"Transcription: Bill Roesch Interview

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	Audio File "Roesch Interview 1 of 4", 58 Minutes 33 seconds
0:00 Demonstration of materials	BR: … demonstration stuff here. The unique thing about TriQuint compared to other semiconductor companies is the materials that we use in our semiconductor. And just as a touchy feely demo, I have two wafers here. You can hold them in your hands. One is a silicon wafer and one is a gallium arsenide wafer. You can notice there's a difference in weight. MA: Definitely a difference in weight. BR: So it feels like one is thicker than the other but they're both the exact same thickness. [Chuckles] MA: Yeah because this feels thinner than the – BR: Yeah, but it's not. MA: Huh. BR: So the heavy one is gallium arsenide and the then the light one is silicon. So silicon is what everybody else uses, like Intel and other companies that build semiconductors but we use a compound

	that's gallium arsenic. Gallium's an interesting metal because if you could hold this in your hand it would actually melt. MA: Oh!
Explanation of the name TriQuint	BR: So it melts at body temperature, about 35C it melts and so on the periodic table gallium is in the third column and arsenic's in the fifth column and so TriQuint's name came from those columns; Tri and Quint and so that means gallium arsenide to us as being the three-five compound, that's what they call it, three-five. So that's where our name comes from and that's what we were building and we continue to build; three-five compounds and other- we use a lot of other materials, you know, from this area of the periodic table. So all the ones that are not shaded here are materials we use in our company to make semiconductors. So you might wonder why do we use gallium and arsenic instead of silicon like everybody else. MA: Right
Difference between gallium arsenide and silicon	BR: And the reason is is because a compound semiconductor like gallium arsenide, the electrons move faster. Actually in gallium arsenide they move about five times faster than silicon. So for certain applications it's much better performance, right? So most of those applications are things that we call analog or RF. So things that you would call wireless are things that work really well in our material compared to silicon. So we have that advantage that we can make those kinds of things easier than the silicon folks can. The way they compensate and the way they build more circuitry is by shrinking, right? So they shrink, you know they're on a cadence of shrinking you know,

	like, 30 percent every two years. So everything gets smaller and smaller and smaller. For us we don't do that. We're the same size as we were 25 years ago [smiles] because our material's already fast enough that it's still better than even really small silicon stuff. So that's kind of the difference between us. But we can't make, like, microprocessors or memories or things that require a whole lot of transistors. We make things that just use a few transistors. Mostly, again, analog stuff like amplifiers. So when your phone makes a call and you connect to a base station, that's through a TriQuint part. So the parts that actually transmit through the air are the parts that we build. We don't build, like I said, we don't build microprocessors or displays or memories or any of those other things that's in your phone. But just the part that sends and in some cases we also have the part that receives or the part that will actually talk to a wireless LAN instead of to the base station. So if you're surfing the web in a Starbucks, that would also be through a TriQuint part.
Fabrication process	So that's the material we start with and so they would, they would take gallium and arsenic and put it together and melt it under really high pressure in a big pot and then they take a- I actually have a picture- [looking through papers] they would a take a seed crystal and dunk it down into that pot of molten material and then pull it out and they… this thing that's called a [inaudible]. So they turn off and they this molten material and you have a little seed crystal that's on this puller and usually it's rotated in one direction and actually the pot of melted junk is rotating in the opposite direction. And so they dunk that down in and they start pulling it out and the slower you pull it, the bigger this gets. And so you can make different sizes, and it's pretty heavy if you lift it. So for gallium arsenide they can't make very big ones because they get too heavy and then it just breaks off.

MA: Right

BR: And so that's the way it works is it's a heated mass of metal or semi-metal materials that gets pulled out. And then of course once that's done they polish the sides and then they slice it up. And that makes, like the thing you held in your hand a second ago, right?

