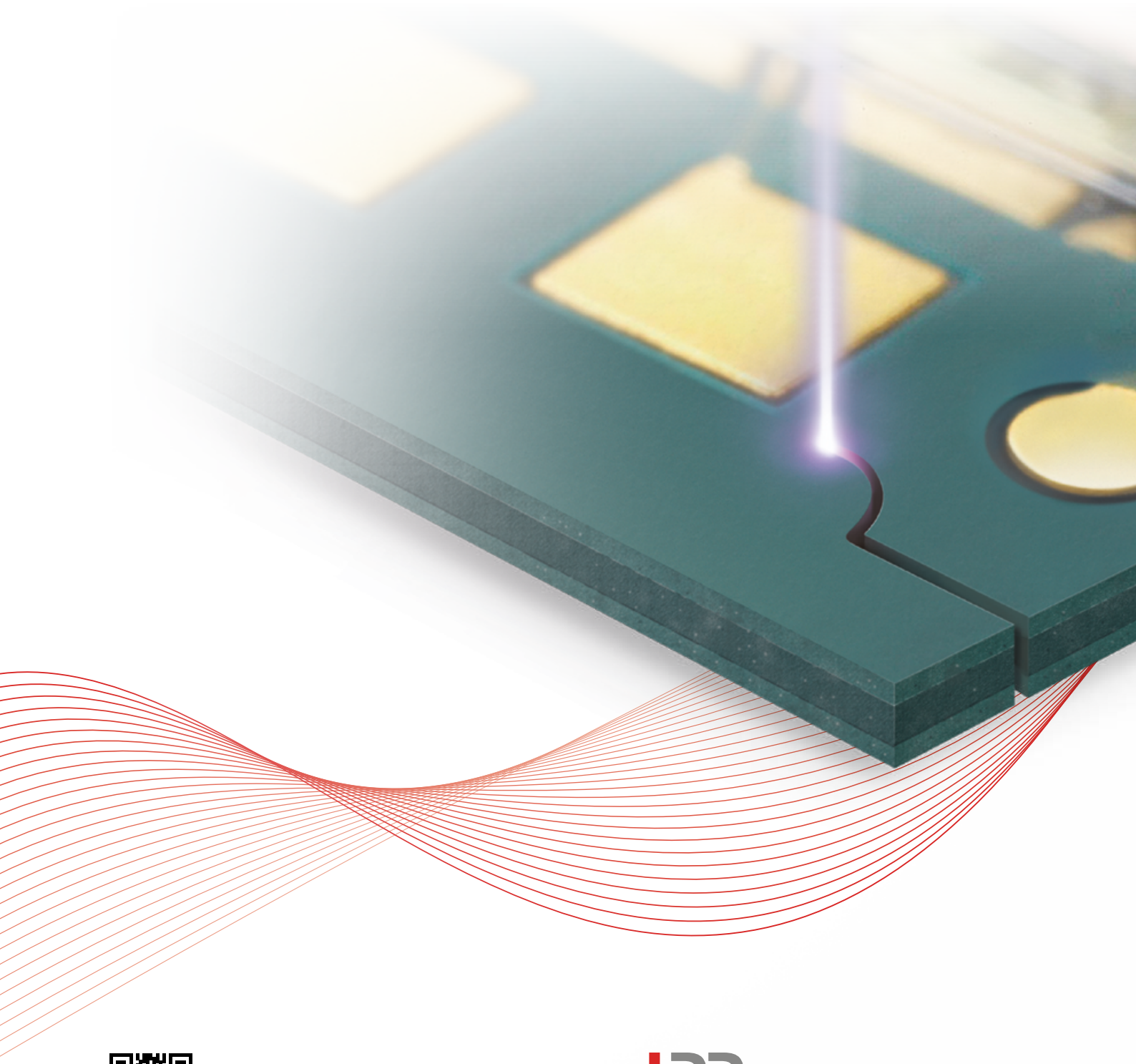
Cutting, Drilling, and Structuring

Micromaterial Processing with the Laser



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LaserMicronics

MICROMACHINING SERVICES

Rising to the Task ...

