Laser Cutting of Flex Circuits

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1. All right, it is that time we're straight on the hours, so let's go ahead and get started here, I'll have a few late arrivals but that's all right, we've got a few intro slides to get going here anyways. So first off, I'd like to welcome you at the webinar. Thank you for attending today. Today's topic is "Laser Cutting of Flex Circuits, depaneling of completed circuits, cover layer and rework all on flex". Flex circuits have all the capabilities of a standard rigid circuit board: precision, high density, reliability and repeatable production. The most importantly they're able to move outside of standard 2-dimensional geometries and assume nearly 3-dimensional shapes.

2. Flex circuits play a very important role in the PCB industry today and precision, accuracy and complexity are always being a challenge. Laser systems offer a range of capabilities for processing flex circuits and are opening up new opportunities for what's possible with them.

   My name is Josh Brown. I'll be your presenter today. I'm a Market Development Representative with LPKF Laser & Electronics, a company that provides UV-laser depaneling systems. We'll talk about those later in the webinar.

   Throughout the webinar if you have questions, I'd very much appreciate you asking them. If they are pertinent to the topic that I'm on at the moment then I may or may not stop and try to respond to them at the time. If I can't get to them during that time then we will save about 15-20 minutes at the end of the webinar to address all your questions. Also we'll have our Sales Engineer Mirela Orlowski on the line with us though that time and she'll be able to answer all the system specific and varied technical questions.

3. You can see that you can enter the questions in the "GoTo Webinar" interface where the red bracket here and arrow are pointed to. So like I said, please feel free to ask as many questions as you'd like. It helps us determine what you would like to see out of these webinars in the future and it's a good feedback for us.

   All right, so let's move into our topics today. First off, we're going to talk about the laser processing overview. So really quickly we'll just cover how it works and some basics of the systems and how they're gonna interact with the boards. That'll be really quick and then we'll move into the main topic which is depaneling or cutting of the circuit boards. I'll talk about things like accuracy, the materials that can be cut, speeds, and a few others. Also cutting is a very broad term, I might use depaneling as well, so just depending on the jargon that's used within your company, keep that in mind that cutting and depaneling are going to be simply synonymous throughout this webinar.

4. But outside of depaneling, topic number 3, we're going to cover other capabilities. So the laser systems are set up for depaneling, however, they can also cut cover layer, they can do ridging flex decap, skiving and then even laser etching or surface metallization removal. I will talk about those as well. This webinar isn't designed to be a direct comparison with other depaneling

methods but I will do some comparison to routing, die cutting and a few other methods as well, just to give you an idea of how laser fits into this round of depaneling flex circuit boards. And then finally we'll finish up with systems, show you some pictures, and show you a couple of available options and then we'll finish up with the videos and you can get an idea of how the boards are actually being processed by the systems.

So it means, let's jump in to topic number 1, which is the process of cutting the circuit boards.

5. So, to start we have the laser system, the laser sources of 355nm wave link, UV-laser. So this is an ultraviolet light spectrum.

   The idea here is that we want to use the laser beam to vaporize the material. We don't want to melt it or burn it or with mechanical methods, we're cutting it or breaking it, such as die cutting. So, again the goal is to vaporize the material. In the past other lasers have been used for depaneling with higher wave links in UR-spectrum (infrared). These were typically CO_2-lasers and although they were very fast at cutting circuit boards, they tended to provide too much energy to the material and you'd see a lot more burring and deformation. That's why today we're going to focus on UV-lasers, they are a little bit more surgical in nature and we will do a comparison of UV- to CO_2-lasers in the webinar.

6. You can see that the laser beam is controlled by galvo scanning mirrors, these are very precise mirrors and you are centrally controlling the laser beam like a knife. So, it's similar to the concept of a routing system for cutting circuit boards. However, we're using laser energy to vaporize the material rather than cut it. The mirrors are very precise, so we have a repetition accuracy of plus or minus 4 microns and there'll be more getting to precision again further in the webinar as we go along, but this is definitely one big benefit of lasers is their precision.

   Also I want to mention that it's a dynamic process. So, the contours and the cutting geometries are all maintained by the direction of the beam which is controlled by these mirrors. So, you can efficiently control the contour with data input into software. So essentially you prep the data on a standard computer in typical files: gerber, .dxf, etc., you can assign layers:

7. A fiducial layer for recognizing where the beam actually strikes the material, the cut layer, and then you can add other layers for other capabilities such as drilling or different energy inputs. And then you export that in the system, the system will change the parameters and run the file directly through the interface. And again we'll talk about that a little bit more as we get into the systems later on.

