Oral History of Tu Chen

Interviewed by:
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Abstract: *Tu Chen's background included working with IBM, Northrop and Xerox PARC. After extensive work in developing various magnetic recording technologies, he started his own company, which became known as Komag. At Komag, he pioneered new types of production equipment and magnetic disk materials, and became a pioneer in the successful production of the sputtered magnetic disks which are now generally used in magnetic disk drives.*

Chris Bajorek: I want to welcome everyone to the beginning of the interview of one of the pioneers in the magnetic recording industry, Dr. Tu Chen, who has played a very significant role in the early development and subsequent commercialization of thin film magnetic recording media. Tu, welcome to the interview.

Tu Chen: Thank you.

Bajorek: We will start with perhaps a little bit of your personal history, for the viewers' benefit. It would be nice to know a little bit about your background, your personal background, your family history. Where were you born, Tu?

Chen: I was born in Taiwan, Ilan, Taiwan, a small town northeast of Taiwan Island, and it's a rainy place all the time.

Bajorek: And when were you born?

Chen: I was born in 1935, March 19.

Bajorek: Yes, very nice, and what did your parents do? Your mother and father do?

Chen: Oh my parents actually they were the small businessmen, had a small textile store in Ilan, ah…, for all of their life actually.

Bajorek: Very nice, very nice. Did you have any brothers and sisters?

Chen: Yes, I got four brothers; including myself four, that means 3 extra sibling brothers and four, five sisters.

Bajorek: Big family.

Chen: Big family, yes.

Q: And you survived all of that competition?

Chen: As a matter of fact I'm the second, I have an older sister but she passed away when she was young, ten years old. So I became the eldest of the family, I had to help my parents, actually.

Q: Yes, very interesting. Can you tell us a little bit about the earliest thoughts that you can remember about what you wanted to do when you grew up?

Chen: Well, that's the interesting part because I went to school in Ilan, from elementary all the way to junior high, actually I was pretty lucky when I was in fifth grade I was able to pass an entrance exam to the junior high. We have to have an entrance exam, if you fail, you forget about it, you never go to school after that, right. Well I was lucky I was able to get into the junior high on the first try and it seemed so easy, in the junior high I never studied, I always played, except something I like to study science and math and not too much in the Chinese history and stuff like that. So I was kind of in high school, I was kind of flunked, in an entrance exam to high school, I kind of get flunked, flunked out. So I went to work for a doctor, you know, a private clinic doctor as an assistant. So I got completely lost at that time, of what I wanted to do, when I was 15 years old. At that time I thought maybe I should go for-- become a barefoot doctor you know, training by this doctor to become barefoot doctor. So I was kind of anxious to do that and worked very hard with him for almost a couple of years. Later on there was, however, a chance to take entrance exam and I went back into school.

Q: And this time you passed?

Chen: Yes, of course actually in the second year I already passed, it didn't, very easy for me to pass the second year, but then I didn't prepare actually, I only spent a week to prepare before I decided to take it again. And I was able to get into it and pass. And went back to school for four months, I hated school, so I quit the school again and went to work for the doctor again for another year. So finally I decided I'm getting too old so I better finish school, that's how I do it, all right. So you ask me what I want to do? At that time I wasn't, kind of confusing but one thing I liked to do that time when I entered high school, I became a Christian and then I decided-- I read a book by Albert Schweitzer so I said, wow, if I can become a doctor I can go help people, that's what my dream was. But, of course, my language is not very good, even though I passed to the college, I went to college by passing entrance exam but my language is so poor I barely hung in there to get into the university , Cheng-Kung University. Based on my science and math. So I was never able to become a doctor.

Q: Well you've made breakthroughs in other areas. Just to clarify, can you spell the name of the city you were born in?

Chen: Ilan, I-L-A-N, Ilan.

Q: Ilan.

Chen: Ilan, Taiwan, yes.

Q: I-L-A-N, Taiwan and that's also where you went to school?

Chen: Yeah, that's where I went to school and grew up.

Q: And this early attempt, where you failed the entrance exam, was that to the university or to the high school?

Chen: No, to the high school because it's kind of interesting because I was doing good on the math and science but I was completely flunked on the history so I wasn't able to get in.

Q: And then you had to take an entrance exam to go to the university? Or not?

Chen: Oh, later on we have to go-- after high school for three years I had to-- everybody had to take an entrance exam. And it was pretty hard to get into the University because there were only a few Universities in Taiwan at that time. And actually I took two, one is become, one is called a United Examination it means four universities combined, university and college combined together become one entrance exam. I was able to pass and barely, but my score wasn't too good so I was assigned to the metallurgical department, mining department, mining and metallurgy department at Cheng-Kung University.

Q: Was it near your house?

Chen: No, it's in the southern part of Taiwan.

Q: Very interesting. Did you have any idols when you were growing up, during this period?

Chen: Well as I said earlier the idol is Albert Schweitzer when I was young and when I was to college I said wow, I saw the movie you know I was kind of interested, I went to the school of, the department of mining and metallurgy, all right. So at first I wasn't too sure which one I wanted to pick, so I decided to go to mining and, my idol was at that time, I watched a movie that called 'Giant' and Giant was you know the oil digging, the tycoon in Texas. So I said I want to be a mining engineer, maybe become a tycoon some day. And so I picked mining for that time, all right. But then you know, later on I went to, after the junior year at the college, I went to practice in the, I mean I had to go to training in the field. So I went to one of the gold mines which is a couple of thousand feet down the earth and it's so claustrophobic, I decided I wanted to give up. I went back to -- I don't want to be a miner anymore so I went back to pick up the metallurgy. So in certain way my life is kind of all by default not by choice.

Q: Very interesting. Now did you stick with metallurgy through the entire college period? Or then did you then branch out to other subjects?

Chen: No I studied all the way to metallurgy, you know it's a very, another one I really got help at that time was a professor from West Virginia University, I think that's Fulbright Scholarship or something like that, went to Taiwan to help and this professor called Fairbanks, Professor Fairbanks from West Virginia University. He's a teacher, professor for the physical metallurgy, and I learned a lot from him, so that's how I became so interested in the physical metallurgy. Material sciences as matter of fact, and he is a guy who helped me a lot.

Q: Very interesting. Now you completed your university studies in Taiwan and then you transferred to the university in the United States?

Chen: Right.

Q: Can you give us a little bit of that history?

Chen: Yeah, I was -- on my senior year I was working with this professor and I was -- at that time people had to write a thesis, all right. And so I was kind of -- one day I was kind of -- I tried to find a thesis subject. So I started myself and figured out how to do it and I went -- one time in my summer work, I went to this steel factory, you know, this iron mill place and blast furnace. And I noticed there's a shortage of the ore, it had to be imported from outside the country. In the meantime I worked for the mining, in the gold mine area, they have a lot of pyrite and they save this pyrite to extract the sulfur out. And once they extract sulphur out they call the pyrite cinder, this cinder is used for the, I mean they extract the sulphur and then the cinder had to dump it away into the ocean, they had no place to put it. So I figured out if I can convert the cinder and bring the iron concentration up and eliminate all the sulphur, I can probably make it, iron ore, for the iron factory. So I started to write a thesis about it, and do my design of experiments, and calculated, and someone let me calculate how much to reduce to remove the sulphur, and reduction to make a-- yeah pure iron and become magnetite, all right. So I was successful in turning the, bringing the iron content to 62% or more and sulphur is practically zero at that time, all right. So I filed a patent as a matter of fact and wrote a thesis. And that was my senior year, and that's under the encouragement of this university, I mean this Professor Fairbanks also. And after that I had to go to ROTC called in Taiwan government regulations. So I become, I became the artillery officer and been stationed in Kimmoy Island, Kimmoy Island for nine months. So total a year in half I was in army and after that I went, after that I applied for entrance, you know, to scholarship in the United States. And in the meantime I was teaching high school for a year, about a year and a half. So afterward I got about three scholarships from University of Minnesota -- and also University of California, Berkeley, and Rolla, Missouri, and another one from Toronto. So finally I decided to go to Minnesota because of the recommendation by Professor Fairbanks, he said that's the area, the university is doing more materials science instead of classical mechanical metallurgy.

Q: Very interesting, so you went to Minnesota?

Chen: Minnesota, yeah, I was lucky because--

Q: When was that? Can you pin down the time when you made that transition?

Chen: That was in 1961, and I was lucky because the professor, Professor Sivertsen who is my biggest benefactor, my second biggest, biggest benefactor, actually. He was training, he was doing all the magnetic research and magnetism research, that's how he, so I stuck with him for six years and turned out that I learned a lot from him in magnetism.

Q: And you got a Masters and PhD?

Chen: Yeah, I got a Masters and PhD, yes, in magnetic materials.

Q: So that's, is that when you were first interested in magnetic materials?

Chen: No, first interested in, I was in Taiwan when I doing conversion of this pyrite into the iron ore, magnetite, yes and that's where I designed all my particle separator, and I became very intrigued to me magnetism, is so interesting. So when I have-- actually I have a choice, either to go to Berkeley or Minnesota and I went to Berkeley at that time and I didn't know, I say okay, I got to take a look, and I look at Berkeley. And Berkeley look so lousy you know. The buildings is so bad, so I went to, I spend my last

$50 bucks to pay for the Greyhound bus and went to Minnesota and met Professor Sivertsen and he was a guy who was doing all this magnetic material and it turned out it's very, very interesting to me, actually.

Q: Very nice. Now did you-- can you remember when you were first exposed to computers? Was it during your academic work in Taiwan?

Chen: Yes, I had a computer, I heard of computer when I was in Taiwan, right, and I was, I think it was a senior time and I heard so much about computer, you know. And kind of very interested about it, but I never had chance to use it, because there's none in Taiwan, right? So when I first time I encountered the computer was in Minnesota and I had to take some Fortran because I wrote my thesis, had this involved in these x-ray diffraction of this analysis of atomic structure and stuff like that. And I needed to go through these, you know the analysis with Fourier transform and stuff like that. The program was there but I had to take some Fortran and to learn about it and I went to use the computer to help my thesis. That's the first time I really used a computer.

Q: Do you remember by any chance the type of computer it was?

Chen: I think it is Control Data which one was--

Q: One of Control Data's minicomputers.

Chen: Mainframe, mainframe, yeah, I forgot about.

Q: Yeah, I was just curious and by the way, when did you get married? Were you --

Chen: Actually--

Q: -- after you finished your studies at Minnesota?

Chen: No, no, I was married in Taiwan before I left it -- I dated my wife for over a year and then before I left and I said I better get married. I wanted to get married you know before I left.

Q: And she came with you?

Chen: She came in year and half after, I'm sorry, two year after I left.

Q: Her name is Nancy--

Chen: Nancy Chen.

Q: Very nice. And what was the first job after the university, obviously you had jobs along the way, right? Your medical experience--

Chen: Yeah, but first --

Q: Your mining experience. But the job after you got your PhD what did you do when you finished your PhD?

Chen: I, actually I was hoping to go either to Bell Laboratories or IBM, you know that's a typical people who really like those things. And then Bell Telephone offered me a job, not in Allentown, in New Jersey, but in Western Electric, in New Jersey. Okay, and I said well I --

Q: You want to go to Bell Labs but they didn't offer you a job

Chen: Yeah, not in Allentown, yes, and IBM, the same with IBM, they gave me a job in Endicott.

Q: You wanted to go to --

Chen: Well I just didn't know, at that time use, IBM had a Yorktown Research Center. But anyway I asked, I needed a job, so I went to work for IBM, of course I interviewed the, what they call it? In Cleveland, the Union Carbide and stuff like that, right. But they mostly deal with mechanical metallurgy types of things, so I wasn't too excited about it.

Q: And did you go to work for IBM?

Chen: Yes, I worked for IBM Endicott because they want me to go there to help, develop these, at that time IBM was doing these hybrid circuits, you know hybrid circuit with nichrome film developed by, what is the name? Who published the book?

Q: Maisell

Chen: Maisell, yes, Maisell sputtered the nichrome film for the resistor. So they saw my background perfect, pretty good for it, because I did magnetic materials stuff, and when I do the magnetic material I do a lot of the system measurements. So they say they want to give me a job. However, once I went to IBM there, I find out the job was not, did not end up, didn't give it to Endicott, they gave it to East Fishkill, developed by Maisell in the Research Center.

Q: Yes.

Chen: And they want to change that from, I mean they want to bring development to the production type, development right? And that's what I was assigned to do, but then, Endicott never got the job, become a second, the third, I mean second supporter to--

Q: Fishkill

Chen: To Fishkill, so I just don't have a job to do that kind of work, so I went ahead anyway, I learned some sputtering there, just kind on occasion and then I looking for new job, new work to do such as super plasticity for one guy and then many other, odd and end work.

Q: What year was it that year?

Chen: That was 1967 to 1968 and then I decided that's not my life, I want to do something in research and there's a guy who used to be teaching in Minnesota, Minnesota, called Gupta who is a professor there--

Q: Gupta?

Chen: Yeah, Gupta, Assistant Professor, and he left university and he went to work for Northrop Research Center, so he gave me a call several times and wanted me to work for him.

Q: At Northrop?

Chen: Northrop, yes and so one day, the apartment I was living in caught fire, so I said, might just as well have to move, so I moved to Los Angeles, so I accepted the job and went to work for Northrop, for him in Northrop.

Q: Was that late 1978 or?

Chen: Yeah, mid 1978 -- actually early 1978 (meant to say 1968), I only worked at IBM eight months, I don't like the company.

Q: You don't like that atmosphere. Very interesting. So you moved to Los Angeles, is Nancy with you now? Is she moving with you?

Chen: Yeah, everybody moved, yeah that time, Nancy went to join me in 1963 with my son and we have a second son in 1965, so I had the two sons and then after 1967 went to work for New York, work for IBM in New York for eight months, we all together and then moved together to Los Angeles. So I stayed at Northrop for three years, yeah.

Q: Very good. How did you then end up connecting with magnetic recording? Was that done at Northrop or did you move from Northrop to your next job?

Chen: No, because -- that's an interesting question because since I'm interested in magnetism, right and my Professor Gupta know I'm the guy who really did a good magnetism material at University of Minnesota that's why he offered me, wanted me to work for him in Los Angeles. At that time 1960 -- 1967, 1968, 1968 one of the Northrop projects is called the radiation resistant storage, memory storage, right? And you know that magnetic recording is radiation resistant, anyway, semiconductor memory is not very--

Q: Subject to--

Chen: --Subject to radiation damage right, and apparently the air force wanted to find something, which is radiation resistant storage. So one of the area, one of the guys who in the Northrop, actually he's the vice president of the Research Center, all right he had this idea, use a plated wire for magnetic memory, right? Permalloy plated wire and so he looking for, he was looking for somebody and so that's why Gupta asked me to join. So I was in Northrop to doing the plated Permalloy tape, instead of wire we got tape, because tape--you can record more area. And so I was there to do that work, yeah, that's how I picked up storage, yeah. Magnetic recording.

Q: So that's your first encounter with magnetic recording?

Chen: Right, right, right, right, right.

Q: And what happened to your Northrop projects? How long did you stay at Northrop?

Chen: Northrop in a typical aerospace, and every project had to apply every year, and we finished part of the work, and then the second year, you know, we have to apply for some more budget and I did continue for a couple of years, finished part of it, how to plate it and how to do that, but the end result is too much magnetostriction, it is not very practical, you know. So it kind of got to me, all right? And so, but in the meantime there, I'm always looking for new things like, I was also working for the holographic memory materials because there was a big group of people working on magnetic, yes, magnetic materials guys. So I had to work for somebody in the materials.

Q: New materials.

Chen: Yeah, new materials, for example I work on the "BANANA": Barium, Sodium and Niobium, for holographic storage. I also, we were working on cold cathode for displays for you know, pilot, for fighter jet for the cold cathode. And they don't have -- they use a cold cathode based on gamma ray, gamma particle, which is not good, not acceptable. So I had and an idea there, I went to work for cold cathode using field emission type and I work part of that too. And work for the Schottky barrier diode, yeah.