And so we start with those wafers and then we process everything from there on until you get to the final part. And so we have different steps that we go through in the process. Don't worry I'm not going to go through all these, I just have is as a, again, as a demonstration where we start off with a wafer and you can just barely start to see a pattern in there. And so the processes that we do are pretty simple. There's just three kind of types. One is what we call photo process where we put a photo-definable material on the wafer and then we shoot light through a mask like this a make that pattern on the wafer…um… in the photo-resist material. And then we either deposit into that pattern or we etch into it. So those are the three things; photo, etch, and deposition. Kind of just to generalized the kind of steps we do. And in a minute we'll walk down and you can see the place where we do this but-. So then we just build up different layers and put like a metal down. That's the deposition part. And then we'll etch part of it away and make patterns and kind of go through pretty different colors like this and so on and so forth and then kind of a finished wafer would look pretty much like this. So, but there's all kinds of pretty colored patterns and different things that we use. And the other thing that's different about our wafer process from silicon is that most of our metals are usually gold. Silicon used to use aluminum, now they use copper. We also have some layers that are copper that we do here at the very end. But for most of the connections and things that

	we make inside of our wafers they're done with gold. So it's very expensive- MA: Why do you use gold instead of aluminum or copper? BR: Well that's a very good question. It's mostly a legacy I think, I mean, when we first started building structures, gold was the easiest thing for us to use and there are certain properties about gold that made it very good for the kinds of things that we were doing. So it matched up with our material set, the gallium arsenide. In silicon, gold is not so good. It's actually kind of a… what would you call it? A um… well it's a material that you don't want. It's a fast diffuser, it doesn't, it just doesn't make things work right. For us, it's a kind of a material that we want. We could use other materials and some other comp-, some of our competitors, primarily in Japan, used aluminum for a while but it didn't work so well. So it really is matched well with what we're trying to build. And since it- because f that we just got used to it. And so all of our processes are developed around that material. So for us to change it would be a pretty big thing- MA: Right BR: Even though it'd be a lot cheaper to go to a different material. It still doesn't really match as well as what gold does. So that's kind of my best explanation of that. So anyway that's the main processing that we do here, is we go through and we work on wafers and kind of when we get near the end…um… we're processing these full wafers like the one that you held but in the end we take them and mount them on to a glass carrier. So that's a wafer that's mounted on a carrier [shows a

	wafer]. Just to show you what the carrier is by itself. This is the carrier. So we put the wafer onto there and then we actually grind off most of the wafer. [Both laugh]. We get rid of most of it because all that we want is basically the part that we processed on the very top of the wafer. So the rest is not really useful to us. And we can make the circuits smaller but also less resistant by getting rid of that material. And so it's kind of a funny thing but we actually grind off most of, most of what we need and the reason we need the thickness that I showed you is because gallium arsenide is also a brittle material. So breakage is a constant battle for us. So you have to make them a certain thickness in order to keep them from breaking so often. But we don't need that thickness for anything else. So it gets, it gets ground off, and I'll show you where that happens too, and then after those steps, we'll take the wafer and mount it onto, after it gets thinned it's really fragile, and so we never handle it in that mode when it comes off of the carrier. We just immediately stick it on to this tape that's a little bit sticky and then we'll saw it up, we dice it and then we take the parts off that we need. So each one of these little teeny squares is actually he device that we would use. And so this one's just partially picked, to show leaving behind the ones that we don't want, for some reason we determined those to be not good parts. We might go and see how we do that in art of the tour too. So after that, then those individual pieces there get put into a tape like this, which looks like a movie reel [shows tape]. MA: Right BR: And if you look here you can see these little teeny squares inside of here. Those are those individual die, right off of there. So

	you put them in here and then we send this tape format to the Far East. So either, right now we're using Korea, China, or Malaysia and they'll take the individual die like this and...our devices kind of are built on a little circuit board that's like that. It's really thin and they'll that the die out of the tape and they'll mount them on to that circuit board. So here's one that's got a few die on it if you want to see that. So for these parts in particular you can see there's three die. There's two small ones and a big one in the middle- MA: Right BR: And that's what's built into the package. After that then they put plastic on so it looks like this, just a solid sheet of plastic. After this then there's another sawing process to individualize these guys. And then they'll look like this once they're cut out. And those parts get put into a different tape, like this. And these are a little bit harder to see because the black side's up not the gold side. But this is starting right after this empty one are those individual parts that then get shipped to our customers. And so they'll take this tape and then take their phone board and take the part out of the tape and mount it to the board and then build the phone around it. So these are just different phone ports here. So that's the process. MA: So you go from a wafer this big to this little tiny thing? BR: Yeah. MA: Wow. BR: And some of these will have, like this one, has I believe four