   So, that's kind of a basic process overview. Like I said that'll be pretty quick. So, let's jump into the bulk of the webinar which is depaneling topic. So, today's focus is on flex circuits. We'll talk about depaneling completed boards or we can do rework as well. So, as you can see here, this is a complete board with surface metallization, connectors and stiffeners. Lasers capable of processing all of the… So let's talk about materials really quickly.

8. Obviously in the flex circuit world materials are pretty standard across the

board like a polyimide most of time, so brand names will be Kapton and Akaflex, PET is quite often used and then Pyralux is a Teflon/Polyimide combo. All these are very easily cut by laser systems and I should mention that polyimide especially really likes to be cut by lasers. So, because we can control energy so well, it makes for very efficient cutting of polyimide when you talk about laser systems.

It is noteworthy to mention that the laser systems are capable of cutting other materials outside of the flex circuit world so FR4 and other epoxy, substrates, rogers materials, ceramics, PTFE and even aluminum and copper. Some of these will depend on the material thickness but the idea is that the laser can cut through all of them.

9. Also, and I'll cover this much later in the webinar, is etching - so actually removing surface metallization and etching on flex circuits, which is rather new and definitely kind of an important innovation in flex circuit processing. But it's, like I said, it's new and still somewhere in the R&D stages. Also I wanted to mention, naturally since you can cut flex materials and rigid materials, rigid-flex circuits are very easily possible.

   So here is a quick overview. Like I said we'll do slight comparison here when we're talking about the capabilities we're going to be looking at today. So, we're going to be comparing these methods. Hand cutting, routing, die cutting, 'cause they are mechanical methods. And then UV-laser and CO2-laser are going to be obviously our laser methods.

10. The comparison we're going to look at today and, actually, the factors of comparison we're looking at today is, first of, stress (we'll talk about mechanical and thermal stress) and we will talk about accuracy and precision, yield, or maybe called mounting density, speed and versatility. So, no need to memorize this, we'll cover these in details as we go through the rest of this topic section, but this gives you a very broad overview of these capabilities comparatively with other methods for depaneling. So, we won't provide you with too much focus on hand cutting because, in relation to these other methods, hand cutting is relatively primitive. However, I decided to include it because a few of you mention on your registration forms that hand cutting is still being used, so, it is of note. And again, just to show you, UV-laser is our focus today, although we will be doing some comparisons.

11. So before we move on and jump into this section and start talking about those factors that I just mentioned, let's do a quick poll. The question that's going to pop up is: "What is your primary depaneling concern?" You should see the poll launched on your screen. It will take about 20 seconds, maybe 30, we have quite a few attendees on-line today and see if we can get that question answered. So, your primary depaneling concern: cut quality (so you are looking at minimal damage, burring or deformation if it is that issue you're running into), throughput/cycle time, flexibility (so you're doing a lot of app. changeover, maybe you're heavy on R&D and not so much on production), precision (for high density components are very small circuit boards) and then cost as always (usually a favorite as well).

12. So looks like most of you, guys, had voted, there are still coming in. We have quite a big crowd today so we'll probably give this one a little extra time here. If you're not sure, feel free to just leave the poll and I'll close it down – you don't have to vote. We're almost there, I'll give it about 10 more seconds. All right, I'm going to go ahead and close the poll, so I apologize if you didn't get to answer but I would like to move on here. And now I'm going to share so you guys could see the results come up on your screen. So, looks like overall cut quality is very important and then precision as well. And naturally some of these are going to overlap: cut quality and precision have a lot to do with each other.

13. These are definitely issues we're running into as circuit boards become smaller, is trying to achieve the cut quality we're looking for or the densities we're looking for without damaging those boards. All right, so I'm going to close that poll. Okay, so, moving in to our first factor which was stress. There are two different types of stress I want to talk about. First off was mechanical stress and when we talk about mechanical stress naturally we talk about mechanical depaneling methods: die punching, routing, hand cutting, sometimes dicing saws. And when you introduce mechanical stress, the stress can cause burring and deformation. So, there is also… typically you're not going to see… with rigid applications you would see cracking, etc. But burring and deformation are going to be big ones when we are talking about flex circuits.

14. So, the main point I want to make here is, as far as mechanical stress goes laser systems are a non-contact process, so you are not going to be causing any mechanical stress to the circuit board. Remember, we're trying to vaporize the material with laser light but not cutting it or breaking it. This brings us to the next type of stress which is thermal stress. So, when you're talking about thermal stress this is strictly for laser applications. So, in this comparison here we have CO_2-laser vs. the UV-systems we're talking about. We're cutting a polyimide of 125 microns width capped on. So, on the left you can see CO_2-laser with a little bit of a dirty cut. You see more burning and also the curve is a little less consistent and slightly wider as well. So, the cutting speed, you notice that the CO_2-laser is very fast, so there a lot of energy input and it is going to burn through this material very quickly.

