On the Cutting Edge of Laser Technology
Laser Processing Technology, Inc. has been providing high-quality machining services since 1992. We’ve established ourselves as one of the few laser houses that can meet the most demanding schedules, exceed the tightest tolerances and still maintain extremely competitive prices.

We have one underlying goal that guides every decision we make, and every part we machine: satisfying the customer. Without our loyal customers, we wouldn’t exist.

Laser Processing Technology announced its entry into the state-of-the-art laser services industry on February 24, 1992. LPT is capable of handling sophisticated prototype laser services, as well as both short and long production runs. Our mission is to provide advanced laser applications for military, medical, telecommunication, electronics, avionics and other commercial markets.

CAPABILITIES, AT A GLANCE...

- Over 30 years of technical expertise
- High Precision, High Quality, High Volume Applications
- 500 watt CO₂ Laser Systems with multiple heads that scribe and drill over a 17” workspace
- High purity ceramics (96%, 99% Al₂O₃), plastics, metals and other exotic materials
- Ability to import CAD Data in nearly any format
- Quality Assurance provides for process inspection from start to finish
Design Guideline For Ceramic Substrates

Ceramics used for electronic circuitry (usually "thin film" or "thick film" metallization) are typically alumina (Al2O3, several types), beryllium oxide (BeO) or aluminum nitride (AlN). These materials are available in standard sizes, thicknesses and flatness ("camber"). In designing electronic circuitry for ceramic substrates, it is not always optimum to use a standard size of ceramic for the circuit. It is frequently best to optimize the size and shape of the circuit and then process arrays of these on standard ceramic. Also, circuitry is frequently placed on both sides of the ceramic, and there is a need to connect one side to the other, perhaps by putting holes in the ceramic and metallizing the holes. There are several methods for “singing” the parts, including sawing, laser machining, and scribing & breaking. Laser machining, scribing and drilling are often the most economical methods for creating these features. When designing laser machined ceramic substrates, it is important to understand the limitations of the material during the laser machining process. Although ceramic is a material with hardness just under diamond, it is also brittle and susceptible to breaking, chipping or cracking due to impact.

MATERIAL FLATNESS AND SURFACE FINISH

As-fired ceramic substrates typically have a camber of .003 inch per inch, as produced by the manufacturer. If the application requires a tighter material flatness, there are two other processing options to select from: camber sorting of as-fired material or mechanically lapping and polishing the substrates. A flatness (or camber) of .0005 inch per inch can be achieved by lapping and/or polishing the substrates.

Lapped substrates have a surface finish range of 20 up to 60 micro inches for thick film applications; polished substrates typically will have a surface finish that is <2 micro inches. The polished substrates are primarily used for thin film applications, as these surfaces require a finer finish for plating or sputtered metals to form good adhesion.

CO2 LASERS

CO2 lasers focus an intense, coherent beam of infrared (10600 nm) radiation onto the ceramic which rapidly heats and vaporizes the ceramic. Because a lens can focus only on a single plane, the exit side of the ceramic is usually the focal plane and thus the cuts or holes will have a taper of about 2° rather than being perpendicular to the surfaces as would be a saw cut or mechanical drill. Laser machining and drilling are done essentially the way single-axis mechanical milling and drilling are done on a CNC machine, with an x-y table providing the motion instead of the tool (laser) moving. Location tolerance for the x-y table is about ±1 mil (25 μm). Beam diameter is typically about 3 mils (75 μm) which practically limits hole size to about 5 mils (125 μm) on the entrance side.

Holes and laser machined features will be larger on the entrance side than on the exit side due to the taper mentioned above. Near the cuts or holes, the walls of the ceramic are melted leaving a glassy surface. Some of this glassy material (slag) will also deposit on the entrance surface in a “heat affected zone” which is about one or two mils (25 – 50 μm) wide. Metallization typically does not adhere as well to this heat-affected zone. Also, since the laser creates intense localized heating, stresses or even microcracks may be induced which can be detrimental to further handling of the parts, because ceramics are relatively brittle. These phenomena can be mitigated by annealing the ceramic (see Annealing).