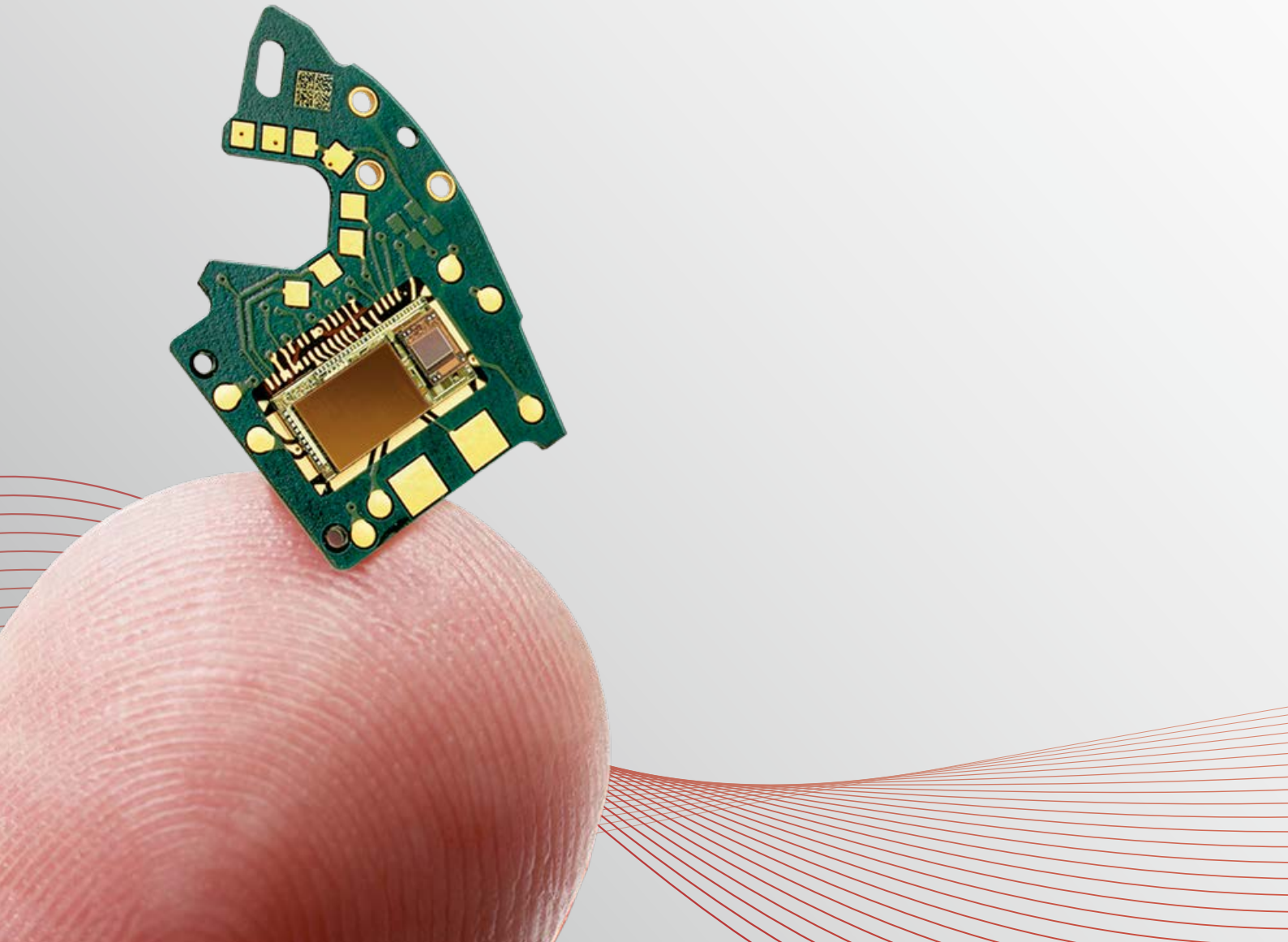
Cutting applications with the laser provide the greatest precision possible. Thanks to non-contact laser cutting processes, even delicate component assemblies right next to the edge can be depaneled cleanly, without any stresses, and with the highest precision. LaserMicronics can process PCB materials, ceramics, and metal foils using the high-performance laser systems from LPKF Laser & Electronics AG.

Production Services and Consulting
LaserMicronics has many years of experience in laser microprocessing. The range of services offered includes the selection of suitable materials and layouts, process planning, and manufacturing.

Physicists and application engineers accompany each product from idea to optimized production process. As a result, LaserMicronics can also offer pilot lot and mass production at attractive conditions.

LaserMicronics provides a number of qualified services in the field of contract manufacturing:

- Laser plastic welding
- Laser cutting
- Drilling of microvias
- Cutting of sheet metal parts
- Micromachining of ceramics
- Laser direct structuring of etch resists and galvanoresists
- Removal of defined areas of solder masks and protective films
- Structuring of TCO/ITO layers
- Repair and rework of populated and bare boards



- Minimized cutting channel sizes
- Flexible contours and processes
- No mechanical loads
- No dust and no chips

Material Processing with a Laser

In laser processing, a finely focused light beam with special characteristics acts on the material. The laser beam can cut through printed circuit board materials, ceramics, and metal foils so quickly and precisely that there are neither thermal nor mechanical loads. Thus, the demands placed on component fixtures and the associated costs are considerably reduced.

Laser processing usually takes place without the use of additional tools. The part is either moved in relation to the laser beam or a scanner optical element guides the laser beam along the desired contours. As a result, even complex cutting contours can be produced through input of contour data – and easily changed.

The LaserMicronics cutting laser can perform challenging cutting tasks at the best quality, using suitable, material-specific laser parameters and without long lead times and high associated costs. LaserMicronics has extensive experience in handling this range of tasks and an equipment pool that includes several laser systems.

High technology – The specialists at LaserMicronics work with the latest laser systems from LPKF.

Cutting with UV Laser Systems

Electronics manufacturing requires precise cutting tasks at different points in the production process. Tasks range from machining of individual components for complex stackups to stress-free depaneling of the finished board. UV laser systems are ideal for producing high-quality clean cuts, cutouts, and drilled holes in PCB materials.

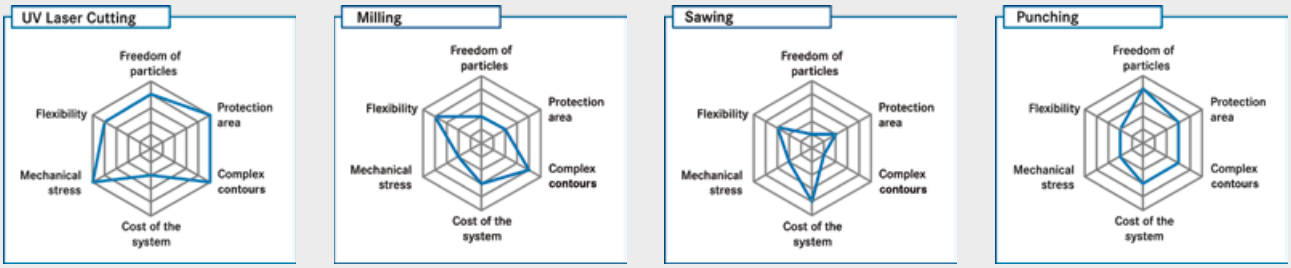
Processing with UV laser systems offers a number of advantages over conventional techniques:

- Processing occurs without mechanical loading and without particles
- The heat-affected zone is already negligible just a few micrometers away from the cutting channel edge
- The cutting channel is just a few micrometers wide
- The cutting depth can be set to individual layers in a substrate package
- There are no restrictions on possible cutting contours

A scanner system guides the laser beam to the cutting position in a noncontact manner at speeds of up to 6 m/s. The contour can be passed over several times according to the material thickness; the repeatability is in the order of a few micrometers. Because it is guided by a scanner, the UV laser can cut any contours without requiring the use of additional tools or masks.