15. But note that you had to make 4 passes. If you slow the laser down any more than that and try to make 3 or even a single pass, you would just completely burn or deform your material. So, 4 passes, cap the laser speed up, and you get a relatively decent cut but again you see a lot more burning than you would see with the UV-laser. Also one pass, but note that the cutting speed is slightly slower. So, 95 mm per second is effective cutting speed compared to 860 mm. Although 95 mm is still very fast in terms of depaneling circuit boards. Also the cut width. Notice, because we're putting less thermal energy into the material the cut width is going to be slightly smaller. So, both of these beam sizes – the CO_2-laser and the UV-laser, about 20 micron – beam spot sizes but because of the thermal energy input difference the CO_2-laser is going to burn away, vaporize more material than the UV-laser would. So, the UV-laser can be

slightly more surgical and the cuts will be a little cleaner.

16. So, accuracy and precision. Basically what I'm talking about here is actual tool cut width. So, I didn't dive into hand cutting 'because it's too difficult to say, obviously, it could vary so much depending on who is handling the tool. With typical mechanical methods such as routing, die cutting and dicing saws, you're looking at about 1 mm. And when I say 1 mm, I'm not talking about the thickness of the tool itself, I'm talking about the cut widths you are going to achieve with them. So, what you have to have in mind is the thickness of the tool as well as certain zone or room that has to be compromised for the stress and damage, that is going to be introduced on the board. So, you can't place components or bridges too close together, if you're going to have a certain amount of damage or deformation on board, you want the damage of the components or the board itself.

17. So, when I talk about 1 mm it is really the actual cut width not the tooling cut width. Lasers down here are again of the actual tool cut width, 25 microns and 120 microns. We saw them on the last slide. Both of these used to seam beam spot size. The beam spot size or the tool, you can say the virtual tool, would be 20 microns. But the actual width is going to be different because of the thermal energy, you are going to be vaporizing material around that. So, again CO_2-laser has a higher energy input – you can be vaporizing more material. I did get a question: "Is there thickness limitation?" With polyimide – not really, you're never going to find a polyimide that's going to be really too thick to be able to cut with the UV-laser. But I do want to mention that thickness does matter when you talk about lasers. The laser is cone-shaped and as you get thicker material you have to take into a fact that cone-shaped beams (the beam shape) and so, if you get too deep into a material, you're going to end of cutting a wider cut width.

18. You'll get a kind of V-score almost on your cut. So, the thicker the material gets, the wider your cut width will get. So, with UV-lasers you're going to see 25 as the lowest but you'll tend to see between 25 and 50 microns as a standard. Very quick I want to answer: "Will copies of the presentation be available afterwards?" Yes, absolutely. I'll have slides available as well as the recording of the presentation just so you know if you have to bail out a little early today. Along the lines, precision and accuracy are the finer features that you're looking for in circle boards today. So obviously boards are gaining smaller, precision is becoming more important and so here is a prime example of the complex PCB. This is flex polyimide, and just to give you an idea of the size: it's about 5.5 cm and in one more relation the inside of this fork is one more mm.

19. So, you can see this features are relatively small and the contour is extremely arbitrary. It's not just a square, it's a circuit board here. So, this would be very difficult to cut with most mechanical methods. Nothing that could not be done, but you could run into a lot of process control issues. In this board, besides the polyimide, which is 70-micron big polyimide, we have copper, nickel and gold, and we also have 200 micron fix stiffeners throughout the

middle. And this can be depaneled with the laser system in about 14.6 seconds.

Again, another quick example of arbitrary shapes enough to settle for simple contours and also, notice the verifying traces. This would be rather difficult to complete with the mechanical system as you just tend to run into causing damage to these traces at time when you really wouldn't want that happen.

20. I got a question about drilling micro vias and I'm going to cover that soon enough in the webinar. So, before I move out of the precision and accuracy, I've mentioned that the beam spot size is small, the energy input is very easy to control, which is fantastic, however, aligning the beam to the board is going to be very important as well. So, whether typically with the UV-systems, when we're talking about flex-cutting we are going to be using a vacuum table to hold the board down. And so, using a fiducial recognition camera, the camera can pick up fiducial points that have been input into the board, have time and then the camera will automatically adjust the laser to those fiducial points to ensure they're gaining accurate position of the laser. So, the camera is also keeping diagnosing if the board has been misplaced, so whether that usual input air or it just happened to, beamiest place through automation system

21. The camera will recognize that and can adjust even if the board is slightly deformed or warped. The camera can take that into account and adjust the contour to make sure it's making a current cut. So, it's a relatively advanced system. And it gives you more dynamic control over the position of the board, so, you're going to avoid issues like you would see with dies, a lot of die misalignments happen quite often. And like I've mentioned a really UV-systems have repeatability accuracy of plus or minus 4 microns.