	die in it. And we have some up to like eight that are even this small but they have eight little die inside of them. And then we have some that are smaller, you know, little teeny guys like this that just have one die inside of those. So for example that's a wireless LAN device right there. So that's the process. So all the wafer stuff is done here and the final packaging is done offshore. And right now we build about a million a day. MA: Wow. BR: So roughly 1/5th of any cell phone that you would come across would have our parts in it. So mostly we're focused- our business is focused on smartphones. So mostly more smartphones than just regular phones would be having TriQuint parts in them. So that's kind of the smart short, the short run through. And, now I'm just going to do a walkthrough of our fab. We can't go inside and our business has been so good that we used to have a hallway where you could walk all the way around and look in windows and see a lot of stuff. But over the years, about every two years we expanded the fab out, taking up the hallway and then the whole building. So now it's mostly solid fab and there's only one little hallway left. But we can go down there and I can show you firsthand what we have and I don't know how much time you have available- MA: I have as much time as we need. BR: Well I, you know, I don't want to spend too much time on the tour but there's another option, we could actually go on to the test floor. So I'm going to take this with me too, just in case you don't get bored [picks up coat to wear onto test floor].

	[Background noise from leaving conference room and entering hallway]
16:47 the tour of the building	BR: So you might have noticed when we walked up here, I'm going to shut this just so we don't get gawkers, that the second floor here is all offices, right? So there's no real production or manufacturing or anything that goes on on the second floor. Just office space. MA: Okay. [Long pause] BR: Let's see, we have so many options of different stairways we can go down but… [long pause]. Years after we moved to this site, we added on this part of the building. So we had a square building- MA: Right
history of TriQuint the building	BR: And then we added on this little wing kind of thing there. That was right about 2000 when the big market crash happened. MA: Right BR: And so we actually never moved into this wing until just about three years ago, we started moving in to the new section of the office building. [Long pause] So it's been just a pretty steady growth for us. Really since the very beginning but the big growth has just happened in the last five years. So when we started getting more parts in the cell phones. MA: Mhmm. So the whole smart phone boom was good for you guys I guess [chuckles]

Acquisition of companies; Texas Instruments	BR: Oh yes, absolutely. Very good for us. But we, you know, we have a lot of diversity in the company and over the years, like starting in the early 2000's, we acquired other companies that do the same thing [background noise, someone speaking]. So in like 2001 we acquired the part of Texas Instruments that did the same thing that we do. It's a real small part. MA: Right. BR: Just a really small part but they built gallium arsenide and so they were being divested and we bought them. So we have another fab in Richardson, Texas. MA: Mhmm
Acquired Infinian, AT&T	BR: And then later on a company called Infinian which was a spin-off of Siemens also decided they wanted to get rid of their gallium arsenide group. We bought them. Before that, AT&T did the same thing, we bought them. So kind of been getting parts and pieces. So TriQuint is not only an innovator but also a consolidator. Right? MA: Right. BR: So we consolidate all these little parts and pieces of other companies that just basically do the same thing as what we do. And so it's been a long story of those. And part of our business is what they call a foundry. And so we basically just built wafers for other companies and they do their own designs. We just process and fabricate the wafers and then they take them and test them and build their own products. And so some of those companies that we

	enable, we also acquired. [chuckles]. And so it's just been constant, kind of, acquisitions through- to help our growth. And get us to a mass that big enough [pause].
20:54 Beginning of tour Deposition Process	So this is the hallway that's left, we're walking down here, but it's pretty much all we have to see anymore to the fab. [pause]. This is the latest build out, we in this corner. We used to be able to walk down all the way down here and look- have a little bit better view. So where I like to start is here. And so if you look, not straight here but kind of to the right there, you can start to see a machine, let me hang up my coat, that is one of our deposition machines. Remember I said we do photo, etch, and deposition. MA: Mhmm BR: So that machine that you're looking at is- you're actually looking at this- that shiny part that you can just barely see down there- MA: Right. BR: Is one of these things [shows picture]. It's a big pump. And so from the top view, this machine is sitting like this so the input and output inside the fab here and we're kind of looking at the back part, the working part of the machine. And so it has these different chambers in it that hold a target. And so these are the targets of metal that we use to deposit. And so for example this is a gold target, it costs about a half million dollars. MA: Wow.