Q: A lot of variety, of different projects.

Chen: Yes, I even grew single crystals.

Q: And how did you -- now obviously you ended up here in the Bay Area, when did you make the transition to the Bay Area?

Chen: Well one interesting thing is this, the -- a guy who lived across from me in Los Angeles, he's one of the, you know top manager, pretty high up manager of the SDS, Scientific Data Systems Corporation and they want to you know SDS, Scientific Data Systems, the company, is making these scientific computers and the traffic control computers. And they even make computers for the air force for defense, I heard was making for these missiles, you know these Minute Men missile control and stuff like that, and there using these I don't know what the storage use at the time but they told me they wanted me to -- he wanted me to work for them to do the to do the Permalloy memory at that time. This was 1980 – 1970 --

1969, 1970 actually, almost 1970, yeah. And because Xerox, I mean 1969, but I never did accept that. But then 1969 Xerox bought SDS --

Q: They bought this company?

Chen: This company, so and then this guy called me up, not called, walked across street and come to tell me, he say, "Tu Chen do you want to go join Xerox PARC, because Xerox PARC is starting up in 1969.", or 1970, right? And have a research center in Palo Alto, some time during summer, and so would you like to go and talk to them and now we are part of, you know SDS is part of Xerox and so see maybe they want to do plated Permalloy, and see if I would like to work with them". And I say, "Oh that sounds pretty good.", so that's when I interviewed the PARC in 1970, you know, in October.

Q: And then you joined them?

Chen: Yeah, I got a job offer right after I talked to them and then I joined them-- I finished up the work in PARC -- in Northrop, so I joined Xerox PARC in January of 1971.

Q: January of 1971.

Chen: Nineteen seventy one, yes.

Q: Very interesting. I gather that that may have been where you first thought of working on thin film media? Was it at Xerox PARC?

Chen: It's not, it's not the beginning of that, originally I was supposed to be hired for doing Permalloy. Once I joined, this was October of 1970, they were talking about it, by the time I joined them in January 1971, I heard they decided not to do the Permalloy anymore. So here we go again and I had to look for new job, new job, new project. So I searched all the books and all that stuff, I say, my idea was this the, you know, when at that time Xerox have this idea of, I think if people read the book by, "Fumbling the Future" talks bout it too. Xerox have this very nice idea, unique idea, because DARPA a that time was helping Xerox to come out with a new business right? And Xerox has this, was so successful --

Q: DARPA was helping or not?

Chen: Huh?

Q: Who was helping Xerox?

Chen: DARPA yeah, DARPA yeah, and Xerox was kind of, you know, when I was interviewed they told me that Xerox was to come up with something unique, I said okay. And I heard about it, afterwards I joined and they told me about it, the idea was to make, because in the 1960's, very interesting, in the 1960's the government find out in order to increase the income of the people, right? Have to make the white collar more productive.

Q: The white collar force.

Chen: White collar workforce more productive, right? Because as you know the blue collar, they say every blue collar when they hire for company, company usually spends $20 million, $200,000 to $300,000 to build a factory, you know, build a hardware, a factory or equipment, automation machine. So blue collar is very productive, whereas on the other hand the white collar they pay about $10,000 almost right away, buy a calculator and a desk and et cetera right? And so send them to work, and then the white collar who have a computer, can work with a computer but it's not interactive, so not very productive. So they decided to say okay, make an interactive computer so everybody have more productivity out of it, right? Very interesting. And the computer cost a million dollars, right? And so cumbersome, so how can you make each one a computer? So that's why in the 1960s DARPA encouraged people to develop this time sharing all right? It turns out that time sharing wasn't done very successfully done, and as a matter of fact PARC they were thinking about using timesharing too, debate about it too. But by the time I was there and they decided to say go, go for different approach, make a low cost computer.

Q: Dedicated for each person?

Chen: Each person, each one have one computer and can afford it. Because what they were doing they set up the goal, if a computer can bring down from a million dollar to $10,000 each, which is a pretty big if, you know--

Q: Big cost decrease.

Chen: Yeah, 100 times cheaper right? And then it can be easily to use, average people can use, without having to taking Fortran or anything like that, and they got to be able to talk to each other and have one that talk to each other, right? So all this thinking there is they're thinking finally they come out with a very good idea, say set a target of a computer of less than $10,000, all right? Now $10,000 is very good because most company willing to pay for employee, personal use, right? So that's a good target and Xerox having this idea at that time, I mean I heard all these things. Xerox upper management I think they're very smart, they think in the future from ten years from there, I mean they make tons of money at that time, from copy machine right? And they under the government, I mean they make a lot- tons money but the problem is this, is ten year after -- if they don't do something about it in the future become electronic office of the future. Paper is gone yeah, office of the future is electronic.

Q: Xerography would disappear.

Chen: Would disappear, so they had to do something, and they figure out one thing they can do, this is a true story I heard about it. One thing was they can do about it is come out with a very low cost, I mean computer, right? And electronic storage and one of the area they think about it, because Xerox think they was able to -- computer, I mean a printer machine, copy machines become very popular at that time and Xerox was able to get to every office because of their printer, I mean their copy machine. So they think if we can come out with computer cheap enough right? $10,000 or cheaper...

Q: Penetrate the offices with computers.

Chen: Yes, so with our sales force we can penetrate all these offices.

Q: Visionary, visionary idea.

Chen: Right, and so the $10,000 is a target, so in terms of $10,000 then the peripheral you know memory, you have to have a memory and for storage. So it would also have to be no more than ten, 15, no more than 20%. Yeah fraction of that $10,000. So that's why they develop a program called LCDM, low cost disk memory. I think in 1973 right?

Q: LCDM?

Chen: LCDM and LCDM is part, is a very big impact, and Gordon Hughes was head of the whole team to drive those. And before that LCDM was developed in 1971, I went ahead and looked for all these technologies and I said “look, I think magnetooptics is a very good way to go, because you can calculate simply, they can tell you, they can go up to ten or eight gigabits per square inch, right? Very simply, right? So physically a very doable thing”. So I went to work for magnetooptics and it first been done in the 1960's, you know in early 1970’s was tried to do it, but 1960’s got so much publication. And at that time they use a MnBi.

Q: Manganese Bismuth--

Chen: Manganese Bismuth--

Q: Memory--

Chen: Yeah, for the magnetooptic layer, Di Chen, and the guy who did that most work was Di Chen, Chen Di, Di Chen from Honeywell. And he published so many papers, thanks to him I learned so much and know about it and I say, "Oh that sounds pretty good.", I went ahead and tried to do it but then one thing I didn't like about it is it's kind of interesting because they think after they write for a few times -- for certain time they start degraded, and they know from publication they change from low temperature phase to high temperature phase because some thermomagnetic writing tend to convert to high temperature (phase) you know, so changed-destroyed the film.

Q: So it has very limited endurance?

Chen: Endurance, and they tried to do is doping with titanium and stuff like that, you know, titanium and copper to try to stabilize. So I'm a materials guy and they're an electronics guy. I'm a materials guy so I'm, I usually -- I look at it in different ways. "Look, let's go back to fundamentals, see what this material looks like, what MnBi looks like". I take a look at the MnBi itself, It's got a phase, phase diagram, the phase diagram shows them not quite well established, the intermetallic compound, MnBi. It's not a real --

Q: Stable --

Chen: Stable compound -- they change from low temperature to high temperature—but nobody knows what the process is. Phase diagram, you know even says it's a dotted line (the phase change is represented by a dotted line), right? So I say "I've got to understand that first", so I went ahead and I quickly grabbed, you know, an old Czochralski crystal grower, from the Xerox in the east coast, all right? In Rochester, yeah --

Q: <inaudible>?

Chen: -- Yeah, in the warehouse I shipped one over to PARC. And then I start grow a single crystal. I was lucky because in Northrop I grow germanium single crystal all the time, so I know how to do it. And so I grow this single crystal and then discover, after I grow the crystal, I find all this very interesting. That is the phase decomposition, never able to stop it. It's not an allotropic transformation, so nobody can stop that. So I published a paper in 1973 and after I published it, and then I said "that's no good", all right? And so somehow, Intermag people invited me to give a talk, have me give a talk in 1974 in Toronto. Talk about how bad the material is and no way can, nobody can stop that.

Q: Not a solvable problem?

Chen: No, not solvable, so everybody started quit, MnBi, so I am a bad guy, you know the story of the whole project. But anyway it helped me a lot to understand that, all right?

Q: Did that drive you then to look for a different alternative?

Chen: Well it was, yes actually it is, when 1973 already discovered, the phase decomposition, right? So I was already looking for it, and then I asked “okay what should I do?” He said, "Go to memory". At that time bubble memory was so hot, all right? And there is some -- later on they even have a Josephson Junction, all right? And then have a hard disk, nobody thinks a memory, you know memory with a hard disk is out of date, that seems --

Q: Old fashioned?

Chen: -- old fashioned, right? And -- but I make some calculation of this, I say, "Okay, what can we do if I do?", so I look at oxide disk was so thick, you know, so I went and collected some papers and looked at it. I said “if I can push the coercivity very, very high and you know, and also then higher than an oxide, and the film thickness, one tenth of the original (oxide), I can really increase the storage density.

Q: Areal density.

Chen: Yeah, and why I'm looking at that -- at that time Xerox already decided in the PARC, in the not in the PARC , the SDS was part of the PARC anyway, they called Advanced Development Laboratory (ADL), the original SDS storage team split out into the ADL, I guess that’s how they do--

Q: Here?

Chen: No, in Los Angeles, in Los Angeles.

Q: A laboratory in Los Angeles.

Chen: Yes, yes, and they come with an idea called LCDM, the concept of LCDM, that’s 1973 the time really talk about it. LCDM is a concept of $2,000 memory, right, drive with 300 megabytes, 300 megabytes, that's a pretty big number you know, at that time. Three hundred megabyte drive for $2,000 or less, right? Now you know that later on the 200, later IBM had the 3370 or something like that, 300 megabytes cost $200,000 or something, right? And at that time they wanted to try to break through the barrier.

Q: They wanted to make a $2,000, 300 megabyte memory instead of a $200,000, again --

Chen: Hundred time, yes --

Q: Hundred times cheaper?

Chen: Absolutely, and so when they come, they know I'm the guy who do the magnetics (materials) guy, so they come out to Palo Alto and present that, and talk about, I join it, I think that's great idea because I'm looking for new job to do anyway. So I was looking at the, you know the magnetic recording, right? And I --

Q: So your second adventure in magnetic recording, first time you did it on tape, first on tape now in disk drive form.

Chen: Right, but the tape is a Permalloy, and so I collected so much paper that time when I was looking for, back in early, about 1971, 1972 I collected a lot of material and when they coming to PARC and talk about it, I said “great, I’ll jump in”, actually my boss actually assigned me to help them. Which just fit, fit just exactly what I want.

Q: Who was your boss at the time?

Chen: That's Rick Keezer, so I was in there and promised to help. And why they need my help them, they don't need me if they have no way, because at that time -- SDS already making those 24" disks, head per track. They already have that, shipped the product out in their SDS computer. And I don't know how or when they started, but I heard they sell it not only for traffic control but they also use for Minute Man or some defense --

Q: Military purpose.

Chen: -- military purpose I don't know what it is. But they already have that and at that time they had a 300 Oe disk for head per track and it worked pretty good.

Q: Was that a thin film disk or--

Chen: Thin film disk, thin film -- yeah, thin film cobalt phosphorus disk --

Q: Plated?

Chen: Plated, electroless plated, electrolitically plated**,** they already have that time, all right? And but it's a 300 Oe and they are plating, shipping to product. And they wanted to convert, Gordon Hughes' people wanted to go to LCDM, they needed higher coercivity, all right? And --

Q: Higher capacity.

Chen: Higher capacity, all right, so they decided to ask me to help. So I said, "Okay give me some money and I hired post doctorate and --

Q: Postdoctoral students you hired?

Chen: Yeah, I hired Mark I forgot, Rogowski --

Q: Rogowski?

Chen: -- Rogowski yeah, I hired him and then we worked together, because I was busy with magnetooptics too, because MnBi, even though died, I went to change to terbium iron. I was still working on magnetooptics, I picked up the more magnetic recording and when I had to do the cobalt phosphorus plating, I was able to come out with a disk, help them to come out with a 450 Oe or higher.

Q: Coercivity?

Chen: About 500 Oe.

Q: Started with the plated disk.

Chen: Yeah.

Q: Aiming to, your main goal was to increase the coercivity.

Chen: Yeah, increase the coercivity and make it square. And that time, everybody has a feeling you have to have it square, I said all right let's go work on that squareness. So I struggled between the squareness and the coercivity. Every time I got the high squareness, my coercivity dropped, right? And that's a problem, you want 90% (squareness), and I didn't know because the recording guy didn't know material and the material guy like myself don't know recording. So I listened to them and said "okay, you have to have it square", so I worked so hard to make it square, but anytime I got a square I got a really low coercivity. Well even though later on I compromised to get a 450 Oe, very square, 92% square. And you know, put into kind of production, so then in prototyping production and the Gordon Hughes in HDS they can make a 14" disk out of that, make 3 disks for 200 megabytes, and it worked.

Q: Two disks for 200 megabytes??

Chen: Huh?

Q: Two disks?

Chen: Three disk for 300 megabyte.

Q: Three disks for 300 megabytes?

Chen: Yeah for $2,000, pretty good all right and they made up 30 drives of it and populated around the, you know, the Research Laboratory, and use for printer, interfaces for many places.

Q: Did you make the disks here at Xerox PARC?

Chen: No, no, in --

Q: <inaudible>?

Chen: Look**,** PARC don't have the facility, all right? Yeah--

Q: It was a research building.

Chen: Right, right, I have to set up one of the old Strassbaughs for polishing the disks, so I did a lot of polishing to help them because they don't have the polish capability out in the south. They -- did an outside contractor to do that, so I have to develop a polishing (process), they plated for me, nickel phosphorus first and then polished again, all right? And then send it back and they sputtered it (meant to say plated). And after that they started the process and went ahead to use an outside contractor to make a polishing and a plate and make a 3 disks per, for 300 megabytes, yeah.

Q: Now you used a word, I thought this disk was plated, you said they sputtered.

Chen: No, no, no, just plated.

Q: Just plated

Chen: Just plated what you want to do is --

Q: So what they did is, they polished the substrate and then put nickel phosphorous as an under layer and then they plated the cobalt phosphorus.

Chen: Right, and at that time it was very interesting, because at that time, even the plated nickel phosphorous was not well established, all right? No commercial all right, not available, right? You had to cook up your own solution.

Q: And you needed that nickel phosphorous to make it mechanically hard? The aluminum substrate was too soft without the nickel phosphorus layer?

Chen: Right, right, and very interesting, at that time they plated the nickel phosphorous, they take aluminum and anodized it, it had lots of holes, so they have to fill up the holes, they have to, after anodizing, plate the copper first, they have to put in the copper first --

Q: To planarize the surface.

Chen: Planarize the surface**,** and then they put a nickel phosphorous and then after nickel (phosphorous) they've got to polish it all right and as -- they already have been using that for a long time but you know they -- for this high performance, you've got to be more perfect, I helped them to polish that. And once you develop the polish to get rid of all these pits and stuff like that and they are able to do that. And then that's how they make the, you know, make a finally --

Q: Prototype?

Chen: Prototype yeah.

Q: Very good. But what, later on right you moved on to investigate vacuum deposited films or sputtered films right?

Chen: Yes.

Q: What motivated you to do that?

Chen: Well so we made a disk, we got a 300, you know 30 drives or, I heard it was 30, I didn't know always the number right? I know that's quite a few and I went down there to Los Angeles every time they plate it, and I see a guy who was sitting there having to use a big giant head to burnishing it, because we hear the clink, clink, clink, clink, clink, clink, clinking of the -- they use a transducer connected to a big giant head and kind of burnishing that.