Now as I see into our next factor, which was yield or some of you, guys, call it mounting density. Yield (mounting density) can have to do with what we talked about width precision earlier. So your tool cut width plus the allotted zone for stress gives you your actual cut width. So, the smaller your cut width, the more boards you can fit per panel and also the more components you can place closer together on these boards.

22. So obviously, high density circuit boards are becoming more and more popular, and because of that components are getting closer together. And if you saw the final features we talked about earlier, you cannot combine all these things: the tool cut width, the final feature size, the stress and gives you the ability to mount components and boards more densely. So, that's very important when you're talking about one – reducing the size of boards and two – eliminating cost issues with trying to mount too few boards per panel.

Cutting speed, this is definitely a popular topic. Throughput time is very important 'because it's going to help with production, also your costs as well. Laser cutting of flex circuits is very efficient, so it's extremely fast. I'm going to give you some ballpark figures: two examples here, and I will cover them just give you an idea of how quick they could cut.

23. But typically to give you an idea on flex polyimide a laser about 2 to 3 times faster than a router. So, if you are using

routing it will be quite a bit faster. Like I said, polyimide likes to be cut by laser and it's relatively quick. Die punching, on the other hand, is one of the instantaneous processes, so once you've lined up the actual cutting process is going to be instantaneous. So, laser would be technically slower, but again, as you saw earlier, that 125-micron tech polyimide has been cut about 95 mm per second, which is very fast. So, the application on the left, the entire contour here is 582 mm and again it's 7-micron fleck polyimide with 18-micron copper, 10-micron nickel and a little bit of gold on top of that as well, and there is 2-micron stiffener here in the middle as well.

24. So, the laser has average cut speed on this piece is about 40 mm per second. And it can cut about 2 to 50 of these pieces per hour, so just under 15 seconds. Now we'll talk a little bit later too about cutting through these different thicknesses and different materials, but note that as well that the laser is not only cutting through just polyimide here but it cut through different material thicknesses as well. And on the right we have this rigid-flex application. So, the laser will go relatively quickly through the polyimide, it's going to cut through the polyimide which is 150-micron polyimide. It will cut with 80 mm per second. And then the FR4, the rigid bar, it's about 50 micron thick, and if you slow the laser down, because FR4 requires more energy, so it's going to cut about 20 mm per second. For total throughput time on this piece of about 50 seconds per board.

25. So, simple graph on polyimide cutting speeds. If you're familiar with the other traditional depaneling methods, this might mean something to you. If you're not really aware of those, then just note that laser is about 2 to 3 times as fast as routing. So, like I said really the thickness of the polyimide as we move right here, the thickness increases, that's going to slow your cut speed, cut speed down a little bit, but even 175-micron thick polyimide you're still cutting around 50 mm per second, which is very fast. So, obviously as it gets thinner, we can cut through quicker.

    Like I mentioned earlier, rigid-flex cutting basically all that's happening is we're changing the trouble speed of the laser. So, it's going to slow down around the rigid bar that ensures that we're going to make up 4 cuts through the rigid and to move the speed right back up. We want to get to the polyimide because the polyimide requires less energy to be cut.

26. Although this is the third time you see this application but it's a helpful example here for talking about versatility and design freedom, which is one of the last factors. So, how easily can you change the cut contour of your board? There is a heavy importance when you're talking about prototyping and even in preproduction and production it's important to be able to quickly change your contours. Whether you're switching to the new application you have a small vision to make or you just want to change you process control, it's important to do that quickly. So, die cutting is most limited, you really have to have a hard tool. If you want to make changes, you have to have a new tool. Routing and laser, on the other hand, are more dynamic. Like I said, you just input your data into the software. The

software will control the mirrors, and the mirrors will control the beam.

27. So, any part of the contour can be adjusted. So for example, here is what it will look like in the software. So, what you see here is different color changes and essentially different trouble speeds and energy inputs. So, certain parts of this board are closer together and we're going to get some more energy and some of these curves and contours. We're going to speed the laser up at those points so we're not going to burn it. So making small process adjustments is very easy and you actually change the contour of your board or just ensure that the board is being cut well. You can do that very quickly with the laser. Also notice these circle dots there, these are the fiducial recognition points I was talking about earlier. And just see another software can handle all standard file types .crbr , .xcrbr, .dxf, .exl, etc. the last goes on quite flexible regards.

