Printed circuit board processing with UV lasers

APPLICATIONS FROM PROTOTYPING TO PRODUCTION

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It is easy to dismiss a technology you can't see, but anyone working with circuit board applications would be mistaken to overlook ultraviolet lasers — one of the most versatile, efficient printed circuit board (PCB) processing technologies available. The beam from a laser generally provides a low-stress alternative to mechanical PCB processing methods such as milling or routing, but UV lasers provide an added benefit other laser sources do not, which is the ability to limit thermal stress. This is possible because most UV laser systems operate at low power levels. By utilizing a process sometimes known as "cold ablation," the beam from a UV laser produces a reduced heat-affected zone (HAZ) that minimizes burring, charring, and other negative effects of thermal stress normally associated with higher-powered lasers.

UV lasers are comprised of wavelengths shorter than those found in visible light, rendering them invisible to the naked eye. While you may not be able to see the laser beam, it's these same short wavelengths that enable UV lasers to be precisely focused, allowing for the creation of very fine circuit features while maintaining superior positioning accuracy.

Beyond short wavelengths and cooler workpiece temperatures, the high photon energy found in ultraviolet light makes UV lasers ideal for working with a large portfolio of PCB materials, everything from standard materials such as FR4 to high-frequency ceramic composites to flexible PCB materials including polyimide.

The chart in **FIGURE 1** displays absorption rates of three common PCB materials for six types of lasers. Included among these are an excimer laser (248 nm wavelength), an infrared laser (1064 nm), and two CO_2 lasers (9.4 μm and 10.6 μm). The UV laser (Nd:YAG, 355 nm) is one of the rare lasers that has quality absorption across all three material types.

UV lasers display very high absorption rates when working with resin and copper and also record decent absorption when processing glass. Only the pricy excimer laser (248 nm) posts better across-the-board absorption rates among these major material groups. This material diversity makes UV lasers perfect for a wide variety of PCB applications across many industries, from creating the most basic of all board features, circuit traces, to performing advanced processes such as pocket creation for embedding chips.

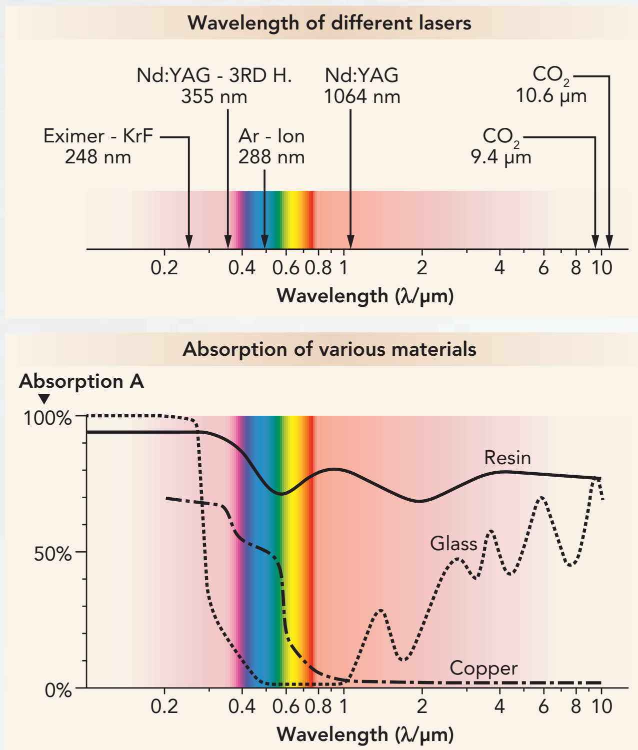

FIGURE 1. Absorption rates of three common PCB materials for six types of lasers.

UV systems work straight from CAD data to process boards, meaning any middle man in the board creation process is eliminated. This, coupled with ultraviolet light's precise focusing ability, allows UV systems to operate with high feature resolution and positioning repeatability.

Application 1: Surface etching/circuit creation

UV lasers work quickly when creating circuitry, etching surface patterns into boards in mere minutes. This makes UV the fastest method for prototyping PCBs. R&D departments are taking note, as more and more prototyping labs are being equipped with in-house UV laser systems.

Depending on optical calibration, UV laser beam sizes can be in the 10–20 μm range, allowing for the creation of fine-line circuit traces. The application in **FIGURE 2** exemplifies the best of what UV has to offer in this regard, featuring circuit traces so small a microscope is needed to view them. The board this image was taken from measures 0.75 in. x 0.5 in. and consists of a fired ceramic substrate (Al_2O_3) with a W/Ni/Cu/Ni/Au surface. Here the laser is able to create circuit traces of 2 mils with spacing of 1 mil, making for a total pitch of a mere 3 mils.

While creating circuitry with a laser beam is the quickest method for prototyping PCBs, producing mass-scale surface etching applications is generally better left to chemical processes. That said, there are many companies with high-mix manufacturing environments that use UV systems to etch small and medium-size quantities.