Precise cuts for depaneling PCBs, drilled round holes, or nonround apertures can be achieved by the laser in a single processing step (source: Smyczek GmbH).

Good Reasons for Processing PCBs with a UV Laser

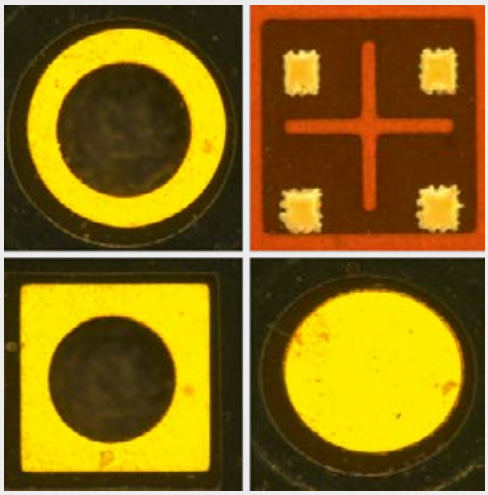


UV laser processing compared with other depaneling methods

Know What's Happening

Vision systems represent valuable aids in the cutting process. Through fiducials, they determine the actual positions of the conductive traces on the surface processed by the laser and can automatically compensate for distortions arising in upstream processes.

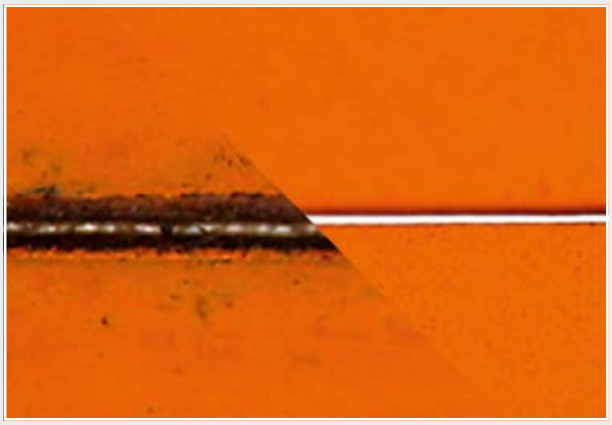
Through this, critical intermediate products can be turned into compliant good parts, even in difficult conditions.



UV Laser Versus CO_2 Laser

Precision instead of kilowatts – this is the main reason for using UV lasers for PCB processing. Common PCB substrates exhibit optimal absorption behavior for laser processing in the wavelength range of the UV lasers. High-performance CO_2 lasers can be manufactured at low cost, but they do not achieve either the precision or the cutting quality that can be obtained with a UV laser system.

LaserMicronics relies on LPKF cutting systems with special laser sources for UV cutting of PCB substrates.

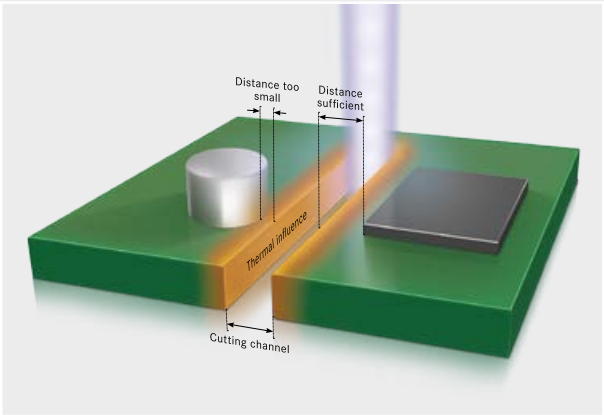


Quality matters: cut made with a CO_2 laser (left) and UV cut (right)

The UV Laser in PCB Production

Depaneling and drilling tasks must be performed at various points along the PCB production chain. For all of them, the laser shows clear advantages over other processes. The aim is to achieve high-precision cutting up to the edges of delicate components and traces without compromising the cut edges.

This can be accomplished with a UV laser. A comprehensive study of the thermal effects will show the relationships between process parameters and heat loads.



The heat-affected zone extends only a few micrometers away from the cut

Prepregs and Coverlayers

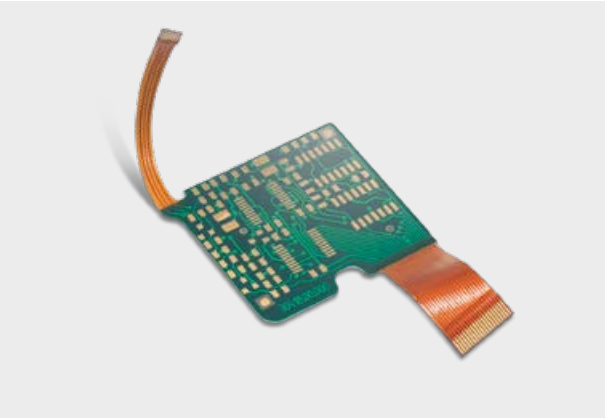
Coverlayers are delicate, thin films that protect structured surfaces on flexible substrates. They must exhibit openings where contact areas and cutouts are situated. The laser can produce these openings without creating mechanical distortions.

Prepregs are used as bonding films in the lamination of multilayers. These films are also sensitive to mechanical loads. The UV laser can hold the films securely in place on a vacuum table and produce the required cutouts without imposing any mechanical loads on the foils.

Rigid-Flex Board Depaneling/Pockets

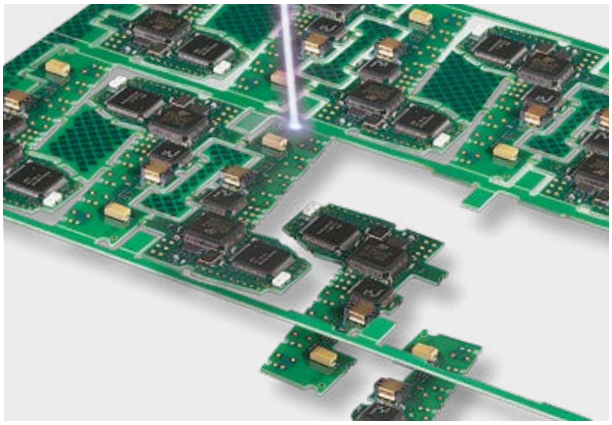
Rigid-flex printed circuit boards are multilayers in which the later flexible segments are covered by a rigid material but not connected to it. The laser removes the rigid passages precisely above the flexible segments.