28. Here is the example I was talking about with drilling, this one specifically to multilayer. The application you see on the right is 50-micron thick copper and polyimide with some adhesive there. And you can see the thicker your hole size, the then slower is going to be. We can achieve pretty small… pretty small beams here. So, 50 micron can be cut by 85 holes per second, that's very fast. Obviously, like I mentioned earlier, as the board thickness increases, the ability to drill cut is going to get slightly larger. So, the thinner the board, the smaller features you can achieve. The benefits of this: you don't see the laser delamination, then the high positional accuracy, and you do get ideal drilling geometries. If you're cutting through boards but not too thick, you can get a very straight cut.

29. So before I move on to our next topic, I would like just really quickly have a recap the trends I was talking about are: as boards get smaller and your higher component densities or your arbitrary cut contours, we're not going to see square circuit boards any more, then lasers are very flexible in those regards. All of the factors that we've just talked about earlier give laser clean advantages to other depaneling methods.

So, we're moving to the third topic, which was the other capabilities. So, first of, we've cover layer cutting, and cover layer cutting typically is, polyimide, like I mentioned earlier, that's very easily cut by lasers but probably the advantages are again: no mechanical stress, so you don't see the deformation you might see with the die punch, the cuts can be as small as 20 microns.

30. Theoretically, cover layer tends to be very thin, and so, you're going to see very close cut width to the actual beam size which is 20 microns. Again, you can cut arbitrary shapes and you don't run into issues like die misalignments.

Here is an example, this is a cover layer cutting application. 12-micron thick polyimide with some adhesive in there as well and it has a lot of pads working out here. So, the total pad count is 646 and this can be cut by laser system in under 30 seconds. So, it can do this very quickly and very accurately.

Skiving is another example. That was one of the things on other capabilities on list. Similar to cutting cover layer, skiving is cutting the cover layer one to thirty on the board.

31. So, whether you're doing rework or just looking to open up pads that have been covered by mistake or if that was intended from the start, you can open up larger conductive areas or you can clean out through also. Again lasers are very accurate and you can control it down to, like I said, plus/minus 4 microns plus the width of the beam. So on the left we have just pad opening, and on the right you have a 70-micron opening on the pad as well.

    The more examples of opening cover foil, you can see different sizes here: 200 micron, 150, 100 and 75. Also a note is that because you can very precisely control the energy of the laser whether that is the power of the laser or time of the laser's acting on the material, we can just cut through the cover layer. And so what's going to happen is you're not going to damage these copper surfaces and you won't get any residue because you're getting a perfect vaporization of the material.

32. I had a question: Does the skiving remove the adhesive as well? Yes, it does. So, it doesn't have to, like I said, you can control the energy pretty well. If you want to leave adhesive, yes, it will remove adhesive, if it's something you would like to do. You can control the laser precisely and you can remove the adhesive or you can remove it layer by layer whether you would like to see adhesive on the cover layer.

    So moving into the next application, here is one of cutting leads. So we just want to do, ablate the polyimide of these flying leads. This, I believe, is a 150-micron thick cut width here. So, again, minimal impact on the lead surface.

33. It's not going to leave any breeze 'cause they're vaporizing the material and have very high positional accuracy from the fiducial recognition cameras.

    This is one of my favorite examples and it's kind of showing all the last things I've talked about in one single step. So, we have rigid depaneling, flex depaneling and then ablation of the cover layer to expose the connectors. And this can all be completed in one single step. So, again we're just going to change the laser power at different points along the contour and then because you can do that, you don't have to have separate process steps set up to do each one of its jobs. Similar to that is rigid-flex decap, so as you can see here laser decap compared to mechanical, mechanical is a little bit more distorted: here we have some deformation. And then laser is nice and clean.

34. Again it's all because you can control the laser energy and speed. You only are going to be ablating the material that you want. I did mention quickly laser etching that is something relatively new, something that has been looked into plenty of times and it is an important step forward as far as processing flex circuits, but it's been difficult in the past, but we have successfully structured copper on polyimide which is a difficult test because as I mentioned polyimide likes to be cut by the laser. This is very easily done on rigid applications but polyimide being so delicate tends to burn right after we remove the surface metal. But we have been able to do this by controlling the process. So again, it's a new development, it's an important step forward and it's something that has been done, kind of research and

development level by ourselves as well as a few of the customers.

