PCB Depaneling with Lasers

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Welcome to the webinar “PCB Depaneling with Lasers,” a comparison of laser to other depaneling methods. Laser has a lot to offer. It’s a newer technology that has many advantages and a few disadvantages that aren’t widely known. So today we are going to put to the tests, we are going to compare it to other more traditional depaneling methods.

My name is Josh Brown, I’m a marketing development representative with LPKF Laser and Electronics, the company responsible for today’s webinar. During the webinar if you have questions there is a questions panel that looks like this on the webinar screen that should have popped up on your screen when you logged in if not then you’ll see that small tab right here. If you hit that little orange arrow that would normally be right here when the thing is collapsed then it will open up and you can enter your questions in here. If I feel that those questions are pertaining as they come in I’ll try to cover them during that slide. Otherwise we’ll save them for the end of the Q&A at the last 15 or 20 minutes of the webinar. Please encourage questions, if you have them that’s great, it helps to keep a dialogue going. Also it’s good for us to understand what type of information you guys are looking for our future webinars.

Topics

So today we are going to cover 3 main topics. First top will be the methods comparison and this is where we’ll spend most of our time today. This will be covering essentially mechanical methods which are routing, die cutting and dicing saws versus laser methods. And again it’s going to be the middle of the webinar and we’ll spend about 25 or 30 minutes on this. Topic number two towards the end of our webinar covers CO2 versus UV lasers where we will focus just on the laser world and we will break down the difference between those two methods. And then finally we will finish up with few other applications and capabilities of UV lasers that are outside of the depaneling but are worth of known. And then finally at the end we will have a Q&A and I’ll give you some contact information if you have questions after the webinar.

Method Comparison

So let’s move right into our first topic which is methods comparison. There you have six methods, the top one here actually hand cutting we really are not going to cover that much. I included it because it is still used not as often and I feel it really stacks up with what we are trying to talk about today. Most of you if you are interested in laser at all it’s probably because you have more complex boards and hand cutting it’s not going to really stuck up to that very well.

So what we are really be focusing on is mechanical methods which are routing, die cutting and dicing saws. And a kind of stack those up against UV lasers and CO2 lasers.

So I prepared this chart and this is just a vague overview chart of basically the topics that we will be covering in today’s webinar. So up top you can see these factors that we are going to be comparing the methods by. And these factors are actually the outline of today’s webinar. So don’t pay too much attention to this, this is just a vague overview, we may come back to it again .Just a kind to give you an idea of the overview of how these methods compared to each other. But we’ll jump in more details based on each one of these factors. Also these factors are split into 3 categories.

So miniaturization, this is a kind of a trend today. Boards are getting smaller and thinner and more complex. And these three factors stress to the part, finer features and damages all fit under miniaturization. One thing I want you to know about the stress to part is the difference between mechanical stress and thermal stress. So when we are talking about mechanical methods hand cutting down to dicing saws, these top four, these are mechanical methods and they are providing mechanical stress. The UV and CO2 lasers however are providing thermal stress to the boards. I'm going to talk about the amount of stress that is one note I want to make right now. Although CO2 has a plus here right now when it regards to thermal stress CO2 is actually going to be a negative in comparison to UV lasers. Again keep in mind the difference between mechanical and thermal stress.

The second of those categories is going to be cost reduction. We'll talk about equipment cost, tooling cost, yield or mountain density of the boards and then throughput which is the big one.

And then finally our last one is versatility and we are going to a few different factors in versatility. And those will be design freedom, changeover and then also versatility in material that these methods are able to cut.

Stress to Part

Let's move into our first factor here which is stress to part. So as PCBs get smaller they are also getting thinner. And they are having higher component densities placed on them. And so essentially it's really becoming easier to damage a board. All these methods especially mechanical methods are running into issues when boards do get small. How easily they can depanel them without having board rejects and failures later on in the board life? So as you can see this PCB is quite small sitting on top of this fingertip here. This PCB is for hearing aid. And it's a prime example of a PCB today, very small tab cuts and it's a very thin board. In fact this board is about 500 µm in thickness and this is an FR4. So this will be a very easy board to damage Different types of damage that you might see on a board like this will be barrier formation, distortion of the board, micro cracking and delamination . All these things can lead to board rejects again or you can see failure later on in the board life.