Pockets for recessed or flush installation of components in multilayers are created in the same way. For this, the laser removes the rigid top layers from the PCB multilayer package. The prepregs themselves exhibit gaps and hence no bonding between layers takes place in these areas.



Tab Cuts

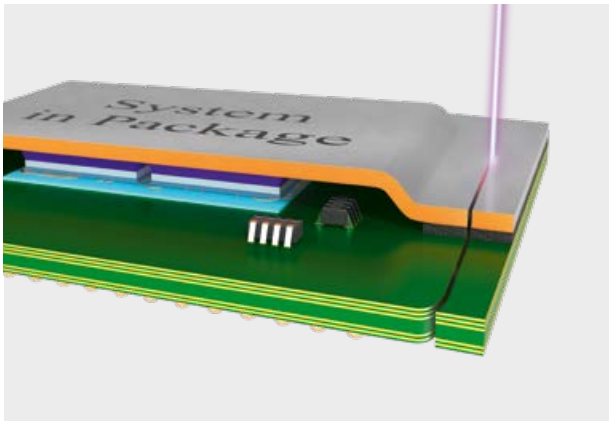
In the last phase of production of the component assembly, individual boards are cut out of larger panels. The laser cuts tabs without creating mechanical loads – either in the middle or, in a virtually invisible manner, in the extension of the component assembly contour.



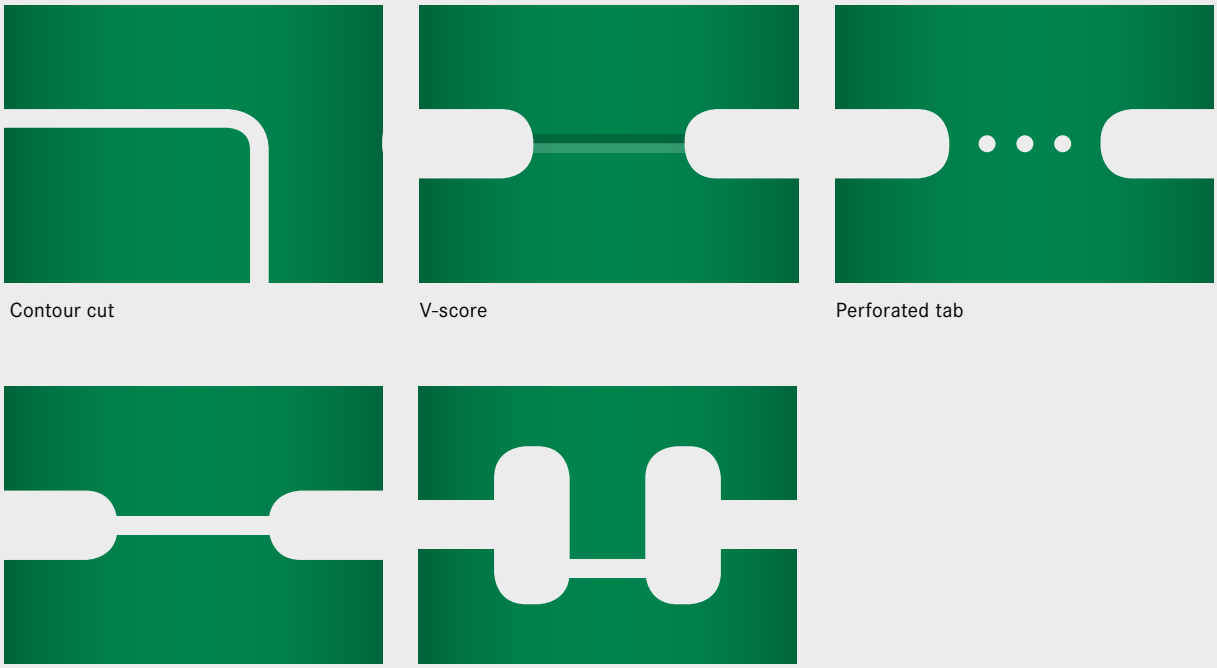
Full-Section Contour Cuts

For high-quality components or complete component moldings, a full-section contour cut is used. The following rule applies: the thinner the material is, the more cost-effective laser cutting is. For complex, expensive component assemblies or near-edge cuts, the laser offers unsurpassed precision.

Even cuts below components are possible because there is no contact between the laser head and the board. Very narrow cutting channels increase the number of panels on the substrate.



Overview of Cutting Contours



Drilling Microvias

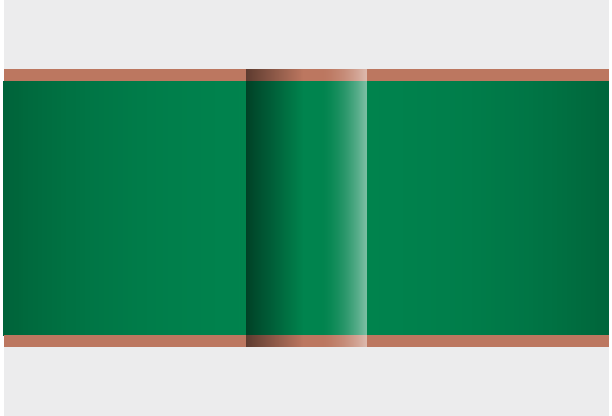
Complex printed circuit boards require drilled holes that are metallized for electrically interconnecting the front and back sides. The UV laser is especially well suited to meeting this requirement: it is positioned inside the work area at lightning speed by a scanner, exerts no mechanical loads while working, can realize high aspect ratios, and produces holes with the diameter of the laser focus.

At present the minimum achievable drilled hole diameter is 30 µm. Larger holes are cut as circles, making any hole diameter possible. Mechanical drilling restricts the choice of hole shape for developers to round ones. Cutting with the laser allows any shape to be cut out, for example, for adaptations or structural cutouts. Given the appropriate handling, flexible PCBs can also be processed in a roll-to-roll process.