Q: They were wearing out the asperities?

Chen: Asperity because yeah, a protrusion, and that's one big problem. So they told me to solve that, so I thought when you are plating like that, I thought you have, no matter how good polishing, you're going to have a chance to have protrusions, nodules, right? And that time they have, that's one problem. The second thing, I was struggling with, the magnetic coercivity, if I try to go up high in coercivity I couldn't get it square and that's a big problem, right? So I told them, “look, there is no other way, if I go to sputtering I can come out with some material”, right? And in the meantime they found, as a matter of fact, it was actually in 1977, Gordon Hughes and Dan, what’s his name, published a paper, talked about, off track writing, right? Because of the gap of the --

Q: The fringing fields from the head --

Chen:--fringing fields from the head --

Q: Caused side writing?

Chen: Side writing and that's what the big problem on this, it becomes noise, poor noise, and poor overwrite. And he had to publish a paper in 1977 and Gordon was giving an invited talk in 1978, in the MMM (Magnetism and Magnetic Materials) conference. So Gordon went ahead to talk about it, unfortunately he never really published it. But when they have this side fringing thing at that time, we already discovered, every time I get a higher coercivity and make it square, I couldn't do it. And I started to come out to Gordon and I said “this had to be some magnetostatic coupling with exchange interaction between grains”. That's how we started calling it exchange interaction.

Q: This meant there was coupling between the crystallites --

Chen: Right, the crystallites.

Q: Coupling, exchange coupling magnetostatic coupling.

Chen: Yes, yes, yes.

Q: --and you think that was influencing the side writing and the noise characteristics.

Chen: Yes, and that's the squareness and the more square you have the lower coercivity you have and then of course the domain problem, become almost like a domain you know, become big, all right? And as a matter of fact we discovered that in the, it was in 1976, 1977 and in 1977 they published it, right? They didn't talk about that I think 1977 published paper but we already discovered that, so I talked to Gordon and I said "That's no good, we got to figure out some way to overcome that.". And I was trying to solve that by plating, you know by isolating the particles, use of phosphorous, but if I put up too much phosphorous they become amorphous. Very hard to control, right? So I said, "Forget it, let’s go to sputter, maybe I’ll come up with some idea”.

Q: So the genesis, all those problems stimulated you to think of sputtering as a better approach --

Chen: Yes.

Q: -- one that would have more flexibility in terms of kinds of alloys you could --

Chen: Right, right.

Q: The structures you could grow, you wouldn't have nodules right?

Chen: Right.

Q: So you may have a better surface?

Chen: Right.

Q: So that's what motivated you --

Chen: Right.

Q: -- to go and do research on sputtered thin film media?

Chen: Right, and then the sputtering, you can always dope it with something to separate the phase, all right? But in the plating, when you try to separate with he phosphorous, the phosphorous tends to incorporate into the crystal and destroy the crystal. As a matter of fact, in a published paper I have one of the best descriptions showing that the grain growth is not that good, all right? So it is interesting at that time, you know and asked Gordon to make some calculations, sit down and make some modeling and make a hexagonal shape, make some calculations. And he did some preliminary calculations, but then after that he gave up, he didn't follow through, and of course Jimmy Zhu came to me and I think later on, in early 1990 or you know, come to -- from San Diego come to-- he read my paper. I published a paper as a matter fact --

Q: So this paper you published in the 1970's?

Chen: Yeah, Gordon Hughes published in 1977, “Side Fringing Writing”, didn’t talk about exchange, 1978 he talked about the interaction between the particles which means--causes exchange, but he never really goes through the details. And when I published myself, presented myself in the same conference, the MMM conference, I talked about that plated media have this, you know particle interaction, all right? Magnetic and magnetostatic, magnetostatic and exchange interaction.

Q: That's a very important discovery right? Because it eventually led to the creation of-- drove you to create media with inter-grain isolation right?

Chen: Right, right, right, right, right.

Q: To break the exchange coupling, and so on,

Chen: But I kept it secret --

Q: Early, early --

Chen: I kept it secret because I thought that's pretty important, right?

Q: It was a trade secret.

Chen: Trade secret and I—for me to allow me to publish and I had to talk about, I mean, so in 1979 in the Intermag conference presented a paper called “The Limits of Recording”, “The Physical Limits of Recording”, and talked about the problem --

Q: Yes, not the solution, you first just spoke about the problem.

Chen: Yeah, the problem, strong interaction between particles, which includes magnetostatic and exchange interaction, caused this big ripple, you know ripple and that's limited recording. And I didn't, I wrote up kind of rough about that and then in 1981 I wrote in more detail how to improve that, all right? And that's very interesting because by then I already know the problem and how to overcome it. And the first I did that -- so that's why I decided to use sputtering early on. So when the sputtering, I find out, I struggled with the sputtering too all right? And then when the sputtering, the first thing I tried to sputter with the use of follow -- follow this cobalt and chromium by Lazzari. This first paper by Lazzari in 1970, which actually we acknowledge, he's a guy who really have this epitaxial concept.

Q: Yeah, he was the first one, right?

Chen: First one, get this epitaxial, yeah, published paper, so I followed that I said, gee, I'm going to do the same thing like Lazzari did on the cobalt chrome.

Q: Try to grow epitaxially a cobalt oriented film on a chrome under layer.

Chen: On chrome.

Q: -- on a chrome under layer.

Chen: Right, right.

Q: To get high coercivity and control the properties --

Chen: Right, and at that time, Lazzari did with Randet, by Lazzari and another guy, by a couple of guys, was by vacuum evaporation, all right? But he never did the sputtering, so I followed his paper, right? Oh, then I have to go back again when I talked to Gordon Hughes' boss I said, "I cannot make a high coercivity all right? You've got to help me." I propose to make a sputtering, so I said "you've got to help me for financing it", and he asked me "how much money you needed", and I said "okay", I went back to find an old vacuum system, I said "Give me $25,000 and I put an 8" inch sputtering target and chamber on the top, I can do it." So I went ahead and designed the sputtering chamber for it, and make that for $25,000 or --

Q: He funded it?

Chen: He funded it, yeah, he funded it, yeah, and then went ahead to do that, that's first thing to do. The second thing what I did was to look at the alloy system so I used a cobalt and chrome and epitaxy, all right? So I tried to sputter that and it's impossible because I couldn't get a good coercivity, all right? And apparently, my vacuum system, is oil pump system, I didn't know at that time.

Q: It's not good enough?

Chen: Yeah, it's not good enough and I know I think have a hard time to make it work. Sometimes you'll get about 300 Oe if you're lucky. Sometime you won't, so I say, oh, okay, this is not practical because you know at that time the vacuum system don't even have a cryo pump, think about that right? They don't have any good except either the oil diffusion pump or ion pump, right? And ion pump is so slow, so expensive you cannot pump it right?

Q: Practically say what can I do with the diffusion pump --

Chen: Yeah, right.

Q: Simple system?

Chen: Simple system and I remember I was at Northrop I try to do this zinc selenide film and I know oxygen is killing the whole thing. So I went to use an ion pump, that's very bad lesson, a very expensive ion pump system and it just doesn't work, it's too hot, it's too non-practical, right? So I decided to stay away from this non-practical thing and stay with the diffusion pump and then figure out how to make it work. Right, and then I know that Lazzari's epitaxy is not going to work because somehow, the chromium is so sensitive to oxidation, all right? So I decided to look for something different, all right? And then I decided that I can never get a good sputtering, so I decided to think about why it didn't work, because I went to study at the TEM (Transmission Electron Microscopy) to look at it and it's a lot of fcc (face centered cubic), original cobalt (hexagonal phase) cannot develop. So I went ahead and look at the phase diagram and look at a cobalt rhenium, at cobalt platinum --

Q: You want to get a hexagonal --

Chen: Yes, yes, yes, and then I figured out that cobalt platinum will probably work and I put -- buy some small target, some mostly two and a half inch target, put a chip on it. I got to get, you know because the time the vacuum system is not good either, all right? And I've got to get a 20 to 30% platinum in there, weight percent, almost 50% that's impossible to work. It's too expensive, right?

Q: Too expensive.

Chen: Right, so I say that is no good either, so I went in and looked at it and I said how do I keep the face centered cubic, hexagonal, I mean hexagonal close packed, hcp, right? And I looked at the phase diagram and rhenium this-- the one which really give you -- hexagonal, you know, phase much more stable. So I went ahead and did the cobalt rhenium and when I did that and it worked, on the same lousy vacuum system. I got up to 700 Oe, all right?

Q: <inaudible>?

Chen: I said okay that's the way to do so what I did was I went ahead to do the cobalt rhenium for that and filed a patent, was getting, you know published a few papers and --

Q: Were you using a special under layer or --

Chen: No, no, no, just directly on glass or aluminum substrate it worked. And when I had to -- I did actually make 8" disk for Gordon to do the recording --

Q: Recording --

Chen: -- recording test and he never, I mean he said it worked but never write or publish a paper on it. But the idea was getting the sputtered media with a similar, like a plated media but with high coercivity and can be isolated -- I said, "So how do I do isolate cobalt rhenium in sputtering?". I find out actually a Maeda publication talk about it (H. Maeda, Journal of Applied Physics, 1982), you put a high argon pressure right? And it's beautifully isolated and coercivity was high too.

Q: What isolates them?

Chen: The argon.

Q: The argon goes into the grain boundary --

Chen: Grain boundary yeah, well the, apparently the, when it deposits so much argon it diffuses out, so it becomes isolated. That's why you get a high coercivity, and I looked at a TEM at that time and the big zig zag is much, much smaller and very interesting And I think it worked and (coercivity) went up to 700 Oe, so that was the whole idea. And then later on, it's kind of interesting, I say that's great and he record, without over coating by the way at that time. So I was thinking over coating too and I bought some silicon dioxide and tried to over coat it but it happened to be 1978, I saw the paper published by Sperry Rand, you know the --

Q: Researcher.

Chen: Maloney, we have to acknowledge Maloney**,** the first guy, if anybody told me the carbon over coating, I'd say that's a bunch of baloney. Okay. Maloney, is the first guy that did using the overcoat of --

Q: Yeah, Maloney.

Chen: Yeah, Maloney.

Q: W.T. Maloney.

Chen: Maloney from Sprerry, all right?

Q: Sperry Research, he published it first in 1975 (meant 1979) --

Chen: Right.

Q: But I think you had the luck to review the paper a year before that?

Chen: Yeah, much before that, he used the Lazzari process by sputtering, he's the first guy to make epitaxy work. He used cobalt and chromium, right? And --

Q: And carbon overcoat.

Chen: Carbon overcoat and Si overcoat both, right? He demonstrated that carbon worked, so after I heard that I said, "That's a great idea." I went ahead and by myself a vitreous carbon, I said well “vitreous carbon (sputtering target) is probably better” because it don’t get the color yellow -- yellowish color, very hard the stuff is all right. So I went to buy vitreous carbon --

Q: Let's take a break here and change the tape and then we'll resume the discussion right at this point.

Chen: Okay.

Q: We were just talking about the Carbon Overcoat decisions you made, the sputtering parameters, particularly the high argon content.

Chen: Right.

Q: It triggered a question in my mind, in the early plated disks, like the ones SDS made, for the head per track drives.

Chen: Yes.

Q: And the prototypes of the 300 megabyte low cost drive?

Chen: Right, right.

Q: How did they manage the tribology, the head-disk interface problem, did they have an overcoat on those plated disks?

Chen: No, actually head per track never needed an overcoat on it right, as you remember, back in the old day in 1964, these Olympic Games, Ampex was the first guy who produce the plated media for recording, instant recording of these ---

Q: 1964?

Chen: 1964, yeah, in the Winter Olympics, yeah I heard about it, and somebody had to get on it. So of course that's only for video recording okay, but for hard disk recording, for data storage, head per track had been shipped out for quite a few years, right, I don't know how long it is, but you have to ask Gordon, maybe he knows better. But they believed it's going to work, however, in their mind they continued to worry about corrosion, right. And the tribology ---

Q: Corrosion of the disk?

Chen: The disk and the tribology too, right.

Q: And the durability.

Chen: Right, the durability. So Gordon was thinking about that but, you know, and his boss was particularly worried about, challenged the question. So that's another reason they're willing to fund me for sputtering. The sputtering for the reasons that I can make a better control of coercivity and hope I can isolate the particle and the product is similar to the plated, you know, the same in plane recording, you know, isotropic and that time we don't even call it oriented okay, but the same like plated media, except higher coercivity, better isolated, and as high a coercivity as I can get. And more important is the overcoat, we can introduce in the sputtering. But I never really did, I always tried to start SiO_2 (silicon dioxide) to overcoat it, kind of in my mind all right, and Gordon and people told me there's a publication done, a patent done by a company called Poly Disk, Poly Data Los Angeles, what they do, they use an oxide, the cobalt oxide, oxidize the surface for tribology. What they do is they flame-- kind of flame apply at high temperature, the surface, oxidize the surface, and they have a patent as a matter of fact. Now he gave me that paper, I look at it and say "That's tough," all right. And so I said my view better is, I mean this is for the plated media right, and they oxidized the surface. But as you know that's not good, "let's go sputter", and that's how they funded me for that. But I never did, you know, I mean I never did carbon until 1978.

Q: When you read this paper?

Chen: Yeah, this paper by Maloney all right, from Sperry Rand. And he, the guy who did SiO2, carbon and stuff like that. I said "Hey, that's a good idea," but of course he claimed that he was not testing the tribology and the reliability, corrosion, but it worked, you know, the spacing is okay, that spacing and the spacing losses is okay. So I went ahead to use a-- I quickly buy some vitreous carbon and make some sputtering of carbon overcoat, that's how it started, okay.

Q: Yes. And it looked pretty good?

Chen: Yeah, it looked pretty good, of course yellowish you know, vitreous carbon. I never tested it, Gordon never tested, a corrosion test or tribology. Yeah, because at that time--

Q: It looked promising?

Chen: Yeah, it looked interesting, put it this way, all right, because Gordon at that time and they were focused on something else, I don't know what they were doing, because I cannot test, I'm the parts people.

Q: You were dependent on them.

Chen: Yeah depended on them for evaluation, I learned a lot of recording from them, but I don't have a setup for doing testing, yeah.

Q: Now related to the overcoat surface also, were the early plated disks lubricated?

Chen: Yes, they--

Q: How were they lubricated?

Chen: Yeah they lubricated, the Kryotox okay <laughs>, use a cotton, you know, a big piece of clean cotton, just smash it in and you just spin it and --

Q: You wet the cotton?

Chen: Yeah, wipe it and then they later on use a head burnish, to burnishing, and then we did-- to see if burnishing finished or not, by connecting the amplifier to the speaker right, they go “bim-bim-bim-bim-bim-bim,” until it completely quieted down and they said “Okay, burnish is finished,” and then they wiped it again, you know <laughs>.

Q: Interesting. Did you think you would need a lubricant on the carbon?

Chen: Oh sure, oh, I didn't know at that time, all right, when the Komag started and that's what I have to really struggle with it, yes.

Q: So coming back, basically, although initially you focused on prototyping plated media for film disks at Xerox PARC, you then moved to sputtering because you thought it had more promise, so now you're hooked on sputtering, and what happens with your work on sputtered media at Xerox PARC?

Chen: Well--

Q: Because I sense the important use is kind of distracted.

Chen: Yeah, they had decided, they thought that the work was finished, you know, 300 megabytes for two thousand dollars in three disks, and they think they're pretty good, all right. And they're waiting to see, maybe that should go to production or, you know, because at that time, Xerox, no Xerox bought -- yes at that time they also bought the two companies making disk drives, one is the Diablo Systems, one is Century Data, right, they all make a hard disk, right. And in order to go into production they had to pass all these technologies, thin film technologies, to them, and the Diablo and Century Data particularly, they don’t want to, they resisted to, because they're making oxide and they are like a typical IBM guy, once you establish something they don’t want to change it, right. And Gordon, I feel sorry for Gordon’s people because they got this beautiful thing sitting there for two thousand dollar cost, and could sell to mini computer, you know, might be a bit, way cheaper. And so they're waiting and then in 1979 IBM announced, the 3370.