35. All right, so long as comparisons we have equipment and tooling costs, so let's talk about tooling costs. All right, we will talk about this in conjunction. Hand cutting, obviously, is going to be… the equipment and tooling costs are going to be very low, whether it's a pair of scissors or a pizza-cutter, that's not going to be a really comparable to what we're talking about as far as these systems serve, we can just disregard that. As far as the routing and die cutting systems are going to be relatively inexpensive comparative to the laser systems and the reason why is because they're not using as advanced technology. Laser systems have the laser sources that in itself seem to be relatively expensive, whereas you talk about the mechanical systems, they're just using standard CNC equipment that's been around for a long time. Depending on whether these are –

36. I didn't include real costs because depending whether these are prototyping of production level, the costs can vary so greatly. As far as tooling goes, however, with routing and die cutting you're running into the issue of having or buy hard tools. So, routing - typically you are going to buy standard bits that might not necessarily be customized bits but you're going to be wearing through them quite often. And so because of that you will have to replace them and tooling costs are going to be higher. Die cutting – they're all custom. So for each application you would have to have a different die and there's design cost that is going to that, obviously the manufacturing costs, and then lead time is on them as well. Lasers, because you are dealing with the virtual tool, there is not going to be any wear on the tool, and therefore, tooling costs are technically irrelevant. However, I do want to mention, and we get this question quite often, laser sources do wear out over time, however, laser sources allow for about 10 to 20 thousand hours of laser time on.

37. If you factor that in, that is a pretty long time before your laser source is actually going to wear out. We haven't seen any of the worn out machines yet because they haven't been installed for that long.

    This slide dives into the tooling costs a little bit more. So, again, bits: you don't have to be constantly replacing them, so you'll have lead times slightly quicker than in the die cutting which can be up to weeks because again they're all customized.

    So one more poll really quickly. I just want to get an idea of what your annual production level is. So I'm going to launch this poll. We'll spend about 30 seconds on the poll. Hopefully, everyone will get to answer, but again we have a larger crowd today. So, just 3 options on this one.

38. Are you doing prototyping and R&D, small or medium production where you're doing a lot of custom runs, not necessary the high level of runs, and then lastly we have full scale production, so you are not necessary doing a lot of variety, but you are doing large quantities of a few different types of depaneling applications. All right, so most of us have come through, I give about 15 more seconds. Again this doesn't have to be exact science, just a general guess of where you are with this. Some of you, guys, may be covering

more than one of these. If that's the case, just choose the primary one. All right, looks like the voting slowed down enough and I'm going to close the poll. I apologize if you were not able to answer.

39. And then I'll share that very quickly. You should see that pop up on your screen. It looks like 55% of you are involved in prototyping and R&D, so a lot of variety in your applications, again, we talked about this with the laser systems: they are great for that because you can dynamically change your applications so quickly. Small and medium production: we've talked of these advantages, whether it's speed or flexibility, or just the overall quality of the board cut. Let's go ahead and hide that.

    And we'll move on. I have a quick video here. I just want to show the system in action. So, this is the Microline 6000P – a production system. This video is relatively quick, I believe it's about 25 seconds.

40. So essentially what we are seeing here is where user has put the data here on the software. This has likely be done on the PC and then uploaded to the system. Within the software you can control all the different layers, whether it is your fiducial layer or your cut layer and you drill layers, so that the system can handle all the steps it requires. User uploads that data to the system, adds the board, as you can see here this is the flex board, it's on the packing table on a conveyor system for the production Microline. Then a fiducial recognition camera will dynamically pick up the fiducial points regardless of where the board has been placed on the packing table. It's just going to go ahead, move along and cut out that board.

41. The difference in this constant scan technology, it is just showing, that rather than cutting out one board at a time, it will just decide which cuts throughout the entire panel are going to result in the quickest cut of the board. The software takes care of it internally.

    Here is a quick overview. The system which was used was our Microline system on top here for flex depaneling. We're talking about these systems on the right because these are vacuum tables for the flex circuits. On the left these are going to handle rigid boards with fix frame. The production level system as you can see comes of conveyor belts. The Microline 1000 series on the bottom are designed for production but also prototyping in the small beta-runs as well. So, slightly smaller capital investment and as most of you have mentioned you are in prototyping and R&D, so you have a large variety and small quantities. Then this is more likely better option for you than the full production system.

42. With the production system there are automation options, so there is the loading magazine and conveyor system and these all connect seamlessly to a SMIME interface. They can communicate with the rest of your automation process.