	BR: This is a nickel target. It's much cheaper. But those targets actually sit upside down in each one of these chambers. So a wafer comes in here, and this is called a dealer. It'll take the wafer and it'll shove it into these chambers. And then we do a plasma process that looks like this [shows picture] if we could see it, where in our case the target's on the top and the wafer's on the bottom. That strikes the plasma and that causes the metal to come off the target and deposit on the wafer. And so that's how we accomplish our metal deposition, is in machines like that. And we have about…fifteen of those machines that have multiple chamber- they're called a cluster tool. And so you can do- we'll put like titanium tungsten, gold, nickel, platinum, different metals that we use to deposit in each one of those systems. So that's how we do the deposition. And so the front looks like this [shows picture]. And that's what you can see when you look in here, if you look over to the left. So can see the- that's the business end, right? Where they put the wafers in there and then it pretty much takes over and does the processing with the wafers. And so those black boxes are what we call run boxes and they usually hold twenty-five wafers. So they'll open up that box and they'll take out what we call the cassette and set the cassette in there and the robot takes over from there. So that's what's mostly all the way down as far as you can see on the left hand side are those metalizers.
Electroplating process	On the right hand side, just right here close is a sink that we use either to clean or sometimes we use sinks to also to deposit metal. And that's what we're going to see in the next tunnel, is a different kind of deposition system. You can't really see the front of the machine here, but we also plate, plate our metals using electroplating process. So when we want really thick ones, we do that. So it's just like on jewelry and stuff, right? Where they plate

	metal, that's what we do on our wafers. I don't really have a picture of that. But we can talk about it a little bit when we look in over here. The fab is laid out so there's areas that are called bays, that's where the people work and the wafers go. And then there's chases. So it's bay, chase, bay, chase. In the bay, the air comes down from the top, it goes through filters, and so it's very clean. Very clean air. It goes through the floor or sometimes through the wall and into the chase and it goes back up. So the chases are kind of dirty compared to the bays, and that's where all the equipment is. So this is a chase. And there's not usually people in here unless they're maintenance people, and the wafers aren't in here either. The wafers are in the clean part. On the left hand side there you can see kind of a big machine, that is a plating system that you can actually plate two wafers at a time. And it holds the wafers upside-down and then it sprays liquid onto the front surface of the wafer while it's making an electrical connection and it'll plate up. And that's the way it works. So there's two of those here on the left. And then we have one farther down that you can barely see that does ten at a time. MA: Mhmm. BR: And so those are kind of the two ways that we put metal on, either with a plasma process or plating process [inaudible]. I'm going to grab my coat and we're going to go look at the rest of the fab, as much as we can [laughs]. Sorry I can't show you much but- oh actually this is the front side of the plating system where the fountain heads are inside there. There's pumps and stuff underneath but this can do two wafers at a time. And it plates up what we call thick metal. So the really thick layers [inaudible]. So like I said it

	used to be the fab was just in the middle and we actually had like offices and other support room around it. MA: Right BR: But now it's filled up the whole building except for some parts of the right hand side, there are still supporting areas and maintenance areas to help them out. It's pretty much filled with processing equipment. So about… for the last six years or so we've doubled about every two years. MA: Wow. BR: So we're just building everything we could possibly build right
Photo-processing technique	now. So this area of the fab is a little bit different than the bays and chases that I've described before. We call this the ballroom because it's one big room where the photo process happens. So like I said before what we do is we put a material on the wafer. It puts it on there and spins the wafer so it makes a really thin layer of photosensitive material. And that's why we have the yellow lights is because they don't affect the sensitivity of the photo resist. But different colored light does and so we have machines that shoot the light through those masks that I showed you before. And the machines look like this. And so we put a cassette of wafers on here and the machine will automatically take the wafers in there and shoot light through them. These are like the coating tracks that put the coating on them. And so it kind of is laid out so the wafers comes in on this side that we're looking at, they get coated, they go through the stepper and then they get developed on the other end. Then they come out and they're finished in this area. And it just has rows and rows of sinks, six rows here where the wafers just

flow through that way.

But there really wasn't enough. And so now the guys have expanded the photo layout and you can get a little bit better view if you look in here of some of those tools. This is another extension of the photo area. We have a couple more steppers here. And they're working on those. That's pretty much the story for the fab. This actually used to be - the entrance to the fab was right here. So we would come in and out here and we didn't want to use up that space as an entrance so we built on a little building that's out here. And that's so the change room, we call it, is over here. This is actually kind of a addition to the fab that's new. And so you can see they have different colors of bunny suits that they wear inside there. Mostly operators all wear a white and then the maintenance engineers wear the dark blue. There are some light blue, those are usually worn by the supervisors. And then the ones that wear all different colors mixed up those are the anarchists.

MA: [laughs]

BR: And so sometimes they have all different types. But usually they kind of stick to those colors.

MA: And is that to protect the wafers or to protect them from chemicals?

BR: The suits are to protect the wafers from people.