Q: 3370.

Chen: Yes.

Q: It was an oxide disk, a particulate oxide disk.

Chen: Yes, with a thin film---

Q: With a film head.

Chen: That's where they killed the whole project.

Q: So when Xerox learned of that --

Chen: Yes, Xerox were kind of waiting say -- was hoping, and we were hoping as, me and Gordon was hoping that they would announce the film disk with --

Q: Ferrite head.

Chen: Ferrite head. And so we can convince the Century Data, right, Century Data is the production arm of Xerox, right. But what happened is when the announcement came out, 3370, the film head and the oxide DD --

Q: That was 19--

Chen: 1979, killed the whole project, completely killed.

Q: They didn't have a film head.

Chen: Right, right.

Q: And without a film head they wouldn't be able to compete with IBM?

Chen: Well no, yeah, no, then Xerox itself, the Century Data, right, they'll go ahead continuing running that way because they're the business arm of it, right, they're going to go ahead to buy the film head and do the oxide disk.

Q: So they just would follow that.

Chen: Right.

Q: They would copy IBM rather than take new ideas.

Chen: Right, we were the researcher guys, we were at the bottom of the totem pole, right, and they don't want it, they don't even talk, right. And so I think that's why that Gordon just kind of shut up and we drifted off to do something else. And I was continuing doing some overcoating studies just for fun, I mean I did my publication, that's almost my publication done by then, we saw that the project is dead, you know, it's dead. So I can publish it, published a lot of stuff, you know, in 1979 on the limits of recording and stuff like that then. But finally but I still focus on MO, so I focused a lot on, I worked a lot on MO, on magneto-optics.

Q: So you went back to, you kept at it, at MO, but now you reemphasized the magneto-optical recording.

Chen: Right, so we started to build the 14 inches magneto-optic disk, actually it's the first gigabyte single disk that was ever produced, it's by me on, magneto-optics.

Q: What material were you using?

Chen: That's terbium iron.

Q: Terbium iron.

Chen: Yeah, after I killed MnBi, I look at an IBM publication by a bunch of IBM researchers and --

Q: I know who it was, Cuomo.

Chen: Cuomo and --

Q: Chaudhary.

Chen: Yeah Chaudhary and the guy, it start from G.

Q: Gambino

Chen: Gambino, Gambino did a lot of work. So I said “hey that's a great idea”, but they did on the terbium--

Q: Gadolinum iron cobalt.

Chen: So somebody passed on terbium, so okay, I look at it and I say “okay, I'll do the terbium iron”, and later on migrated to terbium cobalt iron, okay, for better performance. But I was able to gradually build it up, and by 1979 when the plated media is out, and in 1970 I already started making the disk of three inches of terbium cobalt iron, and then by 1979 I created the first big giant disk, you know, that's in 1979-1980, I created this --

Q: Was it 12 inches?

Chen: 12 inches, yes (meant to say 14 inches)

Q: And it had a gigabyte capacity?

Chen: Yeah, finally David Treves recorded that, helped me, after Xerox hired David as a consultant to build up the system, because the people in PARC couldn't build it, couldn't get the system to work.

Q: A full recording system.

Chen: Yeah, it cannot work.

Q: Can make a disk.

Chen: Yeah, I can make a disk, but the optical science people cannot make it work, and I only get starting to test, right, and I don’t name the name. Anyway, he spent years trying to make a system who make it work, until they'd be coming in, they came about- he come in for one year, I think in only six months to build up the small tester for three inches and it worked. And so he told me to change my, you know, the stuff like that, and so I changed it and make it 12 inches.

Q: 12 inches?

Chen: Yeah. 14 inches I think.

Q: That must have been intellectually and scientifically -- engineering-wise very interesting right, the project?

Chen: Right.

Q: But that's not what eventually you chose to follow, what made you decide to eventually leave Xerox PARC, and why and when?

Chen: That's kind of interesting, because --

Q: What did you decide to do?

Chen: Okay, the thing is, let me finish the part of the magneto-optics, so 14 inches okay, that's got to do with this too.

Q: Okay.

Chen: So IBM (meant Xerox PARC) killed the film media project, right, and so everybody left and nobody wanted to work there so I still follow this magneto-optics, right, and we make a 14 inches and David later on would be able to record a head per track, I mean a few tracks, were calculated to come to be a gigabyte drive, and media. So we're so excited about it, I said "okay", by 1982 Xerox decided to get rid of all its computers, all right, the Xerox went ahead in 1979 started a company called the Star Computer, I don't know whether you heard about it, right.

Q: No, Star?

Chen: Star Computer, and they tried to take Xerox PARC to have this, you know, Xerox have Alta computer, which in 1975 I think the vision they have some of their older stuff, they should keep that, because that's the first personalized computer, distributed by everybody, all right, and I call the Alta computer, and that Alta computer I heard was made a set also for Congress in the 1975-1976, for them to use. And so it was so successful that we eventually decided to go ahead to making the -- take some of the technology and build a computer company called the Star Computer, right. And we have a celebration, very successful, and, you know, all that stuff and they start up, you know, in 1979, big shot, you know, very big things and --

Q: Big event.

Chen: A big event. And then about a couple of years later, 1981, they, after two billion dollars are sunk into it <laughs>, and then no market can-- and nobody want to buy it, so they decided to shut it down, and Xerox was becoming so poor at the time, all right and they decided to completely get rid of that.

Q: Completely.

Chen: Get rid of it, complete --

Q: Get out of the computing business.

Chen: Yeah, computing business, and as I said, that's in 1982. So I heard all these things and they did to us to shut it down and all that stuff right. And so I hear I got these just I heard about all these things going, the PC industry started picking up, you know what I'm saying.

Q: Outside of Xerox?

Chen: Outside, yeah, PC's --

Q: IBM, Apple.

Chen: Yeah, right, right, and Apple was, you heard about this Steve Jobs went to Xerox and the guy who wanted to get rid of the -- actually Xerox hired a guy called Bill Spencer to do the replace George Pake, and tell Spencer to get rid of all this computer stuff. So Bill Spencer turned around and said "Okay, first thing to do, let's disband all this computer research, "and try to get Apple to come in, you know, and Steve Jobs and Apple to come in to work together so we can transfer some of these beautiful technology to Apple right. But then Steve Jobs walks through the laboratory and saw all these windows flip back and forth, he gets so excited I heard, this I heard, he was so excited that he tried to do it for several years, couldn't do it, all right, and then finally he went home, called up all the guys' name, you know, and he called all those --

Q: He met during his visit?

Chen: Yeah, he got all the business cards from, you know, the key persons and he called back and said come to join him. So like Eric Kay, and, what is that, Bob Taylor and all these, they left Xerox and went to join him and making that first generation called the Lisa Computer, you remember that time all right? And so that's got disbanded, and that's the time when, of course, IBM started to pick up PC and, you know, because IBM was afraid of Apple and start going to the PC. So I see this opportunity coming, so I said--

Q: Those PC's required small drives right?

Chen: Yeah, small drives and a lot of money in it --

Q: Seagate started the 5¼-inch drive, right?

Chen: Right, right, Seagate had the 5¼ drive and here you got this Ampex, right, announced that it got, you know, you remember the term?

Q: The Alar disk?

Chen: Ampex and then, and so Bob, one time my boss, I changed department to the -- in our department, you know, so to the Optical Science Department, my boss, John Erbach, told me, he said "Tu Chen, maybe you take a look at this, maybe magneto-optics can become part of this too," because what happened is hard disk maybe corrosion is still a problem right, IBM have not blessed it, right. So I put together, he told me to put together a plan, and we had a few people put together a plan to make a magneto-optic drive, right, to meet the requirement of the hard disk, I mean of this PC. So he asking this guy, he ask Jim Porter, John Urback, he's my boss, who asked Jim Porter to have a lunch talk, you know, kind of conversation in the lunchtime, and that's the first time I met Jim Porter. And Jim Porter stated this, I say "Hey, magneto-optics is no good because you have this -- Maxtor has this new motor, hub in a motor, and 5 1/4, and can stick 8 mini disks, 8 or 10 disks or something like that, and they're going to break through this, so magneto-optics is going to be harder," right. So anyway, that's what he said. And in the meantime, I already wrote the business plan, we're waiting for the boss, you know, to send out to see whether Xerox willing to go for it because I don't want to get out, I still want to -- hopefully Xerox spread this and we can spin out, all right. And I wait for long time, and I wrote a proposal and wait for six months, and later on so many people encouraged me to go start it --

Q: On your own?

Chen: Yeah, and what happened, I get started, at that time then there's quite a few people based on Ampex’s Alar disk, started up quite a few drive companies, right. One company is Maxtor, right, of course Maxtor used a different approach, maybe use oxide but they think maybe you can put a film disk and can go to 100’s of megabytes all right. And then you had a Vertek, I don't know if you heard about it?

Q: Vertek?

Chen: Vertek all right, and Vertek was jumping into it too, and another one called the Evotek, these three company was competing for longitudinal recording based on the Alar, okay. That’s in 1982, right, and there is also too another two company, one is Bob Potter’s perpendicular recording --

Q: Lanx.

Chen: Lanx, and AIM, AIM was also perpendicular.

Q: Those were media companies?

Chen: No, they --

Q: Lanx also --

Chen: Well the concept of doing that, who is going to make perpendicular, I don't know, right, but they're saying the drive would make perpendicular work. And strictly for the in plane work, based on the technology they have at the time, usually the in plane plated media is these --

Q: These other three companies.

Chen: Yeah, these three companies, you know, one is Maxtor, Vertek and Evotek. Now Vertek is the most pure based on the metallic thin film, because they don’t have this hub (in hub motor) inside, so you got no choice how to make high density all right. And so Vertek become so anxious to make it work, so what happens, they start to make this disk, buy the disk from Ampex and they start putting it in the drive, and they had these -- they could never past corrosion and tribological problem, they couldn't work.

Q: Achieve the right reliability --

Chen: Right, right. And so in early 1983 I was kind of screwing around, to look at MO, to keep going, and a few venture companies, a guy come to talk to me, asked my opinion as a consultant, you know, a free consultant, I had to pay their meal, you know, I had to pay for their breakfast, anyway, to ask me whether should they invest in Lanx or AIM – or --

Q: These various companies.

Chen: Various companies, yeah.

Q: Media or Drives.

Chen: Yeah, they're saying I'm the guy who really, you know, know this business yeah. And one of the guy with a name called Brett Downing from Robertson Coleman, you know, venture fund company, come to talk to me about it, several time as a matter of fact. So finally, after a couple of meetings he said "Tu Chen, why don't you start it, you know so much, why don't you start a company <laughs>, you start it I am going to fund you a million dollar," that's what he promised, I said "Oh, that sounds good."

Q: What's his name again, he was?

Chen: Brett Downing, Brett Downing yeah. Because he tried to invest in the -- so he don't miss the window, see, he tried to invest in all these companies, you know, this --

Q: Grenex.

Chen: Grenex was later on, the Lanx and the IAM, right, and here you got this Vertek and Maxtor right, so I kind of shot them down on all these things, all right. So anyway, that was between the end of the 1982 and beginning of 1983. Then by spring of 1983 or May, then the guy, one guy from Vertek now saw me, you know, in the conference, in 1983 conference, so he told me "Hey, why don't you start a company," he used to work for Gordon Hughes -- Max Ross, he used to work for Gordon Hughes, "You know so much why don't you start it," I said "Well, I don't have money," he said "No problem, I can introduce to my boss," you know, one of his boss, now at Vertek, he work for Vertek at the time, they said they're in trouble, they don't have a media, they will die, right, and they're venture funded. So he introduced me to Jim Atkinson, was --

Q: Jim Atkinson?

Chen: Jim Atkinson of this Vertek, Vertek is a guy who was completely based on the normal drive, like a Seagate drive, you know, no shaft and tried using Ampex disk to make a 80 to 160 megabyte drive, and they cannot do it, tribology cannot work, they demonstrated it worked to get that kind of density but the 4 disk, 80 megabyte and 8 disk for 160 megabyte, 20 megabytes per disk.

Q: 20 megabytes per disk?

Chen: Per disk, and these were 5 ¼, all right, and they don't have the solution.

Q: Couldn't get the reliability.

Chen: Yeah, the reliability. So he told me after Max introduced me to Jim Atkinson, he say "You can start it, I can help you find the lead venture," right. He said that Jim, I mean the guy, Brett Downing, from the Robertson Coleman doesn't want to be the lead venture.

Q: Lead venture.

Chen: No, he don't want to be, they are also investment bankers too, all right, so they cannot be a lead. So he said "you find a lead venture you're going to -- I will put one million dollars". So I told this to Jim Atkinson, and finally Jim Atkinson told me, he said "Oh, no problem, I will find you a good lead venture." So next day he called up a guy called Art Spinner, and this young guy, you know, was about 30, 27 or 30 years old, he just-- he worked for this English bank who started a venture firm, all right, and called a Hambro Venture Fund, all right, and Hambro Venture Fund is he raised 70 million dollars and he's tried to invest it in something, he was missing the window every time. So he heard about this and he fly over right away.

Q: From England?

Chen: No, no, he's in New York, yeah, the venture fund is in New York, but the bank was from England, all right, yeah, 70 million dollars. So he come in and he started to talk to me and he's so excited, he said

“Okay, I'll fund this, and you put a business plan together,” so I prepared a business plan and gave it to him, and that’s why he funded it, all right. And the idea was to make a thin film sputtered media to support, at that time it was a startup drive company, you got all these drive companies, drive companies dying without a good solution to be --

Q: The plated medium from Ampex was not --

Chen: That's not going to work, yes.

Q: And you saw the need then and you thought you'd fill that need with sputtered media.

Chen: Right, right, and so I thought if I come out with something like a plated media with a higher coercivity, with a --

Q: And the right reliability.

Chen: The reliability, I can capture the market, get into it right away. And when I talked to them, everybody said the Ampex disk is, works great on the magnetics side but no good for all that --

Q: Reliability.

Chen: Reliability. And so when I have that, I said “Oh, that’s an opportunity, that’s how I raised the money,” and once I talked to these people, I went back to Xerox say “Okay, would you like to fund me, I mean recommend me,” I don’t --

Q: Give them a chance of last refusal right?

Chen: Yeah, after reviewing it for six months I haven't seen, so it took me two weeks to make an appointment to see this guy, you know, Bill Spencer. And Bill Spencer, I went to his office, I said “Okay Bill, Dr. Spencer,” they had to call him Bill, he's a big shot, “would you tell me, you know, have you read my proposal?” he said “No, we don’t have time,” or blah-blah-blah, because he's the guy in the process of getting rid of all the stuff anyway, all right. And so I said “Can you give me help and try to get the Xerox Venture Fund to fund some of the ideas I have,” he said “No, Tu Chen, I give you 10 minutes, tell me what you think,” I told him the whole story about the opportunity to get the thin film media into the market, at exactly the right time, all right. And he said Xerox doesn't have any interest in it, all right, “And I tell you Tu Chen,” he asked me how old I am, just 48 -- I said “Well you're not interested, the venture fund was willing to do this, all you have to do is embrace me and with some Xerox backing, probably the venture fund is going to pout more money into it, right." And he told me, I mean the Xerox Fund is not interested, it's not going to be interested, he said pretty sure it's not interested, all right. So after he heard what I said he said "Okay, how old are you?" I say "I'm 48," so he's pretty nice, "Yeah, Tu Chen, I give you good advice, you know, since you're 48 this is your last chance to start a company, so if I were you then go and take it and run to a venture fund," I say "Is Xerox willing to embrace this?" he said "Sure, no problem," all right, "as long as you pay Xerox, you know, license for the patent that you created," I said "Fine." So I asked him to write me a letter to say that's okay.