Stress Analysis

So we are done as we put together a study a stress analysis study. And we have these three methods on a side that we compared. And then as you can see the stress increases as we go up. So dicing saw on top is providing the most stress within this study. And then as we move down you can see mechanical routers. Although they are a little bit better, they are still providing a good amount of stress to the board. Now notice we didn't put die cutting on here. That's because of two reasons. Die cutting it's an instantaneous cut almost. It's really just cracking the board whereas these analyses are done overtime. So it's difficult to measure the same amount of stress. But as you can imagine a die punch is essentially cracking a board of your knee. It's going to have a significant amount of stress to the board. So as far as stress and damage causing factors die cutting will probably be somewhere in between dicing saws and the mechanical routers. Also die cutting in most cases requires tab cuts. It's one of the methods that does require tab cuts because of without tab cuts it's trying to put stress across the entire contour cut along the PCB would provide too much stress. And so typically tab cuts are required. So as you can see down here as we are moving to the laser there is no stress put on a board. Not just because it's a non-contact process. And the material rather than being broken or cut away is being vaporized. And so lasers were capable of controlling energy very precisely. And we can do this through the fact that the beam spot sizes are very small. And also the fact that we can control the energy and the travel speed of the laser to very precise accuracies and this allows us to provide very little thermal stress to the board as well.

So moving back to methods just a quick overview. Again this is mechanical so we have negatives all the way through, routing tenses to do slightly better job than die cutting and dicing saws. And then as far as mechanical stress the laser methods provide none. Thermal stress though again remember CO_2 is going to provide quite a bit more thermal stress than the UV laser. And we'll talk about that towards the end of the webinar.

Finer Features

The second factor we move into is finer features. Obviously as boards get smaller they are going to require a higher level of precision. This is a very prime example of a PCB or a complex PCB I should say. This is a flex polyamide. And just to give you an idea of a size it's about 5.5 cm. so it's not small but it's not a large PCB by any means. And then just another reference point the inside of this fork is about 1 mm. So just to give you an idea of a size of somebody's features. As boards get more complex then more complex depaneling methods are required.

So when we are talking about finer features the number one factor that is going to play in this for your depaneling method is really the tool cut width. So this chart displays the potential cut widths. They can all be higher and in some cases lower than these depending on the tolling used but these are kind of averages for all these methods. Also keep in mind that these all are going to depend on the material thickness. So we are generalizing a little bit here. The material thickness is definitely going to make a difference especially with lasers and we'll talk about it at the end again. But the material does play into the width of the cut.

So hand cutting we are not really going to cover that too much today. Routing and die cutting have about 1mm tool cut width on average. Dicing saws can do slightly better at about 0.5 mm. And then as we move to the lasers this is really where the lasers shine. But the beam spot size and essentially it's a virtual tool, but the beam spot size is about 20 µm for both of these. Now the difference between the UV and CO_2 and the reason why their actual cut widths are larger than 20 µm is because of the amount of energy applied to the board. The more energy applied the more material is going to vaporize and the wider your cut widths are going to be. CO_2 is significantly larger than UV because it's providing more energy to the board and then you are going to vaporize more material. So although 120 µm it's still a pretty small cut width UV can be pretty significantly just based on the fact that it's not applying as much energy to the board.

So here is another example of very fine feature where the feature is actually the contour of the board itself. This small PCB is about 3.2 mm in diameter and it's designed for a mike. So you probably have seen those mikes on actors or interviewers' shirts. And it's obviously designed to be very small to fit inside that mike. So when we are talking about finer features of this, a couple of things to notice is how close the components are to the edge of the board, they are almost perfectly to the edge. Now this board was depaneled with a laser, a UV laser. An issue you will be running to trying to cut this mechanically would be one: you will have tough time placing the components this close to the edge of the board, you are going to create too much damage. Besides there are really two factors that are playing to it, the damage that you are going to create with a mechanical stress has to be accounted for, the more damage the more stress, the larger room that needs to be compensated between the panel and the board. So that amount of stress needs to be compensated otherwise you are going to end up damaging the board. And we'll get into this a little bit more as we will talk about mountain density later too.

The other factor is, excuse me, I lost my note there, so besides the actual stress applied to the board, the other factor is the size of the actual tool. So can the router or a die cut fit within this as far as the width of the tool cut that we talked about earlier? And again this is a very small board so you can imagine with the router or a die cut which has a tooling cut width of 1 mm That's nearly the same size It's about the third of the size of this PCB itself. So you are going to run into issues with that. Also a die cutting you run into issues of die misalignments. And you can imagine with so many PCBs mounted on the board like this. Even a slight misalignment can be catastrophic to the failure or success of this board. So for applications like this laser really does do good job. Precise control of the laser energy, the fiducial recognition cameras on the lasers are able to ensure that there is no misalignment, so the cuts are very accurate and repeatable.