DRAWING SPECIFICATIONS

For the circuit layout, it is important for the designer to depict on the drawing the laser entrance and exit side because of the taper inherent in the laser process and proximity of the metallization to laser features. Typically, the view shown is identified as laser entrance or exit side with a separate cross

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1 Typical as-fired camber is 0.003 in/in (50 μm/cm). Lapped &/or polished ceramic can be as flat as 0.0005 in/in (5 μm/cm).
2 "Singulating" is a term coined by the industry to mean disassembling the array into single parts.
3 These phenomena can be induced with other means of machining and drilling ala.
section detail showing the direction of the taper. From this information, the laser house can then provide the proper set-up for the application.

**LASER Scribing**

Laser scribing involves using the laser in pulsed mode to create lines of holes that are spaced 5 +2/-1 mil (125 + 50/-25 μm) center to center with a depth of 40% to 50% of the ceramic thickness. This standard will be used unless otherwise specified and these parameters adjusted on a case-by-case basis. The scribing allows the ceramic circuits to be processed in an array and finally singulated by “snapping” apart the individual circuits along the scribe lines. Circuitry should allow at least 10 mil (0.25 mm) “streets” for the scribe lines. If the scribe lines are post-machined (added after the circuitry has been processed) at least 4 mils (100 μm) should be allowed from the metallization edges to the edges of the scribe to avoid the laser harming the circuitry. The width of the scribe (i.e. diameter of the scribe holes) will increase somewhat with ceramic thickness, so it is best to be generous with this allowance.

**LASER MACHINING**

Laser machining is done with the laser in CW (continuous wave) mode, where the beam is left on continuously to cut all the way through the material and provide a smooth edge. The standard tolerance is ±2 mil (50 μm); a tolerance of ±1 mil (25 μm) is achievable based on the exit side of the ceramic. Hence, it is better to cut circuitry on the exit side of the ceramic, which has the added advantage of avoiding the heat affected zones. To avoid cracking, the distance from feature edge to feature edge should be at least equal to or greater than the thickness of the ceramic; two times the material thickness is recommended. Circuitry for the entrance side must allow for the 2° taper and heat affected zone. If one side is a ground plane, it’s best to put this on the entrance side. When parts are post-machined after metallization, it is best to allow at least 4 mils (100 μm) between the laser machined edge and the edge of the metallization to avoid harming the circuitry. This should be about 6 mils (150 μm) for circuitry on the entrance side. Also, if singulating by laser machining, streets between the circuits in an array should be a minimum of 0.100 in (2.5 mm) to avoid cracking, since the ceramic is subjected to much more intense heat with the CW beam, and for a longer period of time, than in scribing.

**LASER DRILLING**

Generally, the guidelines for laser machining above apply to laser drilling as well, since holes are simply a special case of laser machining. The smallest practical hole diameter is about 5 mils (125 μm) on the entrance side and 3 mils (75 μm) on the exit side. Again, the minimum distance between the edges of the holes should be at least equal to the thickness of the ceramic; a distance of two times the material thickness is recommended. The guidelines for post-machining above also apply to post laser drilling.

**COATING**

A polyvinyl alcohol (PVA) coating is typically applied to the ceramic substrates prior to laser processing to prevent the slag from adhering to surfaces which will later be metallized. The PVA coating also protects the circuitry during post laser machining operations (after circuitry is printed). This coating is water soluble and easily removed after laser processing is completed.

**ANNEALING**

Since the slag can act as a barrier between the ceramic and metallization, (causing poor adhesion with some metallization systems), a process called annealing can be used to ‘resurface’ the ceramic substrate. Annealing is a heat treatment process that is typically done in excess of 1275 ° C. Annealing can also relieve the stresses produced from the ceramic manufacturing as well as those introduced during the laser machining process. During the annealing process, the material is softened to a point where the stresses are relieved. Annealing, however, can adversely affect tight dimensional tolerances by up to 1.5 mils (38 μm).