Q: Xerox would approve of doing this and not object.

Chen: Right, so I went, take the data, went back to the Art Spinner, the venture fund, and they're very happy, they said "Look, Tu Chen, you go ahead to full speed to start a company." And then I went ahead to talk to Jim Shir, as a matter of fact, Jim Shir, I talked to him earlier, you know, but he --

Q: And Jim was working at IBM at the time.

Chen: IBM at the time, he's interested.

Q: The magnetic bubble memory.

Chen: Memory. Yes right, and, you know, and so I asked Jim to join me right, and he said "Oh you get the money, and then get Scott Chen too," he said "You get money, we'll do it."

Q: Scott was also --

Chen: Yeah, co-founder, yeah from IBM. And they had a big secret at that time, they did not want IBM to know about the startup. But we had not stolen anything from IBM, right.

Q: Yeah IBM was ending its Bubble program at the time.

Chen: Yeah Bubble program at the time yeah.

Q: Jim Shir would have had to look for a new job.

Chen: A new job too yeah, yeah.

Q: So you, Jim Shir and Scott Chen were the --

Chen: Co-founder, yeah right.

Q: Co-founders at that time, did you already pick the name Komag or not yet?

Chen: No, that's kind of interesting, I had an acting president all right, and Ferrell Sanders, he is kind of very nice guy, and who introduced me to Jim Atkinson and Art Spinner introduced me to help me put together a plan, right, the original plan I put together with Jim was kind of rough, you know, and so after he put it together, I mean he didn't change the plan yet, he needed help, needed to raise money. So I take the original rough plan which Jim and I put together, went to New York to present to Hambro Venture Fund, right, and the Ferrell Sanders went with me to New York, so I presented it, I told him the story and it's the greatest story, as a matter of fact it's an interesting story, I brought him Photo Ceram, you know, Photo Ceram, because I told him how important this sputtered media is going to be, not just aluminum substrate but in the future it's going to be glass, Photo Ceram, all right, and this is going to be very strong, right <laughs>.

Q: Photo Ceram was a ceramic substrate?

Chen: Yeah, that was made by Corning, all right, and I have that, I sputtered on it, right, in Xerox I sputtered it, and then I take the Photo Ceram and then I show it to him, I demonstrated how strong it was, I dropped it onto the table, and the table didn't break but the table have a ding. And <laughs> the funniest thing was later on, after they approved the investment in it to me, they asked me, they tell me, you know, "Tu Chen, that's antique table you just destroyed" <laughs>, kind of funny. But anyway, I was demonstrating my point of how important sputtering is, you can never do that on a ceramic substrate, a glass substrate by plating, all right, it'd be very difficult I said. And anyway, I fly down there, I presented it, and they said after my presentation, told me to go outside for a restroom for 10 minutes, I have one smoke and then come in, they said "Okay Tu Chen, we invest a million and a quarter to you-- quarter million dollar first, and you start a company first and then later on we raise three and a half million total, according to your plan," so we'll start again, right, that's how we started. But then, once he hit on that, I recall the time that Jim come out, I called Sputter Tech, Sputter Tech, Sputter Tech, at the time called Tech, Tech, all right, and he said "I don't like the name, you can change the name, I'll put a million and a quarter to you." So on the way I fly from New York back to here, the Ferrell Sanders is sitting by me, he said "Tu Chen, can we think about some better name, like the Japanese sound, some new meaning, or Chinese or Taiwanese or anything," so I kept thinking, I kept thinking, and then that night I come home, and my son is Ko (middle name), K-O, that Ko is a meaning virtue, very good virtue, all right, that's why I like the word, I said "Komag," "virtual magnetic," right, magnetic with a certain virtue.

Q: A much better name than Sputter Tech right.

Chen: Yeah, so I went and called back and of course, I called Ferrell Sanders, they said "Oh that sounds good, did you call Spinner?" so I called Spinner right away in New York and he said "Hey, that sounds

good, Komag, Komag, at least it sounds good, yeah but what does it mean?" I said "Well that is, very good virtual, have a virtual magnetic," and he said "Oh good." So he told his boss and he thought, said "Okay, we invest it," so he sent me a check a quarter million dollar, I start a company in June 7 --

Q: 1983.

Chen: 1983, June 7, so we started and started, you know, prepare and then Ferrell Sanders, we rented an office from Solectron and then started work together and figured out how to develop that.

Q: So you actually rented space from Solectron in Milpitas there?

Chen: Yes, yes, yes, and he's my friend, Milpitas yeah. And the --

Q: Was Ko Nishimura??

Chen: No, no, no, that was -- Winston, Winston, yeah they had just started, yeah, went public, yeah, he's kind of nice and he gave me an office. And well of course later on I, of course, insist to pay him the rent, or anyway, he didn't want to take it, I said "No, no, you have to take it," so I started there. And I started and Jim and Scott said "Once you raise the money we will join in", and every time I went to present this project to the venture capitalists with their name hiding, only just the last name, and venture capitalists don't like it, they say "You are not committed, those guys are not committed, it doesn't sound like you have anybody," <laughs>. So we had to put the name there. So by July 1st, in July 1st and July 4th I told Jim, I said "You got to come in, because we all need to negotiate how many shares for him and stuff like that". So Jim was pretty good, he only got 15 days to go, actually 30 days to go to take a 15 year retirement right, but he decided to join me before he got his retirement fund <laughs> and join Komag. Scott Chen already have retirement fund in bag --

Q: From IBM.

Chen: Yeah, but then he was kind of, when he finished physical test he said “Dr. told me I got too high blood sugar,” and all that stuff right, so his wife said no, he shouldn't join the start up, but I convinced him, I convinced his wife, and convinced my wife, to convince his wife, so and he come to join me <laughs>.

Q: So they got committed?

Chen: Yeah committed, funny --

Q: And involved, right?

Chen: Yeah, because we needed him, you know, he is an expert on application side all right, and Jim is very good at research all right, and he's very well organized and I'm not, I'm well organized in my mind but I don’t put together into a book.

Q: Jim was very methodical.

Chen: Methodical on everything, yeah right.

Q: He was not only smart but methodical.

Chen: Yeah.

Q: So tell me, terrific, Komag is off, you have three people on board, you have this small space from Solectron, take me through your first year, how long did it take to get a product, and you had to make some major decisions right, what equipment, what substrate, what facilities, right?

Chen: Okay, let me -- Komag started. When Komag started, you know, I kind of missed, I mean I forgot this part, it's very interesting, because, you hate to remember that at that time, there's no knowledge of what's never been produced in the sputter media, period, plated media yes, all right, and there's a substrate yes, you know, a nickel phosphorous substrate, commercially started to come out, the nickel phosphorous chemicals, aluminum and stuff like that right, for the plating, and even then the plating was not in the mass production in a certain way, so there's a sort of defect problem was not well understood either, right, except we can start buying it commercially, you know, nickel phosphorous chemicals, right. And you can buy the substrate from a company like Burton (Burton Magnekote), quite a few companies, you know, they're here in Los Angeles, quite a few companies making those plated substrates, all right, and everybody wants to jump into it, right, and many people want to jump in, and many sputtering companies jump in too at the time, all right. Let's talk about that, it'd be interesting, because in the earlier time when I was in Xerox research, when I went to present my paper in the 3M conference in Cleveland, around 1978, there's nobody there in my session, you know, when I talk today I went to present a couple of talks, in the 1970's when I presented MO (magneto-optics) there were more people interested, listened to it, than the sputter media, thin film media, nobody is interested, all right.

Q: Everybody would go to the Magnetic Bubble Sessions, right.

Chen: Everybody go to Bubbles, right, and only very few on that, except one actually one time it's very interesting, in 1978 in the Cleveland I have a lady from Control Data, Magnetic Peripherals, right, she saw me and she invited me, went to talk to them, in that, and because they tried to start a plated media also, and they liked to see my concept of sputtered media, so we talk about it. So in a certain way the plated media has been around, the substrate's been around, the chemical's been, you know, formulation started to go up in 1979, 1980, but until Ampex started to become big, you know, 40 million dollar right, there's no other technology. So polishing machine is there but it's not as good, right, and there's no such thing as a texture, nobody know the texture, you don't need a texture at the time right, everybody's polished it and plated it and shipped it out right. And then, here you come in with, except the substrate which already got established some technology which you can use, there is no production machine for sputtering, right. And here you got this, the Bob Potter started Lanx, and all those guys tried to make a sputter machine for perpendicular recording, for example, all right. And so no commercially had really established sputter machine except many people jump into it, the company Leybold Hereaus, Ulvac Japan, a whole new company called CPA.

Q: CPA, Leybold Hereaus, Ulvac.

Chen: Ulvac and Comptec too, there's Comptec, and there's another small company with the rotating magnet, and stuff like that. And so I had the first thing, they say "What kind of machine should I buy?" I don't want to develop a machine, I only got limited resources and my business called for not even the substrate, buy substrate, polish substrate <laughs>, and sputter it, lube it, overcoat it, and lube it and ship it out, test and ship it out, that's all my business plan called for. I was fortunate though, because I was fortunate, you know, I was fortunate, I raised five and a half million just, you know, instead of three and a half million, so I even though I raised five and a half million, it is not enough to go for that all right. So I had the toughest one is to find what sputtering machine should I buy, right, and you cannot deviate too much from the industry standard like a glass substrate, and so you had to buy the aluminum substrate right, and fortunately the aluminum substrate, polished substrates you can buy.

Q: It was at least available.

Chen: It will solve problem, right, and maybe there's a defect problem I can solve in my own way. But sputtering is just a problem, and certifying it was not even commercially available, just started up this company and do the certifying, and Scott Chen was responsible for that. So the biggest problem is to do is find, a really, a sputtering machine. Now, I had to decide what substrate to use, what the process to use, of course definitely not a perpendicular, right. And the double layer, which is too hard, you know, cobalt chromium is just impossible, I already tried it before, right, and I know that the vacuum is not good enough for doing that. So I went ahead and to say “okay, I'm going to do the isotropic media, like the plated media, nothing else”, because I got so much other things to do, I cannot focus too much on the other things, and which I proved myself before with the RF sputtering, with the isotropic media I can do it very easily, the cobalt rhenium. So I license that cobalt rhenium from Xerox, but then before I start I said “No, no, no, I got to do something,” but it's very fortunate, before I started as a matter of fact, in 1982 I saw two papers, I was the reviewer, sorry about it --

Q: Again, you seem to have had the luck of reviewing --

Chen: There's two papers, one is by IBM, Aboaf.

Q: Joe Aboaf and Kaufman.

Chen: Kaufman, yeah that's a group of people, they published the cobalt platinum and they're hitting the, you know, thousands of Oersteds, right, with about 20 percent platinum, right, which is better than when I try to do it earlier with a double layer, somebody demonstrated that it worked, all right. Then another one, more important paper is beside IBM, is called the Yanagisawa, NEC, NEC, Yanagisawa right, and that paper is so important, he described using nickel, in addition to the platinum he also added the nickel also, right, and I said “oh”.

Q: Yanagisawa.

Chen: Yanagisawa.

Q: Yamaguchi and Saganuma.

Chen: Yeah.

Q: They were with NEC?

Chen: NEC, yeah. That paper is so important describing one of the very facts, you can use 10 percent platinum and still get over a thousand Oersteds, right, by adding of the nickel. So it hit me, when I saw -- he didn't explain it but when I saw that paper it hit me, I said of course, just like a cobalt nickel phosphorous, you add in nickel and you can dilute the moment, right, you know what I'm saying. And if you got nickel, and it don't get too high, I got 20 percent and 10 percent, you look at its phase diagram with a hexagonal close packed, still going up, the transition from fcc (face centered cubic) to hcp (hexagonal close packed), as a function of temperature they keep going up, they're more stable, up to 10 percent, then after 20 percent it drops, right. But with platinum, the same thing went up but not as good, however most important, platinum, I mean the nickel then, it put in, it dilutes the moment, to make the coercivity higher. So when I saw that 10 percent platinum can be used I said "Okay, I'm not going to use a cobalt rhenium." So before even I started I told Jim when we started the company I already decided to use the cobalt nickel platinum, 10 percent, all right, and so I went ahead to design the whole sputtering system based on RF sputtering, because what is the RF, platinum is so damn expensive right, if you use a DC magnetron, the earlier part of the magnet target is very highly magnetized, you know, moment is very high, so susceptibility is very high, right, so if you use the magnetron it shunts the magnetic field and it becomes useless, all right. so you've got to use the very thin target, like 2 millimeter or less. Now, particularly with a race track erosion, they will wear out pretty fast, so you had to change targets practically every other day, you know, stuff like that, right, and for the platinum target it's too expensive to do that right. And so I figured out if these are-- at that time I already know the cobalt chromium, people talk about cobalt chromium because based on the perpendicular recording a cobalt chromium on chromium, actually in 1983 I have some records to show that. Jim Shir went ahead and calculated that the cobalt chromium, the chromium underlayer, talking to the vendor to see the target costs, and then finally I found out it's more expensive, use the cobalt chromium with the chromium, than cobalt platinum if I can make a cobalt platinum erosion of more than 80 percent, with a start with a one centimeter thick target. So we went ahead, used a one centimeter target design and with RF sputtering, right, and erode very carefully for more than 80 percent, the costs were cheaper than --

Q: Than a DC magnet on cobalt chromium.

Chen: Right, because the target you can use for months and you don't have to clean up the system for two weeks, every two weeks, or one week actually, it was already designed one week. It turned out we were right, but at that time the hardest part for me is, because of my experience of course, luckily I do the RF and sputtering, so I said the hardest part is which machine should I buy. So I look at all the machines, it's all in line anyway, except one actually called Comptec, it's a static machine, and Varian talked about it but was not producing it. So only one machine really available, was CPA, Leybold Hereaus and Ulvac, all right. And then I talked to all these companies, I wanted them to help me design the whole sputtering machine with an interior, my concept of RF, right, and they cannot sell that machine to anybody.

Q: You wanted it as an exclusive.

Chen: Exclusive, yeah, lifetime, yeah. And nobody willing to sign it, they only sign two year right, except Ulvac said they'd sign for a lifetime, I said “great”. You know, the difficult part of that is you try to sputter RF facing, that both sides simultaneously -- that’s a big risk, that’s a big risk.

Q: Big unknown right?

Chen: Big unknown.

Q: You could do it right?

Chen: Yeah you could do it, I even so conservatively designed it, I even make a design, I invented a plug, so they don’t see each other, all right. And fortunately when I talked to Ulvac’s people they have experience in the common exciter, and they did it before with their two targets, not facing each other, but next to each other, they used robbing the power, so they have a common exciter to changing the phase, changing, it worked. So I take a chance, I said I think we'll go to Ulvac because they're willing to sign the lifetime agreement right.

Q: They want to give you lifetime exclusivity.

Chen: Exclusive.

Q: And they were willing to help, they had knowledge.

Chen: Yes, yes, yes.

Q: To apply and so that’s how you focused on that.

Chen: Focused on that. So our focus at that time, most of the money put in the standard equipment, like plating, and they polish it, we buy some polishing, just to be sure, we buy the aluminum plated substrate and we polish it, we had a control --

Q: You had to build your own certifiers.

Chen: Yes, but now we work with the outside vendor to do it.

Q: Which outside vendor?

Chen: I forgot about it, Scott Chen knows what's the name.

Q: Not Phase Metrics?

Chen: Yeah, the Phase Metrics beforehand, yeah Phase Metric yeah.

Q: The company that preceded it?

Chen: Yes, yes, yes, and that was run by some Scott, what his name, anyhow. So that part, and we like to buy as much standard as possible, because we put all the money into where most critical, hard, all right, that's already got a headache, because you got to have a sputtering machine really commercialized and can produce a disk with a lousy, you know, vacuum system, all right, and low cost machine. So I went to Ulvac, after I raised the money in September 10 and 11 I fly home, to Japan, I talk to Ulvac, actually before that I already talked to Ulvac and Ulvac's willing to give them a design, all right. So they come back in August with a design which is no good, all right, so I had to quickly go to Japan to solve the problem. And I went to Japan, signed the agreement and then designed a machine.