MA: Okay. That's what I thought.

BR: Because people are a source contamination and particles and things like that. So we try to keep it really clean and keep down

	those kind of particles and stuff. So people that work in here for example, they can't wear makeup, they- I don't think we allow smokers, even if they're, you know, they can't smoke obviously, but they can't even be smokers if they work in here because, you know, the extra particles from that. So those kind of things. So you try to keep it really clean. So that's pretty much the fab, do you have any questions? MA: How many people work in the fab compared to upstairs in the…
24/7 shifts	BR: It's… not quite half; it's more- closer probably to a third. So as I said we have about a thousand so there's like 350 or so people, I think, maybe 400 max that work in here and it's across four shifts. So they work- the fab is running 24/7. MA: Wow. BR: So people work a 12-hour shift. So they start at 6:30 in the morning, they go until 6:30 at night or start at 6:30 at night and go until 6:30 in the morning. And what they do is they work four days one week and then three days the next week. So they have a swing day so they just an extra long weekend on some weeks and then not on others so it's four day-three day-for day-three day kind of a situation for them. The swing days are different days. Some swing days are Wednesdays and some are Sundays. So the shifts overlap with each other. So day one will overlap with night one and night two and vice versa. So they see all the, basically they never see the other day shift but they see both night shifts because of the way they split up the times. So some people just really thrive and they love that kind of a schedule because they get three day and four day

	weekends, right? But it's hard. It's a really hard schedule. I know that I couldn't do it but some people just love it, it just fits exactly what they want and it works out. But we usually have to hire two or three people to find that one person that likes it. But, like I said, some people just really thrive with that kind of work schedule and those are the people that we're after. MA: Mhmm BR: So most of the people in here… a college degree is not required to work in here. So the production folks mostly are just high school degree or, you know, there are quite a few that have college degrees and so on but it's not a requirement for that, for those people. Any other questions? MA: No, I think that was it [laughs]. BR: Okay, so next we're going to see the area where we grind off the back. MA: Okay.
fab finish area	BR: We call this the fab finish area. That was the fab, so this is what we do at the very end of the wafer process. In between we do a lot of testing, where we test wafers all different ways that we can think of and then after they're tested then they come back to the fab finish, which is this room right here. And so if you look halfway down there and farther there's three machines on the left- MA: Mhmm

	BR: -that are shorter. Those are the grinders. So those grind off, you know, like 95% of the wafer. We just need the top part, is all we want. All the other machines in this room, that you can see at least, are for dicing up the individual parts on the wafer. So there's two machines here on the left and one on the right that are lasers. And you can actually watch the second one there, as it's moving along the wafer. And it shows a cartoon of the wafer on the right. And then it shows you actually what it's looking at as it's cutting the… those things apart. And so it's very fast [background noise, voices]. These other littler machines that you can see that guy standing there, right there, are mechanical saws. So they actually have a little saw blade in them with diamonds in it and we actually mechanically saw the wafers. They're slower. MA: Mhmm BR: But we do both. For different reasons. But we do both mechanical sawing and laser dicing. And so we have the three machines you can see here and then there's a forth one that's on the other side, we'll see in a second. But you can see already the process that it's made on that wafer. It's only about a quarter left now that's yet to been sawn out. So, it will finish pretty quickly. And sometimes the mechanical saw will take about ten hours to cut a wafer. MA: Wow. BR: [inaudible] And so this is called fab finish here. We can get a little bit different view into the fab finish if we go around the corner here. [Pause] Okay? Are we doing okay?

	MA: Yeah. BR: So this is just a different view where you can actually see, straight down there is one of the mechanical saws that we use cut up the wafers. And then here on the right is another laser saw. We actually just put that one in over the Christmas break so we're filling out the space pretty rapidly and running out of space so- MA: Are there plans to expand the building more or-? BR: No, what we've chosen to do, because we have a much larger fab in Texas- MA: Right.
Other fab buildings, Micron Technology, Texas Instruments	BR: We actually bought a fab building from... Micron Technology down there. And we moved those folks that we acquired from Texas Instruments into that. That it's probably six times bigger than our fab here. And they just occupy a small part of it. So we said well if we're to need more capacity, we'll just build it there. So we've spent basically the last year building that. And s now they have exactly the same equipment that we have here and the exact same processes. So we can build identical wafers there that we can build here. So we're still trying to cram more in here, but we're using those guys as our increased capacity. Another way that we increase capacity was we actually moved the very last fabrication steps into this room right here called the copper room. So this is the place where we plate the copper and tin on the wafers at the very end. Right here, it's this room. And so if you look in there you can see the sinks and if we could go in, inside the sink is a chemical called copper sulfate. It's really fun because