So moving back to our methods comparison. I will just give you a quick overview. Finer features you run into issues really a kind more neutral with these more traditional methods, the mechanical methods. And then UV lasers are excellent for this. CO2 gets a neutral plus mostly because it does have a slightly larger cut width than the UV laser. Remember this is about 120 µm and actual cut width compared is about 25. One thing to know about dicing saws we will cover this a little bit too is the flexibility of it. Remember dicing saw only cut really in a linear fashion. So with routers, die cutting and laser system you can get more complex contours. Dicing saws are pretty limited to just a straight line.

Debris

All right, so we are moving to our next factor in miniaturization is. I really have listed it as damages but we have a kind of talked about the damages, the deformation, the delamination and all of those are covered during the stress. And so one thing I want to bring up on its own is a debris factor. Debris is caused typically through mechanical methods. It's when the board is cut or broken and small amounts of particles are released into the air. And they can be undesirable for two reasons. One, they can contaminate your board or they can cause cleaning and maintenance on the equipment. So whether the board has extreme cleanliness requirements, say there is a small camera or a lens on the board then that can obviously cause rejects or issues processing of that board. And then secondly if it's a lot of debris like some methods cause such as routing then you can see the issues where you will have to clean the maintainer equipment more often. Laser typically doesn't have issues with this. UV laser definitely doesn't but CO2 can run into issues with carbonization sometimes. As the laser cuts through the side of the board it can actually burn the board. And this burning turns into char or carbonization. And then as the edge of the board is rubbed either on the conveyer or with through a clamp tooling that carbonization can be broken away from the board and can become airborne. And again it can contaminate your board or the equipment. So typically lasers don't run into these issues much as mechanical methods. With the CO2 laser depending on the way you process your board you can't see some debris from it.

Equipment Cost

So let's move into, actually I'm going to come back here. So we've covered miniaturization, we are going to move into the cost reduction section here. First thing of, we are going to cover equipment costs. So just a kind of a general overview. It's really tough to give exact pricing for all of this because different systems can vary so much, especially depending on if you are talking about production system or prototyping system.

So we just a kind of throughout plus minus rating system here. So obviously hand cutting is going to be very cheap if you are talking about scissors or pizza cutters. The equipment cost involve is nil. Routing, die cutting and dicing saws these machines are significantly cheaper than laser sources. This is typically because they are not using a lot of high tech equipment. Really it's just a CNC style machine in the way they move and there is not a lot of other high tech components involved in these systems. However they can get quite expensive especially as you get into production systems. This is definitely one of the big barriers for getting into lasers for depaneling. It's just the initial capital investment. The laser source itself tends to be the most expensive part of the laser depaneling system. And although the laser sources are getting cheaper they are still very expensive. So these methods on the bottom are slightly more high tech and so definite barrier to enter.

Tooling Cost

However one thing we do need to take into consideration is tooling costs. So tooling costs can be incurved throughout the life system and depending on the method you use and the tools you use and the requirements you need out of those tools. In some cases tools can cost you even more than the actual system itself. So it's definitely the factor that needs to be taken into account. Hand cutting same deal. Very cheap we are not going to cover that too much. Routing however can be one of the more expensive methods as far as tooling cost goes. Bits can cost quite a lot, they have to be very specifically machined especially as you start to get down into smaller bits with more specific purposes. With mechanical tools remember you are going to run into the issues with they are going to get doll, they are going to break, they are going to wear out and they have to be replaced. So not only how the tools are expensive but the more that they are used or the more precise the tool is, especially. Then it's going to cost more and it's also going to wear out faster. So you are going to have costs all the time.

Also I have introduced this new header over here which is lead time. So bits typically they are not custom designed like a die cut would be, I'm sorry, like a die would be but they are very precise and so they can cost quite a bit but they still take days or weeks to ship to you. And so you have to take into consideration that the administrator of cost on this, it's the logistics of it, the handling of the tools and the storing of them and then the time it takes and you can lose on the opportunity cost in that way. Die cutting also can be very expensive. You have to get a custom die for every new cut you want to make and because of this your lead time is going to be even longer. Dicing saw blades don't tend to be as expensive just because they are a little bit more standard. However they still have lead time and they can cost quite a bit depending on the thickness of the saw that you need. Here is another advantage of lasers. There is no tooling cost involved. The tools are virtual they are not going to wear out. So you don't have to account for this. There is no lead time involved. If you want to change for application you don't have to go and buy a new bit or design a new die. You just upload new software. And the laser is dynamic and it's going to change and adjust to the contour that you tooled it to.