Q: You stayed there and worked with them to design it?

Chen: Yeah, for one week, and designed the whole detail. My target was eight hundred thousand dollars for a sputtering machine, as a matter -- that's not violate anything, I hope is, but Ulvac showed me there's a machine on the floor, doing the hard disk, it turned that machine was, he didn't tell me anybody who that machine owned, they didn't tell me, but later on I figured out that's from IBM <laughs>, that's for IBM.

Q: They showed you a machine, they were telling you what it was for.

Chen: I saw it, yeah I asked him was it a US company or Japan, he said "Oh no comment," and so he said "Well we have this expensive " tried to sell me that right, and they said DC Magnetron, all that, I said "How much the machine cost?" he said "Well almost three million dollars," that's too much for me <laughs>, I've only got totally five and a half million, I cannot afford that, right. So I say yeah eight hundred thousand is the maximum design, so I say "How about doing this," I proved before with RF with the diffusion pump I can make a very high good coercivity, right, you know what I'm saying, and then "So therefore I want you to build that for me, the same thing, the lowest cost." So they went ahead, they designed it, we only got two small cryo pumps in the loading-unloading chamber, that's all, because there is already a pump, and then we don't have so much called big sputtering, we've got to the turbo pump -- really suck the argon out of it. I tried to sputter at high pressure to isolate the particle, up to 40, 50 micron, mili Torr condition for sputtering to have, that's what my design, original design was. (To reduce cost, Komag used two 8 inch cryo pumps in the loading and unloading chambers. In the buffer and process chambers it used diffusion pumps to pump down from atmospheric conditions, followed by high pumping rate turbo molecular pumps to pump high pressure argon during sputtering).

Q: So the first machine was going to have the turbo pumps or just the diffusion pumps?

Chen: Just the diffusion pump for pump down, and then for sputtering, during the sputtering it's turbo pump only.

Q: Turbo molecular pumps?

Chen: Turbo molecular <laughs>, no -- yeah, no cryo pump or anything <laughs>, and very high rate, keep it simple and a low cost. And that's the first machine coming in.

Q: And they were able to achieve that target.

Chen: Yes, yes.

Q: And they were going to sell it to you for $800,000?

Chen: Yes, they had it slightly over 800,000 beginning of it, later on I got a two target and because I wanted to know underlayer for introducing a seeding layer, so I have a first, I called it glow discharge layer, the seeding layer, so one RF, second RF for main target, all right. And then a carbon chamber, one carbon chamber. Later on I found that one carbon chamber it's not fast enough, right, then after during the I have to design it and they agreed to it and then we buy the small sputtering machine and tried it and it just doesn't get enough rate. So I had to go to DC Magnetron for that, to get a -- because they have experiences, yeah the guy told me you got to be at DC to get that , I say "Fine DC," but needed two target, so we designed two carbon. But turned out we have to use only one.

Q: Did you have to add a chamber?

Chen: Adding a chamber, yeah adding an extra section of chamber, and that cost more money, say another hundred thousand or so. Anyway, the whole thing less than a million dollar and it worked. And later on we struggled to make it work as a matter of fact, and so --

Q: It was not easy?

Chen: Not easy. But anyway, so we signed it and they went ahead to it and remember they come back with a design and we said “Okay great,” and that was good, and that time it's only one chamber of carbon, right, and we signed that paper --

Q: And you had to modify it?

Chen: We had to modify in the February to get the two chamber, two carbon, all right. But then we have acceptance test, though --

Q: Continue.

Chen: We have the supposed acceptance test, the plan called that by August we're going to have a production, all right, and so then by April of the 1984 we're supposed to have acceptance test so they told me is everything fine, went down to Japan, with a bunch of guys went to Japan. As a matter of fact in November of 1983 when we were designing we have a terrible time too, we didn’t know how to put the panel in, there's a panel in the in line, right, and the guy have a design of this panel and they're coming in, assembled it, and put a disk in and put in and I said “No, no, no good, have to have loaded there, right, inside.” And we don’t know how to design so I have the idea of coming a guillotine, then put one disk, and then two disk and then loading guillotine, guillotine like that. So they finished that machine in April, so I bring the team to Japan for acceptance test, and it was a chaos, because the heating we had to put in, bent all the panels, bent all the stuff --

Q: You designed the heating from the beginning?

Chen: I just wanted to be ensured that the heater is there to, and I mean you’ve got to design something -- yeah in case you have to bake out or maybe there is some, you know, pre-sputtering, or I need it during the sputtering to make a better recrystallization, in order to start right. So at that time I didn't know how much heat I got to do, you know, could generate from there, and so I went ahead to design the whole thing with a heater, but once they start in there with the RF pattern on full power and then heater on--

Q: Everything started bending.

Chen: Bending, and then jumping the chimney, because what it do was-- and the hardest part is each chamber have a different pressure, carbon you've got the low pressure, right, and then the RF has high pressure, you know, have up to 50 micron, which milli Torr and so what they do --

Q: They have these narrow slits.

Chen: The slits pass through, and the carrier come in there and after he bend it and bang into it. And after so many weeks of so many days we so struggled with it, really struggled with it, you know, we're supposed to acceptance test for one week, and the second day, the day, the first day we started we're so excited about it it jammed, and they work 'til midnight and all through the whole morning changing the rail, changing things, and the next day they couldn't finish so I take us to see the big Buddha <laughs> near the Tokyo, you know, area, and all that tour, and then after third day we get excited and they start again, it jammed again. Oh everybody's so crying, you know, my team of people which is four people, when we started, completely demoralized, think we are dying <laughs>, they quit their job, to jump me. Oh that's kind of hard, this bunch of guys, you know, really troublesome, and then about Friday, finally I fixed it, right, and yeah, I saw it running okay, I said "Okay, you guys stay here, I got to go to Tokyo to talk about substrate," all right, so on Friday I went to Tokyo, by Thursday, by the next week, Monday, I forgot which day now, almost pass a week, you know. So I went Tokyo negotiate the substrate, you know, to talk, because substrate is very important, as a subject people didn't know.

Q: You were seeing Kobe?

Chen: Kobe and Nippon Light Metal, and then what they do was, and I know it's going to work, so the guy who started sputter two cassettes of 25 disks, right, and made it through, and now they know how to modify it, all right, so we made two disks, two cassettes, 50 disks and take it home <laughs>.

Q: The machine?

Chen: No, no, machine no. So now they say they had to modify the machine, completely modify it, because that's just temporary.

Q: Now they knew what to do.

Chen: Yeah, what to do, robustness, the rail and stuff like that, the temperature. And then at least we've got two cassettes of disks which we have to take to the US to see whether they work or not right, and so --

Q: So we pick up again, you had just finished telling the story of the acceptance test at Ulvac, and you produced the first 50 disks.

Chen: Yes.

Q: And you brought them back with you. They were going to modify the machine now to make it robust, so it wouldn't jam.

Chen: Right

Q: Pick up from there. But interesting enough you also had probably some key meetings with Nippon Light Metals, and Kobe that probably influenced your source of a substrate.

Chen: Right, right. Before I talk about that one, let's finish the part of the substrate (meant to say disk). I brought back from Ulvac, okay? And they promised me, that's the first acceptance test, didn't pass, didn't accept, so I had to do it again. And they promised me that June, and that really hurt me another two months afterward.

Q: So that schedule was hit.

Chen: Yeah, I had a schedule hit of two months, right? And then I took them back, the disks, and they said it was turned out tested 650 Oersteds, beautiful, the recording was beautiful. Jim Shir, you know, for the KFCI (kilo flux changes per inch) we had designed it. You know? It was very much...

Q: Hit the bull's-eye.

Chen: Hit the bull's-eye and performed, noise is better than the plated media. We had a plated media from Ampex as a benchmark. So it's really good, for 20-megabyte drive is perfect like that, all right? And overcoat is done, too, with the carbon.

Q: So the first disks already had the carbon overcoat on them.

Chen: Oh, sure. I miss a part of the thing is carbon overcoat, all right? And we got it done, and but at that time wasn't sure the overcoat can pass, we were just in the middle of designing an overcoat stuff, right? We have, beside this sputtering machine, you know, designed, we have a two-batch system, single side each. And check in sputter both sides, four disks at a time, right? And we got that machine in February of 1984, and we started putting the new building in. We moved in a new building in 1984, so we started, you know, depositing, as the building was delayed too. But anyway, we sputtered it, and then we have a carbon overcoat, everything. Originally I had tried many kinds of overcoats, not just a carbon. I mean, we tried carbon, it doesn't work. Tribology just cannot pass 20,000 times. So we had to struggle with it, we had to go with the, with the development part of it, right? We have two-static machines to do the development. And we had to go with. I had to go with, you know, I tried to do the tungsten sulfide, molybdenum sulfide. It looked very low friction but they wear out so fast.

Q: Very fast.

Chen: No good, all right? And the carbon just the friction was too high. Normally, how we do it. And we tried to do that.

Q: Friction you mean, or stiction?

Chen: Yeah, fric -- yeah, stiction. Yeah, so afterward they started to get stiction, wear out right away. And we put a cryotox, it doesn't work. Really in trouble.

Q: Cryotox is a lubricant.

Chen: Yeah, cryotox is a lubricant, all right? And Monte Edison made that. So by April, we have struggle, you know, but so decided to come out with some solution to this. So I talked to Jim (Jim Shir). I said, "Jim, go ahead to find somebody, something else. Can you find besides the cryotox some polar lube?" And he called Monte Edison, Monte Edison told me they have two, just told to Jim -- Monte Edison.

Q: Monte Edison.

Chen: Monte Edison, all right. Monte Edison, the Italian company who have sales office in New York, and told Jim, I said, "There's a two bottle -- two half-bottles of brand new research, you know, finished the research and they developed two bottles of new lubricant, is a polar, called ZDOL and a ZDAL. And they are designed for...

Q: ZDOL and ZDAL.

Chen: Yeah, ZDOL and ZDAL. And they too try to do this for some other application. So I told Jim to quickly tell them, “Get it! We’re dying, you know, without an overcoat we will never be able to make it.” So we ask them to ship it over, fly it here. So when it fly to California, we diluted it with Freon, right? And then we try to use the conventional spray. You know, those sprayed with a spray bottle, just doesn’t, get too sticky, you know. And even have to freeze it down to keep it cold so it does not evaporate.

Q: So it does not evaporate quickly.

Chen: So we can buff it off. And we try to use a regular thing to wipe it. Just too sticky. So I already almost dying on this, you know. We couldn’t even test it. And so finally that night I went home and I find out my wife have these -- the perfume bottle, which is very fine powder. So I say, “Hey that’s pretty good.” I’m dumping all this perfume into the drain. <laughs> I took that bottle into work the next day, and dumped that in there and it works very...

Q: Atomizer.

Chen: Very, very small atomizer. And it worked. And so we’re exited about it. We quickly ask people design those atomizer head, and I used a paddle with a hand pedal, with an air compressor to do that. And it worked. And that’s our first production actually. And we’re able to pass.

Q: So now with ZDOL on carbon with an atomizer...

Chen: Atomizer applicator, yes, right.

Q: Was the first product.

Chen: First product.

Teacher A: And it passed the 20,000 start stop cycles.

Chen: More than 20,000, yeah.

Q: The requirement was a minimum of 20,000, and this had met that requirement.

Chen: Right. We don't even know how thick it is, actually. We just spray it. And Jim was smart, he come up with the idea, you know, with a stick, with a texwipe, and when he put it on top of the disk, and he could smooth it, it's fine. You hear it like "que, que, que," that meant it was sprayed not good enough. So we had to train all operators to do the same thing, because we...

Q: Squeak test.

Chen: Squeak test. And a drag test developed by Scott, Scott drag test. So the first production, we use all these lubes, you know, like ZDOL. We find out ZDOL is way better than ZDAL. So we use that and the drag test, and operator spray buff, and...

Q: And the squeak test, telling you had good coverage, the right amount.

Chen: Right, it's got...

Q: Coming back to the first 50 disks that you brought back from Ulvac, did they already have the carbon from the Ulvac machine?

Chen: Yes, yes.

Q: Or you added the carbon in the batch machine?

Chen: No Ulvac had a carbon machine.

Chen: We run the test on it

Q: So you made the magnetic...

Chen: We had to make the magnetic layer --

Q: You just had to lube it.

Chen: Right, we had to lube it, yeah. And at that time we had just started finishing up so we can lube it, and Tribology testing...

Q: And you already put the ZDOL on those.

Chen: Yes, at that time, yeah. I think about the same time. So we are so excited about, it worked. And but the thing was, the trouble was -- the thing was we were not able to get that machine on time, right? So they take two months -- they delayed two months to second acceptance test. And after they modify it, the second acceptance test, they deliver to us, and one thing wrong with us, it's August by that time...

Q: Oh, before you go there. Did the second acceptance test go well?

Chen: Yes, go well.

Q: Even though it was late, the changes they made --

Chen: Right, yeah. Can meet all of our requirements, of temperature, and power and stuff like that. Remember, at that time the thickness was very thick.

Q: Right.

Chen: And you had to pump so much power to get the right. In line is kind of passing through, so it had to be four-minute cycles, you know, it cannot be too fast, you know. We had 1,000 angstroms thick, you know. So you got so much power, there's so much hot, in the heat, just by virtue of the heat. And we had to modify the machine, to make a slit, you know, wider and longer, so we can reduce the cross talk. Cross talk, yeah. Well, it come back to that, your substrate. Okay, that's one issue, was sputtering. The second one is the substrate.

Q: Before you go away from the sputtering, you were concerned the machine was late, because of the modifications. But you got it, and you started using it, right?

Chen: Okay, let's finish the sputter. It might be that later on. Maybe talk about substrate, but come back again, you know. What happened is after I got that second qualification test and it worked, asked them to ship it, and usually it take a couple of months, package together, and ship it. And they didn't ship it right. Somehow they screwed up. Because they wanted to meet the schedule they shipped all the way to Los Angeles. So once we got informed, they told us to get to southern -- I said, "What? That far away?" Had to go through the mountains, and that thing is so heavy. And so we are so worried about it, and we said, "Wow, had to carry it all the way from Los Angeles." And that is a heavy, heavy machine. And we had to even modify it, because I heard that after they loaded it into the truck, it was so low, we had to modify our driveway, okay, no bump up. And we have to get somebody going down there to be sure that it arrived all right, okay? But anyway, we're lucky it was turned out okay, get to the Komag in August, middle of August or something like that. So everybody, including Steve Johnson, the president, everybody take off their shirts and start working on the machine. Uncrating -- carrying it into to the by area, and then start assemble it, and take it to assemble it to the end of September. All right? And the first trial sometime in the middle of September. Take a month to assemble it and stuff like that. And then assemble it, and start to fire up, and first part of October, disks come out, beautifully, all right?

Q: Good.

Chen: Yeah. And as a matter I took some disks to Japan to second fundraising-- we already used up all the money, and to demonstrate, and Hitachi, so interesting, because we couldn't find the money here. Steve Johnson couldn't find enough money, second run. Because at that time the US finances real down. So I had to go to Japan. Because some Japanese called me up, they were interested in a license. And I said, "No, no, no license, but let's talk." So I bring disks to Japan, and I raised money. And as a matter of fact, during the talk, the Hitachi manager was interested to work with us. And then she stopped to check the disk. Takes the disk, and they borrow the disk, and they say they want to invest, how many million, I forgot. They want-- we needed $4 million, they only committed half of that, and stuff like that. We needed $4 million. $2 million from US, and original venture fund, and $2 million from Japan. But then they said they will take the $2 million but they didn't want other Japanese to join. And that's what they said, but they wanted us to give them the disk for testing out, to verify it works. Apparently, they took it, and I don't know what they did, but they gave it back to us, before I come back home. But couple, two/three year later on, I find they have a patent describing the alloy, and the stuff exactly.