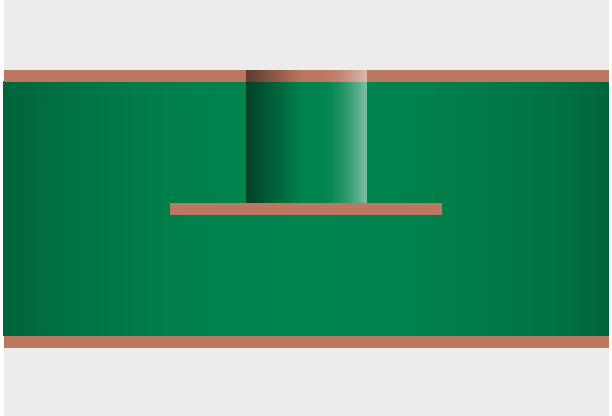
Vias and Blind Vias

With conventional through-hole plating, the laser performs the cutting operation multiple times until the board or the substrate package is completely penetrated. This hole in the printed circuit board is later metallized and hence made to be conductive.

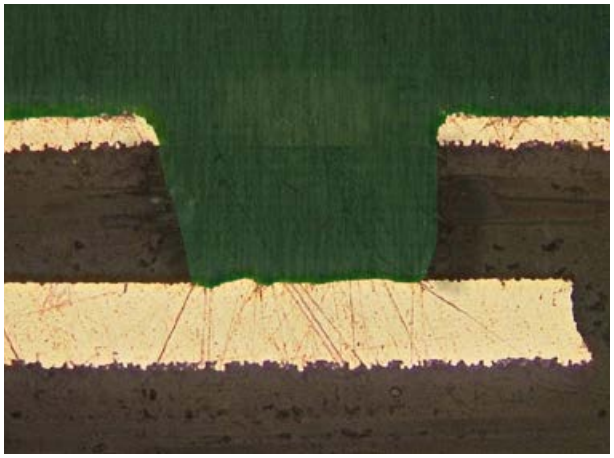
For a blind via, a defined part of the copper surface in a multilayer package must be exposed. To accomplish this, the laser first taps a hole in the top copper layer at a high power. Then the laser power is reduced to a level ensuring that only the substrate material, not the copper, in the target layer is evaporated. The result is a very clean cut ending precisely at the copper layer. At the same time, the laser cleans the affected copper surface, removing any residues on it.



Via



Blind via



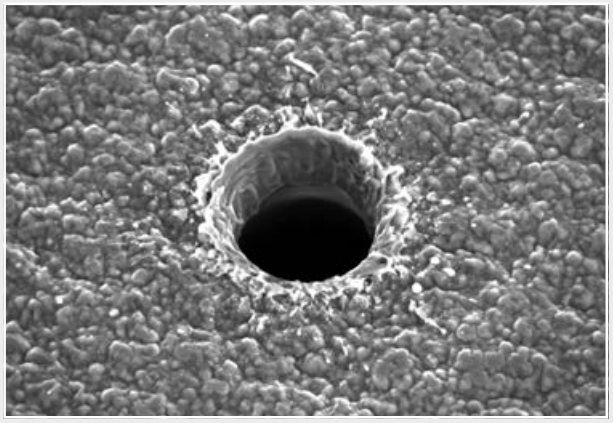
Pushing Back the Limits

Very fine drilled holes with a diameter of less than 100 µm are difficult to achieve by mechanical means: the ever lower tangential velocities of increasingly thinner drills do not permit clean cuts. Tool wear also increases and cost-effectiveness decreases.

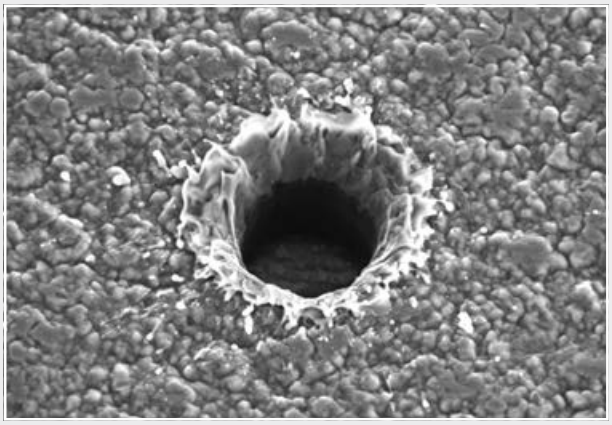
The laser requires no drilling tools and is especially cost-effective and fast for thin, delicate substrates.

High-Quality Microvias with UV Laser Drilling

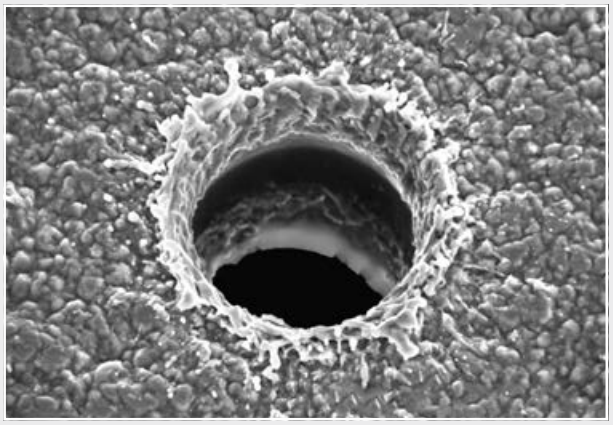
A high yield lowers costs, so faster nonproductive and processing times yield advantages over the competition. The SEM micrographs show through holes and blind vias drilled in double-sided flex PCBs by LaserMicronics using an LPKF MicroLine 5000.