Application 2: PCB depaneling

UV laser cutting is a great option for either large- or small-scale production, and is good for PCB depaneling, especially when it comes to flex or rigid-flex applications. Depaneling, the removal of individual boards from a panel, has faced an onslaught of challenges given the rise of flexible PC materials. Mechanical depaneling methods such as V-scoring and routing can easily damage sensitive and thin substrates, creating problems for electronic manufacturing services (EMS) companies who depanel flex and rigid-flex applications. UV laser cutting not only eliminates the effects of mechanical stress that occur during depaneling such as burring, deformation, and damage to circuit components, but also reduces the effects of thermal stress found with other laser depaneling options, such as CO_2 cutting.

FIGURE 3 displays the same flexible substrate (polyimide) cut with a CO_2 laser (left) and a UV laser (right). There is significantly more charring and burning found with the hot CO_2 laser than with the UV laser, which, as mentioned previously, takes advantage of a cold ablation process.

This reduction in stress means a lot in today's age of miniaturization. The space saved after accounting for the diminished "cut cushion" means components can be placed closer to the edge of the circuit and more circuits can fit on each panel, maximizing efficiency and pushing the limits of what is possible with flex circuit processing.

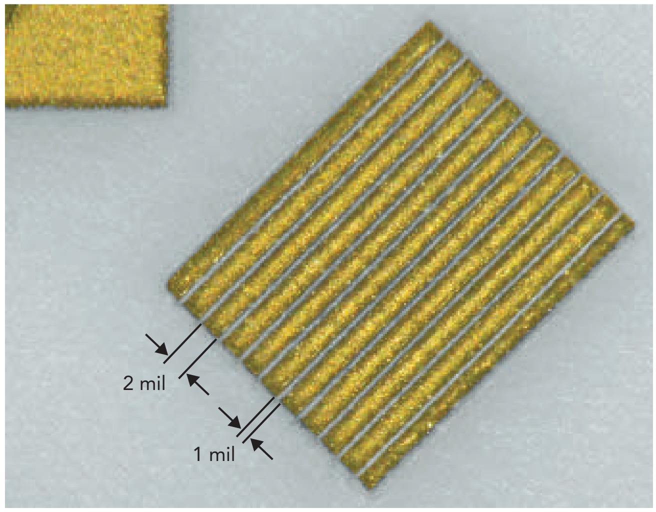

FIGURE 2. UV laser creates circuit traces so small a microscope is needed to view them.

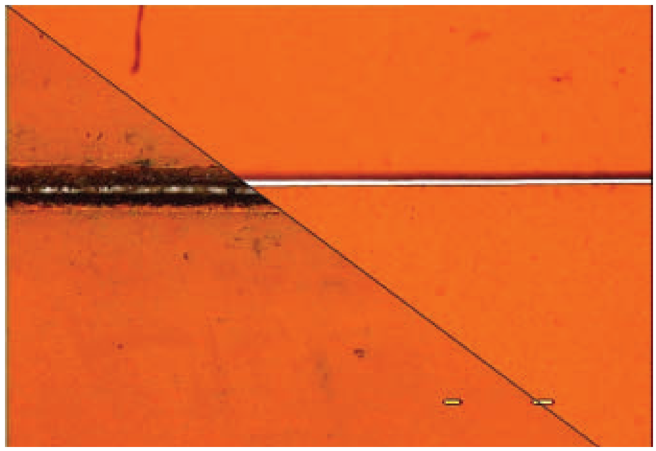

FIGURE 3. A flexible substrate (polyimide) cut with a (left) CO_2 laser and (right) UV laser.

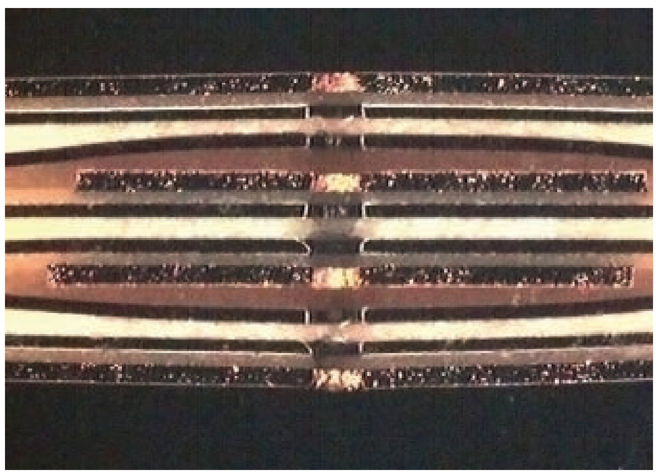

FIGURE 4. In this cross section, a 4 mil hole has been drilled in a 14 mil multilayer board.

Application 3: Drilling

Another application that takes advantage of a UV laser's small beam size and low-stress properties is the drilling of vias, which includes through-holes, microvias, and blind and buried vias. UV laser systems drill holes in boards by focusing the vertical beam in such a manner as to cut straight through the substrate. Holes as small as 10 µm can be drilled, depending on the material being used.