Q: Exactly what you had.

Chen: What we used. <laughs> Kind of interesting, just a side story. But anyway, we had that done, and by December...

Q: Now you did get the funding. How did you come up with the extra $4 million?

Chen: Oh, that, too. Actually it was more than $4million. I got the original US venture $2 million, and the rest of it I -- Japan, $2 some million. And then Max Palewski put extra money in or some movie star, you know, I heard Jack -- the Barbara Streisand and Jack Lemmon, he's managing all the movie stars' money, you know.

Q: Oh, I see, so he invested. Hollywood funding.

Chen: Money from him. But anyway, the machine started to work pretty good, right? But before machine worked-- I gotta back off again. Before the major machine start to run, we had to use a batch system, cranking a single disk at a time. Because I promised venture that we got to deliver the disc by July 1st, all right? Prototype. That's why I bought us two prototyping machines, single side each, and we were so excited by June we got prototypes that can produce that beautifully, and have two people rotated 24 hours, you know, kept going down. And one side at a time, sometimes I take myself and go in there and rotated it too, but we could produce 50 disks to be shipped by July 1st. So, of course, the yield was very poor, causing the defects and stuff like that. You had to select 50 good disks. And that was done between June and part of May into June, and get collect together nice 50 disks. Just before the July 1st, before ship, that day before, and our engineer and manager, Steve Miura, he tested, "Oh, defects are so high!" He wasn't too sure. "What's wrong?" Right? "Wasn't there before. Well, I looked at a microscope, we take a look, turned out they all bubbled up."

Q: No, it had an adhesion problem.

Chen: Yeah, so the cleaning wasn't right, right? So I had to go back-- we told customer, we gave to July 15th. So we worked so hard, and 24 hours shifts, and we figured out how to do it by etching the surface a bit, and it worked. I cleaned it up and etch a little bit. And then adhesion is no problem. So we shipped the disks, too, to Maxtor and Vertex. And they get so excited! They said, "God, this is really, really great! When you gonna deliver? Tribology great! Everything, corrosion great, everything." All right? Here we are supposed to deliver the main machine, product in August, right? We were delayed two months, we're going to be October. So that's why in October we gotta ship this out to the customer, otherwise we miss the window. But we are so lucky, because everybody else was so smart, they were gonna use the cobalt chrome on chrome, right? Or cobalt on chrome, right? I don't know what they used. All right? Cobalt and some alloy.

Q: They wanted to go the epitaxial route, You didn't want to go there.

Chen: Epitaxial route. And they don't have any prior experience at all, right? And hardly even Neil Heiman who did the IBM work but with not as much experience as me, all right? So what I did is say, "Okay, take this route, turn out this will be easy, much easier. I mean, they're difficult, but at least I can ship. So customer so excited to want to get it. Now we have trouble to produce it. So by October, we quickly produced some, ship it out, and they really like it. So by November, just before the Christmas -- we're still debugging. It's not trivial, you know what I'm saying? By November, by Thanksgiving, the week before, the day before Thanksgiving we produced 2,000 disks on one shift. You know, 2,000 disks. That's a pretty good record at that time. Originally it was supposed to be 1,000 disks. But it became 2,000 disks, right? We sent 2,000 disks, until-- well, we didn't stop. It was done in so great-- I was there helping loading the disks, and it's past midnight, 1:00/2:00, Jim Shir from outside start to scream, "Tu Chen there's water on the floor!" Because it was cold and we couldn't see it, all right? So we're loading the disks, and we kept collecting, and Scott Chen was testing the disks. Our target was 1,000 but it was running so smooth, we kept running until 2,000, keep going, until the flood, and then I found out that one of the cathodes burned down. That melted. That water cooling system caused melting. So the next day, Thanksgiving day. Ulvac people still there at the time, so I bring them over, and then fix the whole damn thing. We silver soldered it, just silver solder made it work. But that's the kind of thing we go...

Q: That's the kind of battle you go in that kind of war, right?

Chen: Right. And then started to ramp it up, all right? You know, because there's so much pulling. And they...

Q: Customer...

Chen: Customer, yeah.

Q: Eager to buy these days.

Chen: Right, and so we just kept producing 24-hour shifts. But then Johnson come into me, he said, "Tu Chen, we got an operational guy, VP of operations, complained that we research people, still stayed down there," say, "Oh, Tu Chen," Steve said, "You should pass it to production people." I said, "Steve, this has not been debugged in any process." Said, "Yeah, but the disk is working, put people on it". I said, "Okay, screw it, you can have it." So I went to take my vacation. I decided to take vacation. I didn't want to hear it. Two weeks.

Q: End of the year vacation.

Chen: Yeah, yeah. So sometimes the early December, I take vacation, and when I come back and machine completely stop. I said "What happened?" Oh, they said "Jim cannot make a product..." I said "What happened?" So I talked to Scott. Scott said, "Well, overwrite gets worse, whatever it was, amplitude is dropping." I said, "How can it be? I gave you, passed you guys a very nice machine." So I say, "Okay." Steve has come to me for help. I said, "No, I don't help. No, you took it and you better run it Right? And you don't know how to fix it. Get somebody." He said, "Well, Tu Chen, you designed it, you have to fix it." I said, "No, I'm not gonna do it." Until Scott Chen came to my office and said, "Tu Chen, if you don't do something, we're dead. Dead in the water." So I said, "All right. So I went down there, take a look, and...

Q: Back into the factory.

Chen: Back to factory. I look at the machine. I started -- I told Tom Yamashita, who is VP of Engineering, now at Komag, he's my best student, and I said, "you stay outside. I go inside." I know what's happening. Right? Gotta be perpendicular to do that. Because every time the amplitude, all right, going down, the loop just collapses, right? So when I had to do the sequential of series of power, and send this outside, and the analysis for squeeze, and VSM (vibrating sample magnetometer), and X-ray, all right? So I always say, "all this is perpendicular." Walked around and I went to the core room. I find out there's a box sitting there, an RGA (residual gas analyzer). What's this for?" I asked a guy, "What's this for?" He said, "Well, the guy told me, "Tu Chen, you are completely screwed up," you know, the operations manager, "This machine's so leaky, you know. So we got an RGA last week, and we just started.

Q: They were looking for leaks.

Chen: Yeah, we're looking for leaks. We shut off all the leaks. I said "Oh, God, great!" <laughs> I know what's happened. So I said, "Give me a hack saw," so I went ahead, there is an extra pipe for flow, right? Flow pipe for mix to target. So I say, "Okay, give me a hacksaw," I cut it off. Connected that to the target supply. And then I cracked it open. You know, half a ccm (cubic centimeter per minute), one ccm. So anyhow, I open her up, and the squareness became very good, and amplitude overwrite became good. So right away, that night I told Jim -- I mean, told Yamashita, I said, "Quickly, give me some experiment." We got nitrogen bottles. So, "Mix it and put into sputtering what we should get." So I told the facilities guy to go buy the one percent/two percent -- I forgot -- five percent nitrogen argon. And we tried the next day, and it worked! And then I discovered, the nitrogen actually become much better on squareness and the noise. That's where we have discovered. Yeah, because the nitrogen, it turned out...

Q: The pipe that you had hacksaw. What was it supplying? It was...

Chen: Oh, no, that's extra spare pipe for argon.

Q: Argon, yeah.

Chen: Argon flow to the target, right? Flow meter. There's a flow meter, extra flow meter they designed into it, that we're not using. So I cut it up and do it.

Q: Okay, you changed how the argon was being delivered to the target.

Chen: Yes, yes, yes. I just...

Q: And that fixed the problem.

Chen: Yeah, it get rid of the -- it bringing the nitrogen, all right? You got to have nitrogen. Origin have a leak, was to not have nitrogen.

Q: Okay, so you thought the leak was good, and the obvious thing coming in is mostly nitrogen, right?

Chen: Right, right.

Q: When they fixed it, they starved the machine of nitrogen, so you now had to backfill it with a little bit of nitrogen.

Chen: Right. And then also from that we discovered much better in terms of performance, too. And then also now we can control the nitrogen by giving it a different concentration on the product-- and so because it influenced next year's, the next year product, you know, you have 800 Oe and 900 Oe, we gotta buy a higher target, you know, eight percent platinum. First was cobalt, ten percent, nickel, phosphorous nickel, and six percent platinum. We had a minimum target. And next year we say we buy the eight percent. So we got room. And we can adjust with the nitrogen. We can change the different nitrogen flow to tune the different products. So the same machine, same sputtering time, we can give the customer different products.

Q: Very interesting.

Chen: Yeah.

Q: So go back to the substrate.

Chen: All right.

Q: Because all of this without a substrate, also, would've fallen flat on its face.

Chen: So I told you the original story about the difficulty of the sputtering machine. Of course, there are some more different -- next year we got a problem, we got another water issue, and we figured it out. But that's a long story. When I have time, I probably write it out, but we're doing a lot. During the whole thing, done a lot. So I told you earlier that most difficult part was the sputtering machine. By then, I feel comfortable we know how to do the sputtering, right? We got shipped product. But let me finish this next section, it's very important. So we know we need nitrogen and stuff like that, okay? But later on, the next year, in the February, we ran a lot of production, continued to do it, and we hire...

Q: You're in production.

Chen: We're in production, but the machine kept jamming, kept jamming. In January it keep jamming. So I have the Ulvac president come in, I show him all the gears wear out. So he went back there and to tell people, "Put a whole new gear together with a titanium coat, all right?" Because it's so rugged. And he found out what's the problem with the jamming. You know, sometimes we got 24-hour people sitting there when there is a jam, have to yank...

Q: Yank the...

Chen: Loosen a gear, and go do it again. So otherwise they would have to open the chamber, all right? And it was a struggle. But he decided, he said, "because the design, of original is wrong, it's a DC -- AC motor cannot gradually move, right? So he had to change to a DC motor. He had to cut the whole thing -- section off – turn -- put a DC motor into it, put a new chain into it. And of course, later on they didn't put a clutch, you had to put a clutch on. So that's what the design. So February 14, or something, 15. When the team from Japan, when they brought over all these parts coming in, and they wanted to install it. Well, that day it jammed again. So I told my management, and they said, "Okay, let them have the machine, all right?" They only on the production floor three or four days. So John said, "Okay, take a machine and run it." And then I told a guy, you don't have to clean the panel. We use it two weeks. Only got a three day or four day use. So put in the clean room, and just leave it there. And it take them one or two weeks, I think, over a week to make all the changes. And that time, when my son just got sick, and so I went to -- got a stroke in Oregon, so went down there. And after that I came back, and they started up again, and still had a jam, but of course, that was supposing you had to buy the local store, buy the clutch and stuff like that. But once you figured that out, and then try to start up again, you could never get the coercivity.

Q: Again, you lost the recipe.

Chen: Completely lost the recipe. And I don't understand. I say, "What they did, do it, all right?" And take me, the Board was so, we had monthly Board meetings, so the Board was desperate and asked me. I said, "Give me six weeks, we're gonna fix it," because I know there is no more money left. And we're burning $800,000 per month. So I said "Give me six weeks. I will work so hard, right?" And two weeks/three weeks. You know, the Ampex guy, come to talk to me. They heard, "Are we having trouble?" And try to poke around, what trouble. Buy me a dinner and talk. And then Steve Johnson lost all confidence. Told me this, "Hey, other guys making the disk. Why don't you buy the CPA?" So it forced me to go CPA. I looked at the CPA and there's something else. I gotta fix this machine, I gotta find out why. Turned out it's very simple. The panel which left in the room stay for too long.

Q: Absorbs moisture.

Chen: Absorbs moisture. We never had that problem when they're new. Which tells you, that when you sputter the disk there is lots of porosity, right? And…

Q: A used panel would have porosity and absorb much more water than a new panel.

Chen: A lot of water, yes. So I told the guys, "Sand blast it", after three/four week study, and they discovered all these funny things, then sand blasting worked. And then we started back to production. After that, we learned a lot.

Q: And then you knew exactly how to handle the panels.

Chen: That, and we're also learned a lot about nitrogen. We actually filed a patent for the nitrogen for that. And we know that nitrogen can affect the carbon too. I mean the carbon overcoat, too. And we know hydrogen affect the carbon. We call it yellow carbon, gray carbon because of that. You know, because of the water decomposition. And it's part of a lot of trade secrets, part of the patent that we have filed. But I mean, this tells you a story, too, that sputtering is the most critical part of the whole thing. And it was the toughest struggle for us. And we are able to focus on go to production first, and how to control it. And that's why and we were able to be successful. And during that time we learned a lot, right? And we were also fast enough to go to market and maintain our leadership. Now, other guys started with a double-layer structure, and I think that they have a problem because they didn't know the orienting effect of the texture and of the vacuum and all that stuff. So we are way into production, right? And they have not even been produced. Even though they started about a year ahead of me. So I try to tell you, the startup of the business has got to be focused. And don't try to change too much from the existing technology.

Q: Smallest number of variables to solve, and only solve those variables. Try to use what's available, use it, don't try to reinvent it.

Chen: Now we talk about substrate.

Q: Right.

Chen: Why I bring this up is because substrate's very important. One thing when I was in Xerox, I was working with Alcoa, all right? Because I know, you know, aluminum have these different grade alloy, right? You don't want to have too pure, pure is too soft. So you have to add something there. But every time you do aluminum when I was working in ADL, advanced SDS people, when you etch too much, you get too much pit, right?

Q: Right.

Chen: Impurity.

Q: Because it's etching the…

Chen: Now he got too pure, because of impurity there etched out. You get too pure and it gets too soft, right? So I thought this gotta be soft. So when I would try to start up, Alcoa seen the trouble in the early 1980s. So they're not interested in it. So I started looking at it and said, "Where is a place that we can do aluminum willingly." So I heard it was Japan, Kobe and Nippon Light Metals was interested. And they heard, "We are working on it, on a disk." And one of their sales persons, in the US, came to talk to us, Roy Shimamura, came to, want to talk to us, they want to talk to us about this stuff, right? So I say, "Okay, I'm going to Japan to acceptance test, so I want to know what you have." (meant to say that he had to go to Japan for a sputter system design session with Ulvac) So I went to talk to them, and they be cruel to me first, you know. Put me in the basically in startup. Typically a Japanese company won't talk to the startup anyway. And fortunately, I was able to convince them on a Friday, you know, I told you the day we were there. And the guy told me, "You got a fine idea." The salesman in Japan was also engineer. He know what I know, what needed for. So he tell me to stay extra day, so I stay extra day and they send engineer come to me, the next day in Tokyo, and we talk about it. And they're so excited, and so end up we work together.

Q: And this is Kobe.

Chen: Kobe, yeah. They only become investors to Komag, too. You know, it's very interesting.

Q: Now Nippon Light Metals was not interested?

Chen: No, Nippon Light Metals is interested, too. So actually Nippon Light Metals take my idea. I said, "You put some zinc, put more zinc, but enough, not before precipitation occurs. And that will help you with zincating, all right? But not too much copper. You have a limit to that. The so-called Guinier Preston Zones-type hardness. You can improve hardness, but don't push way out. And they did work, right? As a matter of fact, Nippon Light Metal, filed patent, on this and that <laughs>.

Q: They followed the advice you gave them. But that's the main point.

Chen: But that's one thing that is very important, that once I get in there, I was insured that I get a substrate. And Kobe is a much better company than Nippon Light Metal. Because Nippon Light Metal, partly owned by Canada, Alcan, something like that. It's very difficult, it's bureaucratic. So finally I decided to work with Kobe. And Kobe became Komag Investor. They are really good company, to tell you the truth.

Q: Even to this day, right? Kobe and Komag are still maintaining a partnership.

Chen: I don't know, to tell you.

Q: They do.