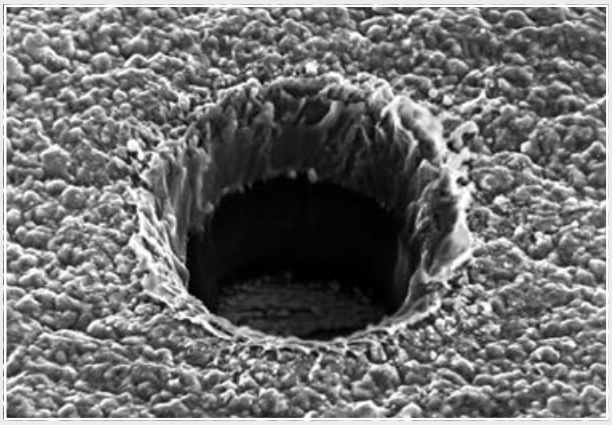
30-µm through hole



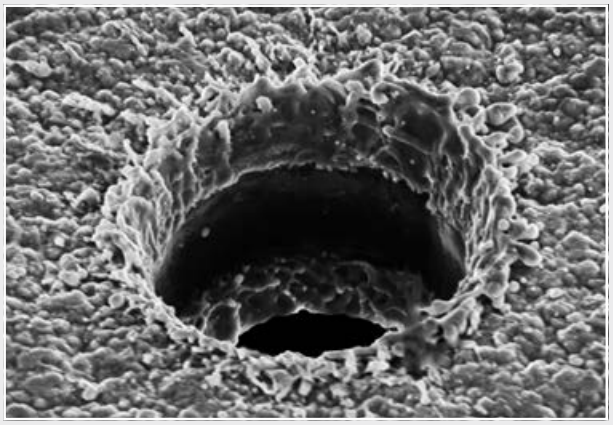
30-µm blind via



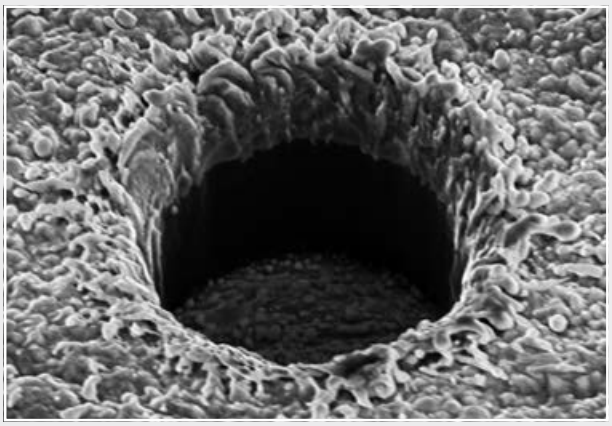
50-µm through hole



50-µm blind via



70-µm through hole



70-µm blind via

Flexible Tool Selection

In micro material processing, there is an optimum laser system for every application. Depending on the application field and material, IR, UV or “green” lasers can be the tool of choice. The laser pulse duration is also a decisive factor for the result. LaserMicronics identifies the appropriate laser system and uses it specifically for each application – providing efficient material usage and best results.

Versatility and Efficiency for a Wide Range of Materials and Variable Applications

Whether it is drilling, cutting or material removal: Different materials require different machining processes. The intended application of the product determines the precision and quality of demands in production. The specialists at LaserMicronics focus precisely on these requirements and use the optimum production system in each case. Fine, compact electronic circuits are particularly sensitive to mechanical stress, dust and geometric deviations. For the highest demands on cleanliness, precision and speed in micro material processing, LaserMicronics relies on ultra-short pulse lasers. These lasers also offer the greatest freedom for geometry and design.

Clean and Fast Laser Micromachining

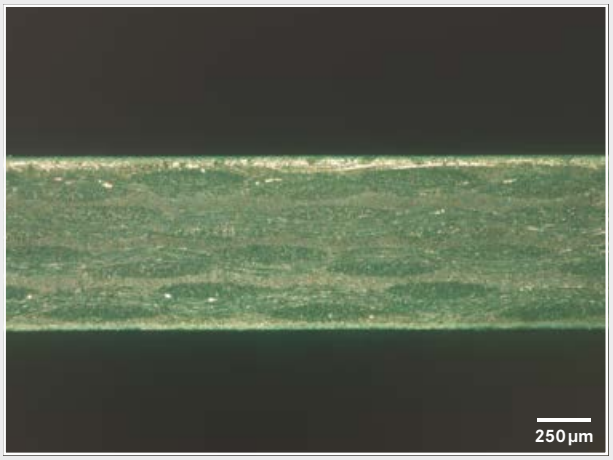
LaserMicronics uses laser systems such as the LPKF ProtoLaser R with ultra-short pulse laser for high-precision drilling and cutting of PCB materials such as FR4, PI-, LCP- and PTFE-FPC in all common plate sizes. The laser pulses of only one picosecond process the materials so gently and quick that they can be used efficiently. The heat-affected zone (HAZ) of the material is negligible, cutting edges remain free of debris. Even thin organic and metallic foils, which are particularly thermally sensitive, can be optimally processed with the technology. The convincing results: Clean cut and precise ablations – well above the industry standard. Virtually without material strain, the precision cuts enable the highest possible utilization of the plate surface which in turn provides considerable material savings.

High-End Processing of Thin Layers and Particularly Sensitive Materials

Companies, development departments in companies and research institutions that work with very different, demanding and often newly developed materials in ever smaller formats require adequate and fast material processing. LaserMicronics carries this out and enables an extremely high degree of flexibility and precision. Laser pulses of one picosecond for “cold” ablation realize exact drilling and cutting in the micromaterial range.

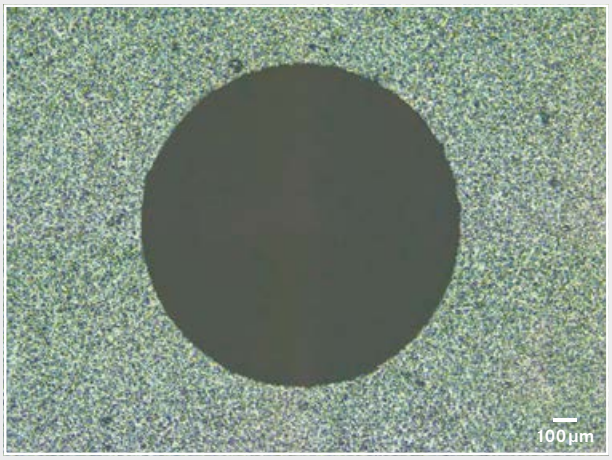
In addition, ablation of thin inorganic layers from organic substrates as well as the removal of organic layers – e. g. polyimide – from metal surfaces may be realized with this technology. The first process is used, for example, in the manufacture of OLED touch panels, the second for solder mask applications.