We do get one question on our slot so I'll just head it off right now: how long does a laser source last? And buying this laser how long can I expect before the laser dies out? And the answer is 20000 plus hours. So it's a long time. If you are running this five days a week on an 8 hour shift that's 10 years. So whereas with mechanical tooling, hard tooling you are talking these things running out on a monthly basis, wearing out on monthly bases or breaking even more frequently than that, so 10 years is quite a long time. And then another question also really quickly that I'd like to dress. The laser does degrade all the time not significantly but it will and the systems do have systems within themselves that will measure the output of the laser and then ensure that it's doing the same, it's making the same cut throughout the life of the laser based on its degradation all the time. So you don't have to worry about it but the laser will eventually die out but it's going to be not for 10 years.

Moving to the third topic of cost reduction is yield or mountain density, as it's often called and basically we are talking about how many circles we can fit on a board with the least amount of wasted space. This is becoming more important as circles are getting smaller you can fit more on a board however you are running with the issues again of the damage. This goes back and plays into the two factors we talked about earlier which was stress to the part and the finer features or the size of the tool cut with. Obviously the larger tool is going to have a larger cut width and so you are going to have least yield and wore waste. So mechanical methods are going to struggle with this little bit more than lasers because the lasers are a little bit more precise. And then again more stress more room has to be compensated in between each PCB. So mechanical methods with the stress slightly more room that is going need to be compensated and you are going to get a slightly lower yield.

Remember we talked with routing and die cutting you have an accuracy of about 1 mm. And recall this is the same PCB we talked about earlier , that's about 3.2 mm across so these cuts need to be smaller than 1 mm and with this closely mounted as these are it's going to be very difficult especially when you have a factor of any stress that can take place between the two boards.

Dicing saw will be completely incapable of this because it can cut a linear fashion so dicing saws are completely out of question here Lasers however very capable of cutting this boards out. This was again done by UV laser very precise, very controlled energy amount These PCBs were depaneled very easily. CO2 lasers can potentially do that but you can see a lot of damage to the board. You won't be able to get the components as close to the side as you would here. So again probably you will have to account for a little bit more widths in between the two boards.

Throughput

And then our final topic I want to cover as far as cost reduction is throughput. So it's really difficult to give a universal quote on throughput, and say this method is much faster than this method or UV can cut UV lasers can cut this this fast because there are quite a few factors that play into throughput besides just a cutting speed. And we will cover the cutting speeds. That's one question we get very often. So what I want to do the factors that are going to determine the throughput can be cutting methods. And that is going to change, have quite a few factors involved also the materials used, the contour of the features, the material thickness and then again the cutting speed what we will talk about here in a minute.

So what I'd like to do because I can't give you a universal quote on all of this and a good throughput time because I'm going to show you some examples and hopefully give you a ball park idea of what we take to depanelize and how long it would take. So this board here, recall this is what we talked about earlier, this was the PCB for hearing aid and tab cuts and this is 500 µm thick FR4 so it's not real thick material which is ideal for UV lasers. This can be cut out the entire board in 3.2 seconds, this is about 350 per hour. That sounds nice and fast and it is. But that's because this board is 500 µm thick, it's in a perfect range for UV lasers to make this cut.

As we are moving to the middle PCB here, this is F, I'm sorry, this is a polyamide and it has a lot of fine features. You can see the contours here the laser had to make some seriously crazy traces to get this board cut out. But still the UV laser was capable of depaneling 250 of these per hour. So just to give you some ideas on cut speeds, the contour on this board was 582 mm contour all the way around and the average cutting speed was about 40 mm per second which is actually relatively slow for this type of material. That's because you have to account for the connectors in here and there is also some inhesion is involved that can slow the laser down plus the contours, this is one where you have all these contours where the laser needs to slow down or speed up in certain parts to ensure that it's not going to cause too much energy and cause distortion to the board .

I've got a question; hold on just a second, I will see if this is one I should answer. That question about ceramics. I will let Mirela handle this at the end. Just so you know. So UV lasers are capable of depaneling ceramics and we'll talk about some material towards the end but Mirela will be able to help you answer that more specifically. Finally our last application over here on the right. We have a region flax application and so I don't have a total throughput time on this but cutting speed wise. So we have a 10 mm thick FI40 and the laser can cut this in 10 mm per second. It's moving relatively fast, it's not a great speed but it's pretty good. As it moves to the polyamide, this is a 6 mm thick polyamide and the laser speeds up to about 35 mm per second and it's effective cutting speed.