Copper room, copper sulfate process	it's really pretty blue liquid. So we put the wafers on a board and they attach electrodes in and we dunk them down in there and then we plate up copper. And we make the connections that we use on the die out of that copper and at the very end we plate up a little bit of tin which acts like solder [background voices]. And they can take our individual die and put them on circuit boards and just solder them on. So it's kind of a new thing for TriQuint to be able to do that because before we would have to use little gold wires to connect the devices, called wire bonding. Now we also have this process, which is really good for us. [Pause] So are we doing okay? MA: Yeah we're great BR: Do you have another 15 minutes? MA: Yeah that's fine BR: Okay because I'd like to take you into the test floor. We're going to go this way.
39:20 Tour of the test floor Getting ready to enter test floor	MA: Okay BR: This is kind of fun, you can see a lot of things happen in here. But to go in the test floor we have to put on these smocks. MA: Okay BR: So I'm going to see if I can find one that will work for you. [Pause] Try this one; see if that one will work. You want to hang up your coat?

	MA: Yeah, that'd be great. [Long pause]. I'm not stealing someone's outfit, am I? [chuckles] BR: No, does that one look like it's going to work for you? MA: Yeah it's perfect. BR: Okay, so the other thing we have to do is we actually have to put on these heel straps. I've already got mine on here. And so you're going to put this on to your heel such that this rubber part is underneath your foot. And this is on the back of your heel and this is Velcro to go around your ankle. MA: Okay. BR: And then this part has to go in underneath your foot or sometimes even underneath your sock. MA: Okay. BR: Because we're making- what we're trying to do is make an electrical contact to you. And then we have a floor here that's conductive and it will take all the charge off of you. And then you can't harm anything that's in here, not that you're going to touch anything. But that's our process that we have to use. So… the way we test to make sure you're okay, everybody has to do this, get all buttoned up here, and then we stand on the floor that's conductive [inaudible] push this button, hold it down, [inaudible] means I'm okay. MA: Okay [laughs]

	BR: Alright MA: Alright BR: Perfect MA: I pass. [Laughs] BR: Good to go. [Entering test floor, lots of background noise] So this is what we call the test floor. And what we do here mostly is test wafers. And so what we're doing in that case is we're testing the individual parts that's on the wafers to do the best we can to make sure- I don't know if you're going to be able to hear me, it's kind of noisy- to do the best we can to make sure that that individual part is going to work for our customers. MA: Okay
Wafer testing area	BR: Now we have another test at the very end after everything's all put together in those little plastic things that I showed you where it's individual. MA: Right BR: And that tests the complete functionality. So we have another test that we do later. But this is just so that we can get only the good parts off of the wafer and finish the rest of the process. Because we don't want to waste money on bad ones, right? MA: Right.

BR: And so what we do is just make measurements on the wafers and [inaudible] it's kind of busy. They're actually measuring wafers that's part of the fabrication process. [Inaudible] Where we saw them working on the wafers, they'll bring the wafers down here to make sure that everything is okay. So all these systems along here, they're probing the wafers, but they're actually only measuring this individual spots. See these ones that are different here?

MA: Right

BR: So, there's nine of those on a wafer and they'll only measure those. They won't measure all of the rest of the things. So they're measuring to make sure that the fab is going okay. It's kind of like [inaudible]. So they'll just measure those nine sites on every single wafer during the fabrication process to make sure it looks good. And then when they finish they make one final measurement and say "yeah this wafer is as good as we could process"

MA: And they do that for every single wafer?

BR: Yes

MA: So a million a day, isn't that what you said?

BR: A million of these little teeny guys-

MA: Oh, okay.

BR: Right? So on a wafer there's about 20,000.