Example: PCB Depaneling



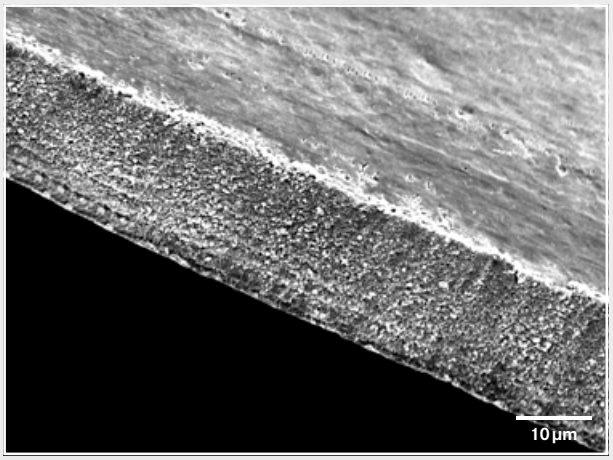
The ultra-short pulse laser ensures extremely clean, carbonization-free cutting edges, as shown here in the example of FR4

Example: Microvia Drilling in Ceramics



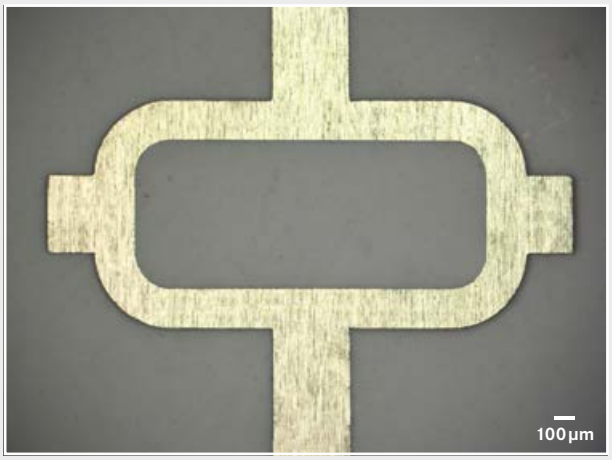
High-precision drilling in ceramics – laser entry side without heat-affected zone and without microcracks

Example: Cutting of Thin Metallic Foils



The laser cuts delicate and sensitive metal foils precisely with picosecond pulses, thus enabling smooth cutting edges

Example: Removal of Metal Foils



The USP laser can ablate thin metal foils flexibly and precisely. Thanks to the powerful CAM software, several paths can be structured in a very short time.

Microcutting

Processing of metal foils with thicknesses of up to one millimeter is similar to processing of other materials – with one important difference: metals melt when heated, thereby significantly speeding up the cutting process.

The first application for the laser was cutting of stencils for solder paste printing in electronics. A doctor blade squeezes solder paste through holes in the stencil exactly on top of the pads on the board. LPKF StencilLasers perform the task of cutting holes in metal foils with sizes of up to 1600 x 600 mm.

The laser pokes a hole in the middle of the area designated for the opening. In the process, small amounts of the metal are melted and are forced out of the cutting channel by a cutting gas. Clean, smooth cut edges result. Because the melt does not have to be evaporated, the cutting speed increases dramatically.

With the available StencilLasers, stencils can be cut with a minimum hole diameter of 25 µm. The laser process is not restricted to round apertures and can, e. g., also generate rectangular or oval shapes – depending on the requirements of the subsequent printing process.

- Stainless steel foils with dimensions of up to 1600 x 600 mm
- Software-controlled cutting of contours of any shape
- Small heat-affected zone

LaserMicronics does not manufacture solder paste stencils, but the company uses the technology to produce high-quality cut parts made of stainless steel foils with thicknesses between 20 µm and 1 mm.

Microcutting

Due to its high precision and cutting quality, laser cutting is interesting for microcutting applications. The laser can cut components out of metal foils of thicknesses up to one millimeter. Depending on the requirements, the StencilLaser can employ fusion cutting or produce the contours by evaporating metal along the cutting contour in multiple passes. Even complex contours – for example, tabs a few micrometers in thickness – can be made without distortions.

Punching and Percussion Drilling

Two additional processes generate round holes with the diameter of the laser focus. In the punching process, a single, strong laser pulse pierces the metal foil, leaving a very fine hole. In percussion drilling, multiple laser pulses hit the same spot until a through-thickness hole is created.

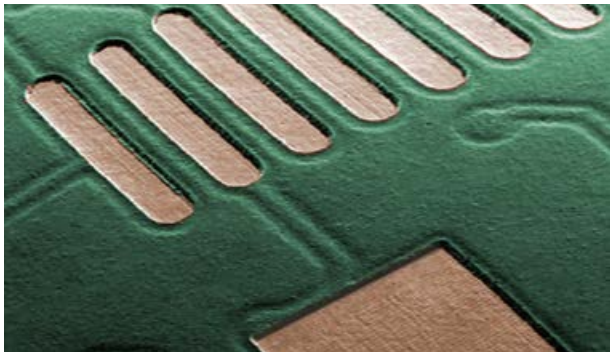
Material Processing with a UV Laser

With clever selection of laser parameters, completely different materials can be processed very precisely. Owing to stabilization in the lower output range, the laser systems used by LaserMicronics can process numerous challenging materials with high precision.