    We talked about equipment costs earlier and if you're looking to get into laser cutting of flex circuits but you're not quite ready to make that capital investment as the equipment can be rather expensive in comparison to other depaneling methods then there are service providers. A-LASER is a trusted service provider that has worked with us for a long time. And they can kind of bridge that gap between actually purchasing your own system and getting started into laser processing of your flex circuits. So they are capable of handling anything we talked about today in the webinar – routing, skiving, drilling and depaneling. If you'd like more information, visit their web-site or contact us at the end of the webinar and we'll put you in contact with them.

43. That being said let's move in the Q&A. As you can see I've displayed the contact information for Mirela Orlowski, she is our Sales Engineer and she is joining us right now. So what will happen is all go ahead and roll through these questions, I'll say who'd answer it and then ask the question and I'll go ahead and repeat the question and then I'll have Mirela or myself who answer it. So as we are doing this feel free to ask any more questions that you'll have coming in and we will spend the next 15 minutes doing this if we have enough questions.

    Mirela, we have a couple of questions about thickness. I know it's a pretty general question but, do you mind giving us an overview on how thickness is going to affect the cut width and the processing of circuit board?

44. When it comes to UV-laser systems or at least RUV-laser systems we say that the sweet spot when it comes to thickness is 1 mm or below. The laser can definitely cut 62 mils thick circuits, so about 1.5 mm or 1.57 mm, and it can probably even cut 2 mm, I think we've done that in the past while doing samples, but what happens is that your cycle time gets affected. The thicker the PCB the slower your cycle time is. So, if you want an effective process in production, probably… If you're cutting tabs 62 mils thick it is not a problem or if you have a scord board 62 mils thick that is ok but generally 1 mm and below will work best.

    One question that I did answer about the drilling applications but I didn't quite answer the full question: Can you drill in a rigid portion of the rigid-flex circuit? - Yes, absolutely, you can.

45. Mirela, what is the largest XY-board that you can fit into the laser system? We have as you saw two different platforms of the laser: we have the smaller laser which is 1000 series system and then the larger system that is the 6000 series system. So, the largest board can of course be placed in the 6120P and that one is 21x24. The smallest system's table size is about 10x14 inches. Keep in mind that system has an opened up front, so we've had customers who had maybe 10x16 or something like that or 10x18, and they maybe had 10% of boards that are large like these and everything else fits in the 10 x14 panel size.

46. So you can really overhang your boards in some cases if you have really low percentage of those and what you would do then is that you flip it over redo the process on the other side? But with the large systems 21x24 is the maximum panel size.

    As I mentioned earlier the material is being vaporized, so Mirela, where does the material go and once it's vaporized can it be contained for places like clean rooms?

    The system comes with the vacuum exhaust, so pretty much every system comes with the triple-filtration system and has a prefilter, charcoal filter and a Hepa filter, so you can technically exhaust back into the room as well. It is completely safe. You can cut all sorts of materials, and we cut them in our application's lab every day, even nasty staff like brilliant copper.

47. That is not a problem, when it comes to clean room it all depends on what level of clean room you're talking about.

I've got a question from Ed: "Can skiving cut traces when needed?"

Yes, the one great benefit of the UV-system over CO_2, for example, is that UV can cut copper. This system can cut, drill, skive (you named it). We've done random samples from of course regular depaneling or drilling all the way to removing paint on acrylic for displays. So, there is really a wide variety of applications the system can handle.

I've got a question from Steve: "For a double-sided flex card would a custom fixture be required for each product since neither side would be flat?"

48. You do not necessarily need some really complicated fixture. What you want to make sure is that your body's link is flat. The demo system we have in house is actually level 20P model which is a model with a vacuum table. So, what we'll often do is we will shim the sides to make sure that the body's link is flat. That is very-very important when you're hitting it with a laser because the beam comes with the 90-degree angle. But you don't have to have some special… a little bit you can shim it, and as long as it is flat you're OK.

A question from Dean: "Mirela, could give you some ballpark figure on the systems?"

Yes, so the smaller systems are in the 220-thousand ranges with installation, so everything is included. The large systems are in the low 400-thousand-dollar range.

49. It depends which system you go with and it depends with what options if you want to add any options. I just want to make one thing clear: you don't have to add any options and it's not like you buy a system, and then options are required for it to work, no, but the large systems have some software options like data logging and tracking for medical companies. So, if you're interested in adding something like this, it would be additional.

When you're processing the circle boards, obviously, CO_2-lasers need like a processing gas. Do we need that for the UV-laser systems? - No.

All right, question from Mario: "Does the table move or just a laser-head?"