Cutting Speed Comparison

Actually I'm going to kick back here. So we are going to move here to cutting speed comparison before I go back to the methods comparison. Cutting speed obviously is going to play a big factor in your throughput time. So we put together this cutting speed chart I apologize I had no time, it's not entirely complete. It's actually very difficult to poll universal cutting times for all these methods. So these are all drawn from individual applications and each one's application is different and there is not going to be a lot of contiguity throughout this comparison. However we do notice it's important we a have a lot of questions about this. We are working on actually compiling a more complete chart. But for now that's what I have to do

So let's cover this real quick. Let's talk about FR4 and then down below here we have different thicknesses in millimeters, so 0.3, 0.5, 1mm and 1.5. These are pretty standard board thicknesses. With routing this can be cut in 25mm per second. Pretty fast routers do, that is one advantage, they do cut boards pretty quickly.

So as we move from routing to dicing saws, dicing saws do speed up but now remember, dicing saws can cut only in a linear fashion, so two D contours and that's all you get. As we move down into the UV lasers we slow down a little bit especially if the board thickness increases and that's one topic I do want to bring up and that the laser systems are going to be slightly more influenced by the thickness of the board. So as you can see here it's about 1. 5 mm. We have 0.88 mm per second. Not a super fast cutting speed but we get faster as we decrease the thickness of the board. And then as we jump from 0.5 to 0.3we see a nice little spike here and speed. So what we typically recommend is that for UV laser 0.8 mm is about a typical board thickness that we would like to see. Anything below that you are going to have an excellent cutting speed, anything above that can be depaneled however you will have to run into issues with cycle time.

CO2 lasers significantly faster than the UV. We are going to talk about this. Again the comparison between these two and the trade-offs you will see later on. But as far as shear cutting speeds the CO2 laser does have the advantage here. As we move into the polyamide, again I apologize for the incomplete data but you can see that polyamides typically a lot thinner and it does really like to be cut by the laser. So you can see it's much faster here, 75 mm per second and 95 mm per second.

So jumping back to our methods, recall, remember throughput is not just a cutting speed it takes into account more factors than that. But you can see mechanical methods do have good throughput times and then cutting speeds. And then lasers do good. CO2 is also very fast and this regards definitely is going to be faster than the UV lasers. But again I'll show you a trade-off in a minute. So let's move into a versatility and finish out methods comparison.

I apologize; I clicked the wrong button on that slide. Give me one second. OK, so here is an example of board thickness that I want to bring up. These are both cut by the UV laser. And so we have 1.5 mm thick FR4 cut here and this is 1.35 mm thick FR4. Actually this is routed out and so this FR4 is probably about the same thickness as this one but you can the routing here. And so the tab cut was actually just done through 0.35 mm. Now you can see the difference in the amount of burning on the side of the board. The thicker we get into with the UV laser the more energy has to be applied to make a cut. And then you are going to see more burning. One thing I want to notice, this is on the side of the board. So it's really just a superficial burn on the left here. Where you really run into issues with burning in laser systems is when the burn comes on the top of the board that's where you can see short through cuts. However UV does not typically have this problem although it does not look really pretty right here functionally it's fine. CO2 laser are going to tend to cause more burning on the top and bottom of the board.

Versatility

So versatility in design freedom, basically how easily can we change the contour of the cut? So this has a heavy importance in prototyping and preproduction but it's also important to have some of this design freedom for high volume runs as well. Whether you are changing to new application and you need to change a contour or you are just adjusting a feature on an existing application then design freedom can help with your time to mark it etc.

So quick example. Again we have this PCB depaneling application. And you can imagine with the hearing aid as this is for that you are going to have a right and a left hearing aid. So using mechanical methods, first I want to bring up is die cutting. You'd have to have two completely different dies to cut both of this out. So the application is going to require switching tooling out or essentially having two different systems depaneling these at the same time. Routing, more flexible it's a dynamic system, it's just the data involved and that's the same as the lasers. So if you want this with routing or laser systems and you want to make a change to the contour of the cut, all as it is, it's just uploading the data to the software and the tools are going to react dynamically. So flexibility with layout changes routing and laser systems are definitely going to have a benefit over die cutting here. And then again dicing saws linear cuts only and so you run into that issue and you are not typically able to cut boards like this with complex contours.

So one more example of design freedom. We talked about this PCB earlier. So if you took this and you looked at it from the software stand point with the router or laser system it looks something like this in your software. Now to change the feature all that it takes almost as dragging draft, it's like using paint, slightly more complex but you get the idea. You want to change the contour you can just move it around and the tool is going to react dynamically. So again great for prototyping and preproduction But if you are in production and you need some quality control say one part of the board is being damaged more than another part of the board then you can make small changes in the speed of the laser moving around this board, I'm sorry, moving around the contour. And you can quickly adjust to quality issues you are having with the board. So definitely another excellent feature of the dynamic design freedom that you get with the lasers and then also you get a little bit with routers.

