev came, the support of government exhausted. And we had no funds and possibilities to work properly. And so, when for instance, German delegation from one semiconductor company came to Svetlana, and they ask us to show the semiconductor production, I was against. But general director, it was not Popov, yet. It was somewhere in the middle of '90s, yeah.

Remacle: 1990s?

Tsvetov: Something so, yeah. 1990s, yeah. Well, he insisted well, I should show. And their specialists, their professionals, they say well we'll look at it. We stopped somewhere in the middle of '80s. <laughs> It was really—

Remacle: So you were somewhere about five to ten years behind the Germans?

<interpreter speaking Russian>

Tsvetov: Yeah, yeah, yeah. And then, we stopped nearly all the time. Now, I think that we're not ahead in this field. But I know that new generations of companies, of teams, created. And even Svetlana may be proud of some teams, which work, for instance, with wide gap semiconductors as gallium nitrides, aluminum nitrides, that kind of things.

Remacle: I think that I'm thinking about something— when you said the nitrides. I think that you have, perhaps, more flexibility in your materials because the U.S. semiconductor industry is so focused on commercial applications and revenue and profit, which has driven some of the creativity out of the

companies. Now, in universities are still doing a lot of research and a lot of government funded research, but like Intel has much less materials research, certainly. They do research on process because their down a really small fine lines now. In mass production I think it's like point seven nanometers. I mean it's very low. What else do I want to ask you about before I move to the kind of overall summary? Is there anything else that I should have asked you about that I haven't asked you about?

Tsvetov: <laughs>

Remacle: That you want to go on video?

Tsvetov: I don't think so. And one of the reason that I'm too tired in English. <laughs>

Remacle: Okay. Then let's ask a couple of personal questions. So, you said what you were most proud of. What was the most exciting and rewarding period of your career, do you think?

Tsvetov: Well, at first the first transistor, I mean germanium alloy transistor, I took part just in— only in part of technology, but I was responsible for alloying. And I did something in alloying. But all of our team made this first transistor. It was— we worked days and nights. And it was quite a job. It's the first one.

Remacle: How big was your team?

Tsvetov: Oh, not so big, about two or three dozen, something. Yeah. Well, the second period I think it's the first planar transistors. It's also very interesting. Of course, I spoke enough about my American experience. And see it's also fantastic. And the last one is all the dramatic events when I came to team of Staros because these twenty years— actually first ten or maybe a little bit more years, they were fantastic. And we had success. And then we were [comment unclear, but seems to be referring to the stoppage of their work]. Well, but it doesn't depend on us. We did, I believe up to now, we did very interesting thing. This set would be very nice.

Remacle: How would you assess or evaluate the contributions of the Soviet semiconductor people, industry, to the world computing and semiconductor industry? What do you think are the major contributions?

Tsvetov: Well, the fact that the Soviet Union managed to create the semiconductor industry, it's already very important fact. And so, we were isolated, and nevertheless, we created everything from raw materials up to devices and apparatus. Of course, they differ from Americans on economical parameters.

Of course, it was not so economic, but the fact that it exists. I think that just forced Americans to do better and better. Maybe it is their influence. <laughs>

Remacle: I remember talking to Jim Morgan, who was the head of Applied Materials. They make a lot of the semiconductor equipment. And he said Intel is the hardest competitor to have in the market place. They didn't compete with Intel, but— and they're the hardest customer to have. But they push us, and they make us better. And so, having good competitors is important.

Tsvetov: I think so.

Remacle: If you were talking to a young college student engineer, or even a young Victor, what advice would you give them about creating a career in semiconductors today?

Tsvetov: Well, in any case, they should be interested in their activity in such a merit to consider that half of his lifetime should be creative, interesting. And so, to have interest to their work. If they have it, we had it early. I don't know what the reason which insist us to create to be proud of results, to quite contrary, to— if it's some failures also to feel bad feelings. Well, but if young engineer feels that this work is half of his life and he has satisfaction if it is something happened. That's good because in another case, it's wasting of his lifetime.

Remacle: Victor, thank you very much for taking the time to talk to us.

Tsvetov: Thank you.

Remacle: And most of all, thank you so much for arranging for this set of interviews here in Russia. I appreciate it very much. And the museum appreciates it. So, thank you.

Tsvetov: Thank you.

Remacle: Okay, thank you.

Tsvetov: Bye.

END OF INTERVEW