Breathing on the glass plate reveals the previously invisible conductive TCO layers

TCO/ITO Structuring

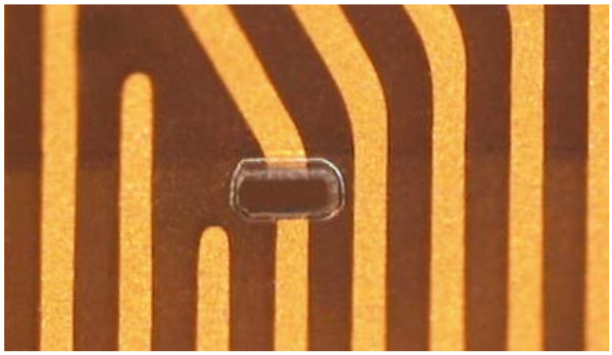
ITO/TCO layers are conductive, transparent coatings on transparent substrates. They can be structured so precisely with the laser that only the coating is removed. In this way, invisible heaters, antennas, and sensors can be made.



The laser removes the full-surface solder mask precisely above the closely spaced contact pads

Selective Area-Wise Solder Mask Removal

The UV laser can remove selected areas in solder masks in board regions with the highest I/O densities. The corresponding regions are coated over their entire surfaces. The laser removes the mask layer above the delicate contacts.



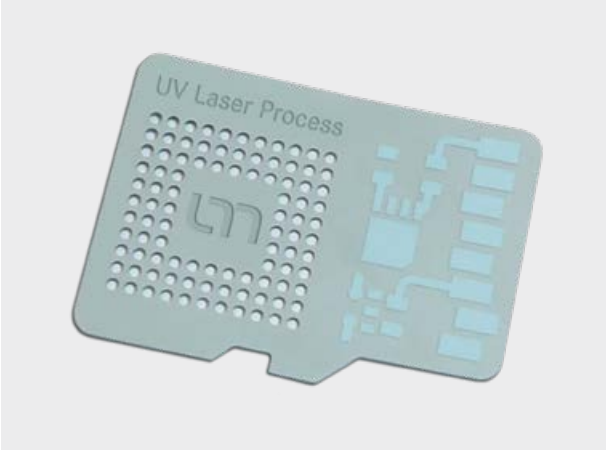
The laser beam does not require physical contact with the board and can thus eliminate short circuits in hard-to-reach areas

Reworking Boards

A UV laser can easily remove conductive traces. This ability is put to use for eliminating short circuits on populated or unpopulated boards. The laser removes the relevant conductive traces in a noncontact process. Board repair can thus also be performed in hard-to-reach areas.

Processing Ceramics with a Laser

Engineering ceramics represent a useful supplement to the classic PCB material. Important electrical properties include insulating properties and dielectric strength. The mechanical properties of interest are strength and hardness. Ceramic substrates are difficult to machine using conventional tools – but not with the UV laser.



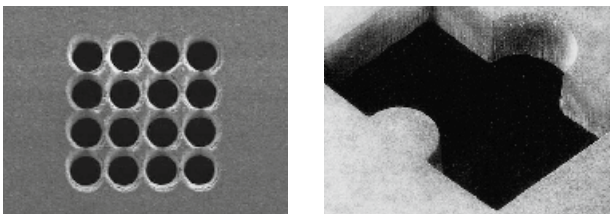
In a single pass: the laser structures the surface, engraves the legend, cuts the holes, and detaches the entire component from a larger green tape board

Green Ceramics/LTCCs

The laser structures or cuts precursors to the fired ceramics called “green tape.” This green tape only achieves the desired strength and geometry after firing of the ceramic. The laser removes a precisely defined amount of material.

With low temperature co-fired ceramics (LTCCs), components are produced from ceramic layers and conductive pastes as multilayers.

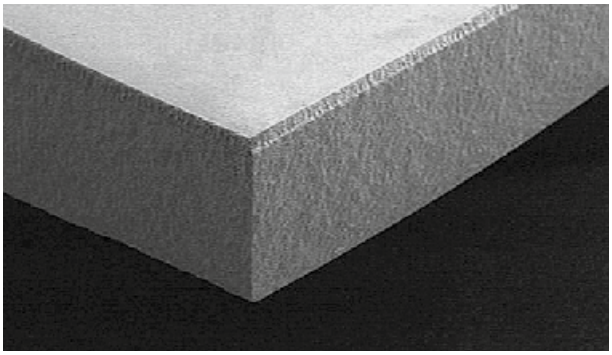
Besides the conductive trace pattern, resistors, capacitors, and coils can be generated using printing technology. The laser cuts the panels out of larger component substrates, but it can also generate holes for mounting or through-hole plating and engrave the surface.



Only possible with a laser: 50-µm through holes and contour cuts in 254-µm-thick sintered tape

Sintered Ceramics

The UV laser can cut complex contours out of fired ceramics with nearly no residues and without any appreciable kerf or damaged areas. It can be used for depaneling, shape cutting, and drilling holes. Because no mechanical loads arise, through-thickness holes with minimal spacing can be produced.



The UV laser generates a very fine score line. Ceramics can be reliably broken at this weak spot in the material.

Scoring Ceramics

In the depaneling of rectangular fired ceramic parts, a great deal of time can be saved if a score instead of a full cut is made. The homogeneous ceramic material later breaks exactly along these scores.

Laser Plastic Welding at LaserMicronics

Hygienic, safe, and economical, laser plastic welding features high-quality welding results, a particle-free process, and low tooling costs. Quality monitoring occurs in the process. The laser beam penetrates the laser-transparent upper joining partner and melts the laser-absorbing lower part. A moderate clamping pressure creates a reliable contact for heat transfer to ensure that the part of the weld seam in contact with the upper part also melts.

The weld seams produced are visually reassuring, durably tight, and particle-free – ideal for challenging joining tasks. If necessary, welding can be performed in an in-house clean room.

LaserMicronics welds everything from tiny microfluidic devices to large vehicle fuel tanks and taillights – with a laser

Call Us for More Information:

- Laser plastic welding
- TCO/ITO laser machining
- Microdrilling
- Structuring
- Ablation of metal and organic layers
- Cutting
- Scoring
- Marking
- Engraving
- Metal micromachining

LPKF Laser & Electronics

LaserMicronics is a brand of LPKF Group

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