So continuing on versatility we have materials, this is the list of materials, the most common materials cut by UV lasers. And so these are all very easily cut with UV lasers: FR4, polyamide, Teflon. As we mentioned earlier, yes, we are capable of cutting ceramics very well. Aluminum, brass and copper, PET and beryllium copper which is kind of interesting new one that we've been doing lately.

Now as far as it stacks up to routing, routing can cut all this as well but with a few more limitations. So let's go through these limitations really quickly. FR4 cuts fine, polyamide routing is going to do good with. However because of the mechanical stress put to the part and the thinness polyamide new tendency some more deformation with routing on polyamide. It can cut Teflon but ceramics feels Teflon it's really going to dull your tools really quickly. Routing is capable of cutting ceramics however it can only cut non fired ceramics, it cannot cut fired ceramics. It's capable of cutting aluminum, brass, copper, and PET. But as we jump into beryllium copper, yes it can cut it but we wouldn't recommend it as the dusting debris of beryllium copper is highly toxic and it can cause safety issues.

Die cutting is also capable of cutting just about all of these. However again you are going to run into the issues of stress as we get thinner boards and the brittleness of some of these types of materials. So really laser has a great versatility through all these materials.

One other factor before we move on to the comparison of the UV with CO2. As far as the versatility and materials go, it's not just the versatility that cuts the materials but it cuts them as the same job. So in this particular application we have regent and flex depaneling taking place and then also we have connector, we are uncovering connectors, skiving or blading on connectors. It's not technically depaneling but it's worth noting. So which methods can handle cutting regent and flex within the same job? Just about all of them. So the difference is going to be again with lasers. Again you have very precise energy control. And so you are going to run into issues, I'm sorry you won't run into issues when cutting through different types of materials, different thicknesses because again you can go back within the data and you can change the power of the laser, the speed of the laser and it's going to adjust to those different cuts very easily. However with the mechanical methods such as routing or die cutting you are going to run into the issues where you are stuck with the hard tool and so you are limited to adjust to that process. So you are probably up seeing some damage to one type of material more than other and you are going to struggle to adjust to fix that damage. So if you are seeing micro cracking within the regent part of the cut and it's cutting the flex fine you are a kind of stuck and it where you are going to retool the entire process.

So that covers versatility. Let's move back. I'll just give you an idea. So again UV laser based on the materials and the contours it can cut and the dynamic design flexibility excellent with this. CO2 only gets a worse rating just because of the fewer materials that it's capable of cutting through effectively. And obviously die cutting is extremely limited on the versatility, the same as dicing saws. Routing gets better, it's a neutral plus, it's going to struggle with some of the materials. However its dynamic design freedom does give it quite a bit of versatility.

So let's move into our comparison. I'm getting some good questions. But again we are going to cover this quickly because I feel like I have some time to answer them still within some of the slides. I've got just a few more minutes on this.

CO2 verses UV laser depaneling

So CO2 verses UV laser depaneling. The big difference is really energy input. CO2 has a lot more energy whereas UV imputing less energy into the board and it's going to be doing the depaneling more of surgical nature. Best way to show you the case is to give you some examples. First one we have has 125 µm thick polyamide. And so the first thing I want to draw your attention to is CO2 over here on the left. UV on the right and the effective cutting speeds. So 860 mm per second with thCO2 laser and it's going to drop to 95 mm per second with the UV which is still very fast but it is significantly slower than the cutting speed of the CO2 laser. However like I mentioned earlier the trade-off is cutting speed for the surgical precision of UV and so you end up with applications that look like this. So yes although you are cutting faster with the CO2 laser you are sacrificing quality pretty quickly. So a couple things just to notice it's burning and deformation of the board compared to very clean cut you see with the UV. And then another thing to know is the kerf width. As we mentioned earlier about 125 µm thick cut width and then UV stays very precise to its virtual tool being spot sized about 20 µm so it's going to have a little bit of give and take here so it's about 30 µm on this application. And then also to know, UV being a little more forgiving with its energy input. It only took one pass to cut through this board. But because CO2 is providing so much power to the board we had to move it extremely fast and it had to take 4 passes to cut through the board. Any slower you would risk just burn this board to the pieces.