	MA: Wow that's still a lot, yeah BR: So it takes about 50 wafers to make a million. MA: Okay BR: So it's not so many. MA: Okay. BR: So after the wafers are finished and the fab guys are done- MA: Mhmm BR: Then is comes to a different machine [inaudible, long pause] so it measures the wafer and every one that's good it marks green. So all of the ones that aren't good it marks as red. And so that's called the wafer map. And we have that data that tells us which are good and which are bad. So we can use that data after we singulate the die and we pick them off, we only pick off the good ones. So we leave the bad ones stuck on there. So all these machines, even those is a little bit hard to tell, all these along here and along that row are all doing this kind of stuff here. So here's- here's one that's showing the progress right? MA: Okay
Creating the wafer map	BR: So if you stand here and watch you can see the green lines get built across there. And then some of these other ones, it's actually probing multiple die. So we can probe sometimes up to like eight at a time. It's got these little, kind of like, needles that land on the die

	and then they can [inaudible] and say that that's okay. So this is doing the same thing it's just at the color there [inaudible]. You watch closely… now I lost where it was, it was just there. It's probably –oh here we go, there. See it go across. This looks like it's measuring four die at a time. Now it's going to go off. [Inaudible]. So it's just probing. [Inaudible].
Probing machines	So you get that map that tells us good ones and bad ones and then we'll take the wafer back into fab finish, grind off the back and saw it all up so they're individualized. Then the wafer comes to these machines in the middle. These are really fun. They're my favorite ones. What these machines do is [inaudible] the wafers and it's on a piece of paper like that like I showed you before…. If you look down in there you can see that it's, it's stuck, oh there you go. It's got different colored lights.
	MA: Yeah
Die inspection machine	BR: And it's actually inspecting and looking at the individual die. And so this is actually the backside of the die and it's being placed into the tape.
	MA: Oh
	BR: So like the black tape that I showed up, those are the pockets in the tape and see it's going across here, picking out the good die and then it looks at them, makes an inspection, it's looking at all different aspects, makes sure it's okay. If anything's wrong, like there's a chip, like that, it'll throw it out. And so as it goes across, you can see it left behind the bad ones. It doesn't even bother with those. Because it knows from those other machines which are good and which are bad. So it's taking the individual die and putting it

	into the tape. The tape is over here. So these are kind of long skinny guys. So if you look, those are the same shape as what we were seeing in the picture. So that inspects. It inspects the front side where it's got these copper bumps that we saw, so it makes sure all the bumps are there and everything looks appropriate like it's supposed to, that's the fab area. And it also looks at the backside for chips or cracks or dirty spots or anything like that. So it makes a multiple inspections of the wafer. But if you stand back and look, it almost looks like it's a fire, right? MA: Yeah. BR: So we kind of a nickname for these machines, we call them the barbeque. MA: [Laughs] BR: Because they look like a barbeque down there right? MA: Yeah, they do. BR: -just a funny shape like that. So it's really interesting. So in that machine you can actually see the front side. MA: Uh huh BR: You can see it's looking at the bumps and making sure that everything's good. So we can do that here if I was smart enough to figure out how to run this, but it's just set up and going. See, you can see all the different various size, shapes and sizes that the… we're looking at the… And usually when the light is red it either

	means that it's finished with the wafer or that something's wrong. It's either out of tape, or it came across a problem it didn't know what to do with it, or whatever. Green lights are good, that means that they're going pretty fast You can see it's putting in a lot of die [inaudible] that's what gets sent to the assembly guys. MA: And that's all automated so nobody needs to stand here and- BR: Only to put on new ones. MA: Wow. BR: Yeah, it's pretty, pretty automated. Not as much as we'd like, but you know this is pretty good right here. MA: Yeah BR: Usually it's- usually there's a few more reds [inaudible]. Again it doesn't necessarily mean bad it just kind of means that it needs some attention, right? Maybe a change out or- MA: Right BR: Make the change. It's going pretty fast. MA: Yeah. BR: Making all those inspections. This is a, it seems like a lot of extra work but what we want to do is we want to make sure that every die that goes in there is good.

	MA: Right BR: Because as you saw, we'll put multiple die inside of an individual part. If one of them is bad the whole thing just [inaudible]. So there no going back, right? So every one must be good so we can get a really good yield by making sure that the die are all good... Well like I said these are kind of pretty to watch. MA: Yeah BR: Now the last thing that we do on the test floor is the actual final test. MA: Uh huh
Test Development	BR: Now of course we do most of that off shore where the parts are assembled. So we send them, they put them all together. They end up with those individual pieces. And mostly they actually test it right there. Since all of them are in the same place. But all the tests are developed here. So we have these engineers that during the daytime, they're all figuring out how we make sure that the parts do exactly what the customers want. So all the test development is done here and it's done pretty much all day long. Now at night, we actually do some production tests here. It used to be a big part of our testing, now it's about one percent. It's just very small part, but we want to make us of it at night. Now if we're lucky we might actually be able to see some parts [inaudible] here. [Inaudible]...the individual parts and they'll dump them into this bowl. If you look in there you can see that they're moving around because that bowl is vibrating. And so it makes the parts go around on this track and this track is set up such that it orients the part in a