Chen: They do? Oh, really? And they're a very good company. I tell you. That one I can admire them. Because they are very good partnership. Actually Komag is not a good partner by itself. Somehow, I don't want to mention names. Our people really betrayed some of the agreements, we say we'll work with them, and we'll buy so much substrate from them, but we wanted to reduce the cost, so we kind of short cut them, "I didn't like that." And they misunderstood, it's me, because I don't. I'm the guy that was the owner.

Q: But in spite of that, in the end I think it turned out to be now a 25-year partnership.

Chen: Oh great. 25.

Q: And still going strong. Here we are, 2005, right?

Chen: Well, that's very good. Now what is important for the substrate. First thing, you have to have no pit. You know, you remember that the Ampex disk, they got a tons of pits. So they had to plate the nickel, because it's very thick, all right? So the cost is very, very high. So I had them reduce the cost by reducing the thinness. So it's got hardness, sufficient thickness, that's all we want. That's where the key, the substrate, all right? The second thing there, you had to polish yourself, because without polishing it, you don't know how to get a surface done. All right? And I was lucky. I was trying to focus on plated media equivalent. All right? So I can use a polished disk without even texturing it. As you know the polishing of a disk can damage the surface, called random scratch, all right? And the guy, the epitaxy guys, did not know abut it, like Lin Data and Tri Media, they started with those. Tri Media maybe knew, but they couldn't buy a texturing machine at that time, there were no texture machines. No concentric texture. Lin Data, I know, later on, they published a paper, the polished disk after (before?) they sputtered the double layer, epitaxy, they have a modulation because of polishing lines, finishing, the last, the last polishing line direction affected the coercivity.

Q: Orientation of magnetics.

Chen: Right, right, and so it become modulation. And they all struggled with it. <laughs>

Q: So you got a partner that saved your bacon on substrates. You went through the war of getting a sputtering machine up and running, on the run. And I think that's how Komag started. I think in 1985 was its first significant shipments, right?

Chen: Yeah, we ship -- after we solve the problem of, jamming problem, we're able to ship five million disks. $5 million worth of the disk.

Q: It was close to 200,000.

Chen: 200,000 disks, yeah. And we shipped that.

Q: In 1985.

Chen: 1985, yeah.

Q: And the following year you probably shipped close to a million disks.

Chen: Right.

Q: Worth almost $25 million.

Chen: $20 million, $22 million. And so we finally make some profitable. So the first quarter of 1987 went public, IPO, yeah.

Q: I think you were the first independent media player...

Chen: Media player to go to IPO, public, yeah.

Q: Congratulations.

Chen: Thank you.

Q: And the rest is history. Komag is still alive and doing well. Although it did go through further.

Chen: Yeah, <inaudible>.

Q: With your help, we've created a list of 15 startups for plated media, of which only one or two have shipped.

Chen: No, not my help. Everybody wanted to do it. <laughs>

Q: And there were 15 startups for sputtered media. And today, there're only three or four that survived. Komag being one of them, right?

Chen: Komag's the only one in the US.

Q: The companies are down to a handful, or less than a less than a handful. Namely, Komag, Showa Denko, Fuji. Those are the...

Chen: Right, and Captives.

Q: And the captive ones. But basically of 30 startups, independents, we're down to three.

Chen: Right.

Q: And Komag's one of them, and it's one of the largest of the remaining three. So it's-- you left a wonderful heritage. Now tell me a little bit about Komag later on as it grew, it expanded overseas, right? How did that happen, and when did that happen?

Chen: Well, originally, when we begin the 5 ¼, I the 3 ½, we sell at $20 per disk, right? And we at that time when this is business so good in the 1988-1989, our year was not that great, productivity was not great. But you know, the costs. That's why the labor costs. Originally we can afford it, originally we can sell $20 each, for 5 ¼, $20-some dollars. And one day the operations guy figured out that labor cost is $3 of the $20, which is kind of -- it's okay at that time. At least you had a gross margin. We still had gross margin of 40 to 50 percent at that time, you recall that. So what happened is the -- you know why the gross margin is so high for Komag. We had the machine, I told you before, can produce. And we went and speed it up. All right, and we can change it to any product we want by dialing. So our productivity is really high in that sense. But the trouble is, the yield was not as good. And so they want to go to offshore to reduce the 3 dollars.

Q: Three-dollar labor costs.

Chen: Labor Costs. So I look at it and I say, "Gee, that's no good." I can't stand it-- let's go to make high-yield first. Then we can go offshore if we have to. All right? So we put a target in 1988 to 1990. We put a target in, as Kobe is a co investor to Komag, very nicely send people. And Asahi send some people, from Asahi, to help Komag's Corporate Operational Committee, to help Komag improve their yield and productivity. And I say go to 85 percent yield. Then we can go. And so what I did was set the target for company and then we hit the 85 percent. I say 80 percent or more, all right? And they would hit 85 percent, went to Penang. Well, the reason went to Penang, is you look at the future and it's very good because their labor cost is one-tenth of US, or one-sixth or one-seventh, yeah. So we did that. And it turned out that's a very good strategy. So in a certain way, okay, because Will Kaufman (COO of Komag), who is from Intel, have the same strategy. So he see this, and so that's why...

Q: He helped make it happen.

Chen: Make it happen, but he made a mistake without increasing yield before he go, right? So I was insisting that you gotta get yield before you go, because that's where the learning curve have to be done, here.

Q: And that was a very good move, because they, 100 percent of Komag's manufacturing...

Chen: It's all in Penang.

Q: It's in Penang, and it really makes Komag a very cost-effective producer.

Chen: Right, right.

Q: Later on, the early battles you had just to make Komag successful technologically, were not the only battles, right? Later on in the '90s I think you drove the transition from-- or helped drive the transition from isotropic to oriented media. Can you tell us a little bit about it?

Chen: Oh, as I said, because isotropic, everybody blamed me for that. Because what happened, the people didn't know, and I didn't start with the oriented media. And for years, I was suffering from that because according to, everybody knows that off-track is getting poorer, particularly if you look carefully the paper published by Gordon Hughes and Dan (Dan Bloomberg of PARC ADL), then, you know, in the 1970s. It already told you that off-track is a problem, right? But we get away with it because the gap gets smaller and smaller, it's less sensitive. But by the time when the tpi (tracks per inch) get higher...

Q: The track density...

Chen: The track density, and so that when 1996, right, and not because I'm stubborn, but we have so much involved in it. So many things grow so fast. We don't even have enough capacity, right. And we did invest in some oriented media machine, like...

Q: You bought a static machine.

Chen: Static machine by Intevac. We got one, and we tried it, and so far, I mean, we found out there's an advantage of oriented media, but having not to the point that it had to be changed. Not until 1996 we started noticing it's tough to compete against off-track. And then by 1996 when you, you know, Chris, joined me, I said, "We gotta get this working." And Chris, you are really helpful. I mean, you are real nice. You trusted me and then try to help me to convert that thing. So we're able to convert. And the AKCL, which is a Komag joint venture in Japan, also they have, under the Japanese customer, so much pressure.

Q: Pressure to go to...

Chen: Particularly MKE (Matsushita Kotobuki), right? So they bought the Anelva machine, right. And we buy this Intevac. So we compare the data. And both machines work a better way for either way. But here we got these-- Komag have these multi-million dollars sputtering machines sitting all over place, right? And Komag had went ahead with Plan A to expansion, you know, in Penang, every place, and buy all these in line machines. So you know, maybe, I'm responsible for that, too. But I told him to not expand that fast. Because I know that they're changing the technology. But I saw if I don't do something, you're gonna die. So finally, I pulled a team together, take the in line machine and make it into oriented media, and it worked. Of course, vacuum had to be much better, water, had to get rid of it. And in the meantime, Ulvac, I mean the AKCL people worked so hard to -- that's a multimillion machine, you had to make it work. So we were able to convert it to multi -- I mean, to oriented media. So isotropic media was, enough, we were able, up to 2 gigabytes, I think.

Q: 2 gigabytes per platter.

Chen: Per platter, or 2 gigabits per square inch. And that's the end of it. And but fortunately, we were able to convert that to oriented media for in line, and after that, we also buy this static...

Q: For extra capacity we bought static machines from Anelva.

Chen: Static machines from Anelva, yeah.

Q: Wonderful. Now tell me, after that you were able to retire, right?

Chen: Oh yeah.

Q: When did you retire from Komag?

Chen: 1999.

Q: And what have you been doing since then?

Chen: I've been -- I wasn't -- I tried to retire, but my Buard was so mad about me retiring, you know. But I told them (Komag's Board of Directors) that I had done my job, and to find a good guy like Chris to help with the technology side. And I was not able to do too much after that. But what's more important is, what I want to do is be -- while I'm still capable, I like to teach people in Taiwan, because I would like to pay back to Taiwan. So after I retired, I have people from Taiwan, they asked me to help. Or startup many new technologies, and I become a Board member of ITRI, Industrial Technological Research Institute, which is funded by government, yeah, in Taiwan. And I'm a Board member there, and advisor there. And I am teaching young people the same kind of thought, you know, all the original Xerox kind of concepts, DARPA concepts, how to make...

Q: Stretch goals.

Chen: Very, very nice goal. You have to have a certain clear goal, right. And but the most important is what you need. What does society need? Very seriously. I teach people.

Q: Try to solve a real problem.

Chen: Research people have to start with this, just like a venture capitalist. First you have to have a need, right? You know that society need what? Then once you know the need, you say, "How do I do it meet the need?" Then you start thinking out your research. And that's the kind of concept that I'm teaching people. And then focus on that. And that's what I'm doing now.

Q: Sounds like it keeps you quite active. If you look back now at this rich and wonderful career of yours, are there any periods that are the most exciting periods that stand out? Or has it been a roller coaster all along?

Chen: Well…

Q: Roller coaster experience all along.

Chen: No., an exciting period is, it's an up and down, but the exciting period is every time I break through something, I'm really excited. It can be just one-day, two-day. Every now and then I can remember the sputtering machine breakthrough, and the lubrication work, all right? And every time we achieved a milestone, and IPO is exciting time. Because now we have more money to put into it. And that's actually the period of which I'm excited the most the beginning of it. And toward later on after IPO, after stock went up, I started to get a headache, because I have to talk about customer, and some customer really want-- I don't want to name the name, but customer is terrible, because they won't buy from you under one condition, teach them how to make it, become your competitor. How many time, I not a very nice guy about that. Many times I told them, "You want my technology, buy me, buy the whole company." They say, "You're too expensive." I say, "That's too bad." I told them, "I'm a virgin. You want to sleep with me, you got to marry me." All right? So I told them like that. They are so mad. Their president is so mad.

Q: So that period wasn't as good as the period at the beginning.

Chen: Yeah, the beginning is the most exciting.

Q: You were building the company.

Chen: Yeah, build the company, bring your concept into the industry, I'm excited about. Now you ask me why I retired? I don't feel that kind of things in building under Komag, which I don't want it. Right? So that's what I'm doing in Taiwan, I'm excited.

Q: It takes you back to creating.

Chen: Creating things. Yeah, I work with young people, and that stuff.

Q: If you look back, is there anything that you'd do differently in your career? Or you'd leave it the way it is?

Chen: I think my life is almost by default. Everything by default. You know what I mean. My schooling, my subject that I pick. Of course, I fall in there, and I like it. Anything I go do I do like it. I do 100 percent of my effort. And that's me. And so by default means that destiny tells you to guide that. So you cannot change it. So what I want to do is now I love it, the research, and care about people. I'm a very nasty guy, but I'm care about people. All right? I like to work with the people. I hate the people who is greedy, selfish, and so you ask me what I would do different, I probably wouldn't do anything. I would do the same thing over again, you know, if destiny take me down there.

Q: And last, but not least. What advice would you give young engineers and scientists today? You know, as they launch their careers?

Chen: Okay, the first thing I would say this, as I said earlier, if you want to be a researcher, right? If you want to be a market guy like my son, that's his business. If what really you want to be is a good researcher, first of all you always look at, first of all society need. What you do this for? Not just for fun, right? I mean, engineer. Now if you are a pure scientist it is something else. If you want to be like Einstein or like Newton, they're looking for that new phenomenon, how to explain it, right? But if a good engineer, or if a scientist wants to be an engineer, who should look at that and say, "What do I do this, for what?" Or like if I'm in Taiwan now, you know what I'm focusing now? In the energy, energy issue, energy conversion, which can be solar cell. That's a very, very needed for the society. We live on the energy now. And so you got to know what the society need. And once you know what society need, you start what that can make it happen? Once you decide that then you focus on it. I don't say it's difficult, or very sexy. Remember back in the 1970s. Why I pick simply media, I think through it first. I thought it was, why I pick up thin film media, and didn't go to bubbles. I think got too many people. There's too-- you know, IBM had thousands of people working it. I only got two or three people working this. I cannot afford to compete in that. That's one thing. The second thing, I look through first and I based materials science thinking there. I didn't try to grow that single crystal gadolinium iron garnet, it's tough to get it perfect. Your bubble has to move. That's the one thing I decided. I said, "That's not a very good idea. You have to move the speed." And so finally I say I go back to look at the disk. I say, "Well, if the disk can be done, that's enough thin, the higher coercivity, maybe I can beat that kind of density. Have a very clear target of the low-cost memory. Remember the LCDM? $2,000 disk drive to build a $10,000 computer. That's where the need. That's what you do.

Q: So the target for your students in Taiwan, for the engineers is what, a ten-cent battery?

Chen: Well, a storage battery, yeah. The capacity of Double AA, but not just a battery, but energy conversion. Like when people use the silicon, silicon is very expensive. So how do you overcome that?

Q: Terrific. Well, Tu, it's so nice to see you still so energetic and so excited about solving -- or at least advising now.

Chen: Yeah, advising.

Q: How to solve these problems. This is terrific. Anything you want to add? I think we've captured.

Chen: Yeah, most of it.

Q: How you got going in this, and your pioneering work. Anything else you'd like to add before we end the interview?

Chen: Well, I'd like to add one thing, though, because people kept saying Komag made mistake by using isotropic media and had to convert. I say that's their mistake. In a life, you have to go start at the time when you start it. The complimentary technology's there that's most important. If you don't have the complimentary technology, forget about it. And I was smart enough to figure out whether the complimentary technology is there at a time when you need it. Then once you get there, and the other guys struggle with other things, then they will eventually will learn, you know, like a vacuum system gets more drier and all that stuff, right? So that will tell you, don't jump into an area -- the younger people, I try to tell people, don't go too sexy a concept. Go through that concept which can be doable at the time when you start it? All right? And that could be now, or could be ten years from now, the product. At least you can see something that has to be done before there. Particularly, you got a venture capitalist now. You have to come out with a product which is done in three to five years, otherwise you'll die. All right? And that's where the thing that people didn't realize how important is that. Money is the king. Like Craig Barret from Intel said, "Time to cash is not a time to market. Time to cash is time to survival," you know? <laughs> So that's my attitude.

Q: That's especially true for any technology or product that's technology, any product, to start a company. You got to get to market very, very quickly, and you got to prioritize.

Chen: Right. And one more thing I'd like to thank the Xerox people that don't do that. Xerox had this vision, all right? They're going to make a $10,000 disk (computer), that's why you created this computer, and then have this talk to each other. That's why you got the Ethernet, right? And then you got to have this Windows that's easy to use, and every dumb guy can use that. That's why Windows is involved there, and you can talk to machine, that's why you've got Adobe and stuff like that. And those companies finally making the Silicon Valley computer technology become real. Without this effort or this kind of vision, you never done it.

Q: It's amazing.

Chen: Amazing, yeah.

Q: How many of the Silicon Valley successes link back into Xerox PARC.

Chen: Absolutely. And who is a hero, "that is George Pake , I tell you". Even himself didn't come out with this idea, but he had the right kind of people like Bob Taylor and all that stuff. And whole team together. And that's amazing, yeah.

Q: That's fascinating. One other example, right, of the influence they had. Because they credit them with having a major influence on other magnetic recording fields over time. Thank you very much.

Chen: You're welcome.

END OF INTERVIEW