It depends on the system. For the small systems the table will move. For the large systems both the table and a laser-head can move.

50. Can your system find an edge and cut tabs relative to that edge rather than from fiducial marks?

Yes, so for the small systems they use slightly different versions of software, so the small system comes with more simplified software. You can do everything with a small system that you can do with the large system with the exception of fiducials. So, when it comes to fiducials the small systems will just read or look at like some dots or circles or something like that. So they will look at marks on your board. You can manually use the camera and go to the edge and use the edge of the board itself but for the large system the software is a little bit more sophisticated and you can actually use the edge of the board as a fiducial and this is used quite a bit if you're working with rigid boards that have been pre-routed because you want, like with the routers that are not as accurate as a laser, you want to

51. Take into account the percent air there. You can read the edge.

A question from Jim: What are the general tolerances for outline dimensions under 30 mm? Is it better than plus or minus 1.5 mm?

All of the tolerances are in microns, so there are all sorts of tolerance numbers that we have depending on kind of this-repeatability and that-repeatability and so on, but in general it is plus or minus 20 microns, and that's a super-super conservative estimate.

A question from Meng: Can this be used to replace plasma etch?

52. It depends on your application. It depends on what kind of etching you're doing and what your material is and so on.

From Brian: 'Have you used this system to remove conformal coding, IE-eurothin or pearlin?

Yes, actually the systems work really-really well on removing coding. It all depend on that we have to test the simple coding 'cause you never know how the coding is going to react to the UV-beam. A pearlin is one of the things that we've done and some of our customers use this system or exactly these applications. They remove coding from some sort of pads or something like that. And in fact I have a couple of samples in house right now where I'm removing coding from stainless steel and glass and so on.

53. I think we've had this question but it's always good to reiterate: Would cutting 100-mil material require 2 tools with different focus on each?

It depends on material itself. So, if you're doing something of 1mm or below typically you don't need two different… I mean you always use one job and you don't need two different tools. When you're cutting that's 1.6 mm, so 62 mils, it is a 2-step process. You want to low your focus and the focus of the beam to make sure to cut through the bottom part clean and straight as well.

Just to reiterate, when we were talking about the size of the boards that you can fit in the systems

54. It's in inches, so that's 21 by 24 inches for the large system and 10 by 14 for the smaller systems. That's getting close to about all our questions. If you, guys have any more, please feel free to ask them now. If I missed any I apologize and will go through them at the end of the webinar and we'll be able to get a hold with you after that. Also as I mentioned, here is Mirela's contact information, so feel free to send her any questions after the webinar. We'll also be sending out e-mails with the recorded webinar links, so you can pass it on the colleagues, and I'll try to include the slides as well.

And I'll send you the specs for the machines as well. I'll try to send everybody an e-mail, so you have my contact info, but please feel free to contact me, and if you're interested in the systems, so we can send some samples for you and so on. But it is definitely, it's application per application basis.

55. So we want to make sure that your application is a great fit for UV-system because in some cases it may not be.

    A few more questions came in; we have about 4 minutes to the hour. How about marking data, bar codes, etc.?

    The system can be used for marking and reading bar codes and so on. The small system – that's the one difference that I was mentioning in the software – where you can add a software option in large system and that will be it. You can actually add the package where there is a data logging and tracking, so you can read bar codes. Sometimes some of our customers don't want to cut all of their boards, so if you have some boards that are, you know, bad boards, they will mark them and then the software pretty much will read a symbol.

56. Notice that it's about board that is not marked and so on. And then of course the system is able of marking anything. When it comes to the small system though to be able to mark series of bar codes you would actually have to load them in the data. We don't have a software option where the system itself can generate the next bar code for you.

    Looks like the last one here: Do you have any demo units available?

    We have demo in house, you can come and take a look at it, and we can run some samples for you, if that is what you meant. If you're talking about demo units for sale give me a call. We'll talk.

57. All right, one last question from David and we'll wrap this up: I know that the accuracy of system was plus or minus 4 microns. Do you know any solution less than that?

    Not really. And this really depends on your application. I mean it depends on if you're cutting something really-really thin, you know, we talk about flex circuits. The accuracy may even be better than that but we always like to be on the conservative side. But personally, no, I don't.

    All right, great, so with that we go ahead and wrap up the webinar. Thank you, guys, for attending. We're right about an hour, so I hope we didn't cut your lunch breaks or afternoons too much. As I said I will send out the e-mail with recorded webinar link, please feel free to pass there along to anyone that you feel may be interested. Also I hope we'll have a link to the slides as well. So, again thank you, guys, for attending, and we look forward for any future correspondence with you. Have a great day!