	certain way. So if it's not right, it'll use these little air jets that shoot the parts off. And so by the time they get to the top, they're in the proper orientation and they'll go down on this track here and they'll go on that track in there where the light is shining. This is actually a camera that's looking at the part. So it verifies that the mark that we put on the top of the part is correct. So the marking is all inspected there. And then it uses that to do the final orientation. Because some parts… these ones in particular are square- MA: Right BR: So it can't mechanically decide what the orientation is. They spin them all so that they're light side up, basically. And then the vision tells them okay it needs to rotate or not rotate. So it will test the part inside of here and when it's done, it puts them on the tape and reel also. So each part comes up on these smaller reels here. So the testing's actually done at this station back here, you can see this board's got these wires and they go up to this system that does that [inaudible] here. [inaudible]… it's actually doing the test that looks pretty much like what happens in a phone. It's you know, it could even be making like a pseudo-phone call, but it's not actually- not contacting the base station, it's just transmitting and making sure that it's transmitting right power. And we check to make sure that it's not interfering with adjacent phone calls and things like that. So it's a very a very extensive test, yet you can see that it normally only takes, you know, second or even a fraction of a second sometimes to do that test. But again this is pretty much test development not actually production. [inaudible] to make sure that everyone we're doing is proper. MA: Right

	BR: So these are probably more than likely samples for costumers. So they'll only put like fifty parts on a reel and send them out [inaudible] play around with them and say yeah that is what we want. That's usually what's happening. Except for at night, then we do a little bit more production. MA: Uh huh BR: So that's the other thing I like to do is watch that bowl where it's- MA: [Laughs] BR: [Smiling] sending those parts around the racetrack. And getting them all ready. Some of the parts are rectangular so it can actually orient them better than these square ones that… gets them all set up. And then we have these rooms that we call screen rooms where we can actually test the receiver parts. So it's there's a part that's receiving things, we don't want the transmitters to interfere with them. So they do these tests in here. If you took your cell phone into one of these rooms, it wouldn't work. There's no signals from the outside world that get inside here once the door is shut. MA: Wow. BR: So that's it. It's really quiet in terms of all the noise that's out in atmosphere. So you can take really sensitive measures. We don't care about those at all with the amplifiers but the receivers it's a different story.

	MA: Right. BR: So that's the test floor. MA: I like it. [Long pause] BR: They have, you know, all different kinds of handlers that will handle all the different shapes and sizes of the parts. Like I said at night it turns into more of a production versus engineering, which is pretty much what's going on. At least the fab stage there. I mean this is still pretty much production, this side here with the [inaudible] die. So that's pretty much the tour. Is there anything else that you wanted to see or that you had in mind? MA: Um no, I think that… that about covers it. [pause] And so there are people working in there 24 hours a day? BR: Yes MA: Too? BR: Yes. Yes. [Background voices and long pause] Okay, I guess my work is done and yours is about to begin. MA: That's pretty much it. [Walking back up to conference room to conduct interview]
	Audio File "Roesch Interview 2 of 4", 1 minute 45 seconds
0:00 Talking about	[Back in the conference room, looking at TriQuint parts] BR: … of things that we do. So here's an example of one of the

TriQuint parts used in spacecraft; Sojourner, Huygens probe	parts that's on Mars. MA: Oh wow BR: So that's in the Sojourner…rover. The first one that they put on Mars. We always have communication devices in the Spirit and Discovery path- rovers that are on Mars and then we have a communication device that's on the Huygens probe that's on Titan. MA: Wow. BR: …orbiting Saturn. So, we have, you know, spacecraft parts and satellite parts, so a lot of GPS and things like that are enabled by TriQuint parts. Communication satellites… MA: Mhmm BR: The folks that we have in Texas are specialists in building parts for dispense- defense and aerospace, so they build a lot of radar devices there. And, so just all kinds of stuff. I mean in the early years that's what we were specialists at and so we did a whole lot of different things but in not very much volume. MA: Mhmm BR: So we charged more money. We'd get, you know, hundreds of dollars per part. Now it's sixty-nine cents, right? [Laughs} So it's just an economy of scale. But the company really grew up as being a… really diverse… abilities in terms of the types of things we could build.