Some more applications with FR4. As you can see again much thicker cut width on FR4 the UV laser is much thinner and more precise. And you can see a pretty big variant with CO2 laser as well, 120 to 220 µm. And it's a lot of burning and differentiation throughout your cut. There is one thing I do want to recommend max thicknesses I say recommend because both of these methods are capable of cutting thicker than what we know here but this is what we like to see for both of these methods. CO2 is going to be capable of cutting slightly thicker than the UV and as I said UV can cut thicker than 0.8 mm but you are going to sacrifice cycle time. So typically with the type of applications you are looking at to be cut with the UV lasers cycle time isn't really the number 1 focus. The clients are asking for quality and precision so that's why UV lasers selected. But cycle time is always an issue. And so it's to know, the thicker you get on the board the faster your cycle time is going to go up. So I hope this answers on the questions a little bit on the thickness of the PCB it can cut, really it's material depending. So I now I say 0.8, it can change based on the type of material you are cutting. And it's hard to give a universal quote, we can cut much thicker than that but then you sacrifice cycle times. So if you want to see good through put times with good cutting speeds as we talked about in the last few slides then you want to stay around 0.8 and if you want to get even faster then dropping that board thickness is going to benefit you significantly.

So let's do a drag comparison UV to CO2. I'm going to go through it pretty quick so we'll have time for some questions. Actual cut width UV is definitely going to take a cake. Burning and damage with the UV you will see it very little and when you do it's very infrequent. With the CO2 it's going to happen consistently and the burning is going to be much more significant and it can actually cause failures to the board. The max board recommended thickness again 0.8 to 1.6 mm, so if you are looking to cut thicker board than CO2 is going to have the benefit there with the cycle time as well. And then material variety UV just based on its energy input it's going to be able to cut through a larger variety of materials more effectively.

So a couple of other applications that UV lasers are capable of outside of depaneling. Micro via drilling, drilling through mall tailor boards, this is depth cutting for ships. I believe this is a ceramics and then also cutting through cavalier and cavalier removing.

Here is another application where you can see four of these skills taking place all in the same job. These are restructuring, drilling, cutting and skiving all at the same time.

Laser systems

Really quickly I want to show some laser systems. Most of you guys mentioned that you are using routing as you main method right now for depaneling boards. Most of this if you are familiar with depaneling you probably have seen a lot of traditional systems but UV as it's newer. I just want to introduce you guys to what the systems look like. These are the production level systems. This is LPKF's MicroLine 6000 System. These do have automation options. So you can see the loading magazine here on the left and this will integrate with some made interface and communicate with the laser system. And also obviously you have your standard conveyer belts. Here are those systems, the production systems on top and we have more entry level systems on the bottom. These are MicroLine 1120 S, 1120 P. These aren't designed really for, they can be automated but they are really designed for one off boards etc. They are going to be significantly cheaper to get into but your automation options aren't quite as good as you would see with the production level ones. So the difference between the P systems on the right and S systems on the left over here, these two 6120 S and the 1120 S. These have fixed 3 in system where the systems on the right are going to be using backing tables. So it really depends on the type of PCB you are looking to put through.

Conclusion

All right, so in conclusion, the big advantages of the UVs are their precise nature, quality of cuts, again the surgical nature with no stress and then versatility is a big one. So that'd be it.

So let's move to some questions. So Mirela has just joined us, the way we'll do this is I'll go through the questions and read them off. And then Mirela and I will do our best to answer them. So please keep the questions coming, we have about 13 minutes and so we'll try to keep it to the hour. We've got plenty of time to answer quite a few of these questions.

So let me move back up here. What is the typical laser power used for UV cutting applications? So our MicroLine systems all come with five laser sources. We found that it's pretty much enough power to cut just about anything we cut pretty effectively. This system or the laser source expected 5w but it's really maybe 6w and it can go up to 9. So you can cut in varied power there. So if you are cutting around 40 mm or even tabs on 62 mm thick FR4 and of course below, it's just fine.

All right, the next question was what is the typical dimensional accuracy that is achievable using UV laser? So the UV lasers are really accurate. Their repeatability is about 2 µm plus minus 2 µm and then when it comes to accuracy in general it's about plus minus 20 µm. But usually when it comes to cutting the repeatability is what our customers are looking at. So it's very precise especially in comparison to others.

For the cutting equipment are you using galvo based or XY stages? It is galvo based.