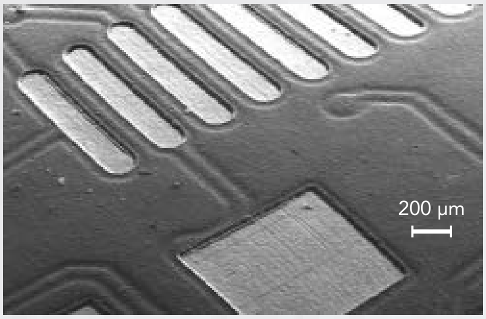

FIGURE 5. A skiving application performed by a UV laser.

One area where UV is especially effective when it comes to drilling is multilayer applications. Multilayer PCBs are held together with laminate materials that have been heat-pressed together. Delamination of these so-called "prepreg" materials has been known to occur, particularly when working with hotter laser sources. The relatively stress-free nature of UV lasers eliminates this problem, however, as evidenced in **FIGURE 4**. In this cross section, a 4 mil hole has been drilled in a 14 mil multilayer board. This application, which consists of Cu on a flexible polyimide, shows no delamination in between layers. It also raises a larger point when it comes to the low-stress nature of UV lasers: the ability to raise yield figures. Yield is the percentage of usable boards that have been removed from a panel.

There are many ways boards can be damaged throughout the manufacturing process, including busted solder joints, cracked components, or delamination. Any of these factors can lead to boards being deposited in the production line waste bin as opposed to a shipping crate. UV lasers greatly reduce — if not entirely eliminate — these harmful effects, providing rapid return on investment in the form of high yield percentages.

Application 4: Depth engraving

Another application that displays the versatility of UV lasers is depth engraving, which comes in many forms. Utilizing controls within a laser system's software, the beam can be set to perform controlled ablation, that is, the ability to cut through to a desired depth in a material, stop, travel, and complete the necessary machining before moving on to another depth and duty. Various depth applications include pocket creation, useful for embedding chips, and skiving, the removal of organic material from metal. **FIGURE 5** displays a skiving application performed by a UV laser. Here you can see the clean cuts provided by the laser beam, as well as the undamaged metal surface below the organic material that has been removed.

UV lasers can also be used to create multiple steps in board substrates, as seen in **FIGURE 6**. In this polyethylene material, the laser was set to create one step at a depth of 2 mils, another 8 mils below that, and another 10 mils below that. This speaks to the total user control provided by UV laser systems. Depth engraving, like drilling, is an application that can be efficiently handled by UV lasers in small, medium, or large production quantities.

Conclusion: One method to rule them all

What's truly remarkable about UV lasers is that they can complete all the forementioned applications in a single step. What does this mean for those fabricating boards? Instead of completing each application on different pieces of equipment with competing processes and methods, an entire part can instead be machined at once.

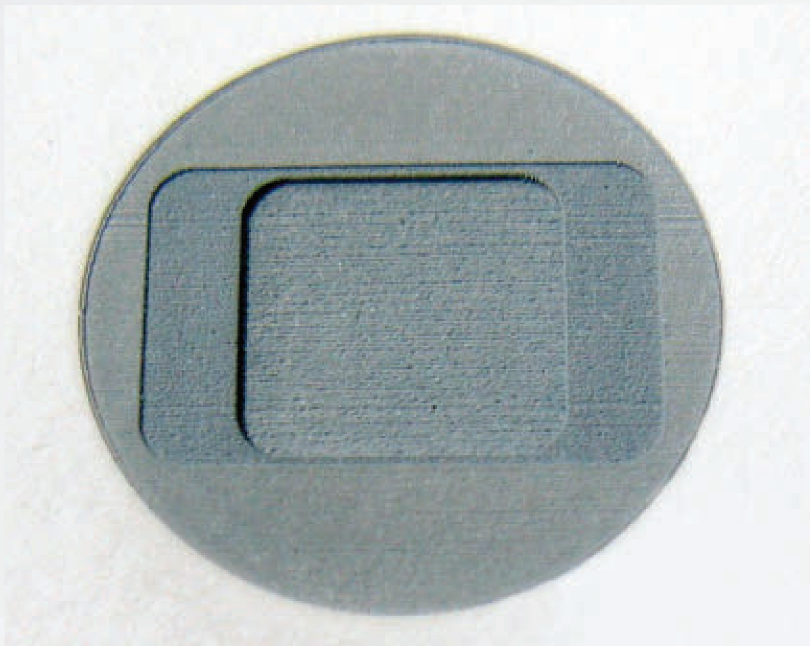

FIGURE 6. In this polyethylene material, the laser was set to create one step at a depth of 2 mils, another 8 mils below that, and another 10 mils below that.

This streamlined production scheme helps eliminate quality control issues that arise as boards transition from process to process. UV's debris-free ablation qualities also mean no post-process cleaning methods are required.

Couple this streamlined approach with the low-stress, material diversity qualities of ultraviolet light, and it's easy to see why UV lasers are growing in popularity as a method for machining circuit boards. Soon, UV will be more than just a technology you shouldn't overlook — it will be something you can't miss.

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