I apologize; this question is going to be a little bit longer here. So this question is from Roger. I'm just going to read it directly. Can you give a better idea of thickness that can be cut more interested than aspect reissue of cuts? Can your system cut 30 µm diameter circles into 2.54 mm thick polyamide at 1.27 mm centers? So give us a seconde. We are trying to work on this a little bit. OK, so this question really relates to the thickness that the system can cut or meaning like what's the smallest toll you can cut in a thick material. And that's very material dependent. So pretty much the way it works is that the beam of the laser is about 20 µm or you know when you are cutting it's more like 23 µm If you are cutting thin materials or drawing thin materials you are going to achieve that beam size, you are going to get 25 µm hole or line width. When we are going to thicker materials if you have to lower your focal point of the laser so if you are cutting 62 mm stick material you might have to lower the focal point of the laser once so the laser can actually get through the material itself. In that case your line width is going to have to change. So most likely you are not going to be able to get to a 25 µm wide line. And the same kind goes with drilling. You know typically we can get, we can drill really small holes even in thicker materials but it's really material dependable. We tried to come up with the aspect reissue before so we had something like 1 to 4 or fewer materials let's say if you want your diameter of your hole to be 25 µm your material shouldn't be thicker than 100 µm. It's really material depending. So I mean the answer is that we have to test your material. And the same with the speed, I've noticed you asked how long it will take to cut or drill 700 of these holes. We will have thicker material tested. That's the only way to know for sure. So we can maybe drill 10 holes and tell you approximately how long it will take to drill 700.

All right, so little more of specific question here. We apply silicone contour for coating some of the PCBs and then depanel them using a router. Does this coating cause any issues with the laser systems? It really depends on the type of the coating. We haven't had any issues in the past with coating. In fact we used the laser to remove some, so parallene removes really well with the UV system. So we have some application where we had to remove parallene from pads. And again if it's a specific coating we would have to test your board. I mean that's the best way to find out.

What is the power supply required for the machine, 110 or 220? 110, these are pretty low watt power machines.

When cutting ceramics, do you have any issues with micro cracking? Can you process all ceramics or there are any limitations? Because we are using a laser that has low power, it's 5 watt laser, we've been pretty successful with ceramics, we've had a lot of ceramics samples both for drilling and cutting and also metallization removals. So we would create an entire circle of using a UV system. And we haven't had issues with micro cracking in the past. Again of course it depends on the type of the material thickness but our customers have would have necessarily complained about that portion.

Also I had some questions about receiving a slide deck for this presentation. We will be following up with everyone who attended today. We will do our best to include a slide deck but we will also include the link to recording the webinar. So you will be able to view this any time and see it on demand.

So a couple more questions, we still have five minutes, so if you guys have question keep them coming in. Question about the cost of the machines. So Mirela, can we give figures on how much our machines cost? Yes, so the smaller systems MicroLine 1000 models are in the low 200 range this quarters, I would say about 215 000 or right about there and then for MicroLine 6000 systems these machines are in the 400 000 dollar range. And again it depends on the options you guys may be interested in, it all depends what you want from the system. But typically the system itself is like 420 000 and then if you need some, but that's a key system that comes with everything but then if you need additional options, some additional software options or something like that. For example if you are a medical company and you need to do some tagging or something like that, this type of things would be extra.

Do you have any info about hybrid ceramics singulation using these systems? I would need you to specify hybrid ceramics. Again we run samples for people all the time. I mean we have samples constantly. We've cut tones of ceramics, fired, non-fired. But I don't know the specifics of your material. The best way to find out is you guys can send us a sample and we can test it.

All right, it looks like this was the last question. So if you guys be having more questions in the future, please by all means please feel free to reply to the emails you will be following up with. And then as I mentioned we do run samples. So if you are serious about checking into this application and we are capable of running samples. And that helps us a lot, the specific questions you might have. Again there are so many factors that go into the questions that you have and they do get very specific and then often the best way to figure it out is to run some samples.

And I just want to add one more thing. You know I noticed during the seminar or webinar. Josh mentioned the max thickness is 0.8 that the UV laser can cut. I mean this is not necessarily true. I would call it more an optimal thickness. The way the laser works, we have cut up to 3 mm which is 120. But what happens is your speed suffers, if you for example have 90% of your project around 40 mm or below. I mean a lot of our customers use the system to cut 62 mm thick material, and it's usually tabs, so those are pretty fast. So if you are 90% of your project 40 mm or around there you might have 10% that are maybe thicker and then you might have to cut a couple of thick tabs. The system will still be an option for you.

All right, great, so that's a kind of our last question. So again if you have some other questions, feel free to reply those email that we send you or take note of Mirela's contact information here. At this time I'd like to thank you guys for attending the webinar and I look forward to our future communications. Have a great day.