**COST SAVING TIP**

When ever possible, the designer should use standard as-fired materials and laser tolerances for the most cost effective approach to circuit design.
HIGH TEMPERATURE ANNEALING
Treatment of Alumina Based Substrates
- Increased ceramic flexural strength
- Reduction of internal stresses
- Improved adhesion for thick film inks
- Microprocessor controlled oven for customer profiles

AUTOMATED INSPECTION
Dimensional Verification Using Computer Controlled 3-axis Positioning System
- Superior resolution and accuracy
- High-throughput without sacrificing reliability
- Closed loop system ensures repeatability

COATING
Laser Coating to Protect Material Surfaces
- Protects surface finishes and printed parts during the laser process
- Guards against adhesion of “slag” to material surfaces
- Easily removed with water

OPTICAL ALIGNMENT
High Resolution Camera for Accurate Laser Alignment
- Precise positioning of beam path to a feature on the part being processed
Laser Processing Technology is capable of processing a wide variety of materials. Our Research & Development team is constantly working to develop new methods of cutting materials, and we are always willing to test your materials for laserability.

ABOUT OUR MATERIALS...

The following table lists the more common materials that we’re capable of processing. If you require processing on a more exotic material, please contact us for more information. If we are not capable of processing your material, we may have some ideas to help you find the best solution.

<table>
<thead>
<tr>
<th>METALS</th>
<th>CERAMICS</th>
<th>PLASTICS</th>
<th>OTHERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kovar</td>
<td>Alumina (90% – 99.9%)</td>
<td>ABS</td>
<td>Cardboard</td>
</tr>
<tr>
<td>Lead</td>
<td>Aluminum Nitride</td>
<td>Acrylic</td>
<td>Duroid</td>
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<tr>
<td>Mild Steel</td>
<td>Beryllium Oxide (BeO)</td>
<td>Delrin</td>
<td>Epoxy</td>
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<tr>
<td>Molybdenum</td>
<td>Green Tape</td>
<td>G10</td>
<td>Felt</td>
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<tr>
<td>Phosphor Bronze</td>
<td>HTCC</td>
<td>GFK</td>
<td>Fiberglass</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>LTCC</td>
<td>Kapton</td>
<td>FR-4</td>
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<tr>
<td>Braze Preform</td>
<td>Quartz</td>
<td>Kevlar</td>
<td>Low Temperature Glass</td>
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<td></td>
<td>KFK</td>
<td>Paper</td>
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<td></td>
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<td>PE</td>
<td>Styrofoam</td>
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<td></td>
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<td>Rubber</td>
<td>Wood</td>
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<td></td>
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<td>Teflon</td>
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</tbody>
</table>
GENERAL GUIDELINES

- Typical Scribe Depth: 40% – 50% of Substrate Thickness
- Typical Pulse Spacing: .005” +.002”/- .001”
- Standard Dimensional Tolerance (after snapping): ± .002”
- Standard Tolerance for "Slag": <.002”

MACHINING TOLERANCE MATRIX

<table>
<thead>
<tr>
<th></th>
<th>Scribe Line</th>
<th>Machined Lined</th>
<th>Drilled Hole</th>
<th>As Fired Edge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scribed Line</td>
<td>± .001”</td>
<td>± .001”</td>
<td>± .001”</td>
<td>± .005”</td>
</tr>
<tr>
<td>Machined Line</td>
<td>± .001”</td>
<td>± .001”</td>
<td>± .001”</td>
<td>± .005”</td>
</tr>
<tr>
<td>Drilled Hole</td>
<td>± .001”</td>
<td>± .001”</td>
<td>± .001”</td>
<td>± .005”</td>
</tr>
</tbody>
</table>

STANDARD HOLE TOLERANCES

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Minimum Diameter</th>
<th>Maximum Taper</th>
</tr>
</thead>
<tbody>
<tr>
<td>.005” to .020”</td>
<td>.005” ± .001”</td>
<td>.002”</td>
</tr>
<tr>
<td>.025” to .040”</td>
<td>.005” ± .001”</td>
<td>.002”</td>
</tr>
<tr>
<td>.045” to .060”</td>
<td>.005” ± .002”</td>
<td>.003”</td>
</tr>
<tr>
<td>.061” to .100”</td>
<td>.005” ± .002”</td>
<td>.004”</td>
</tr>
</tbody>
</table>

NOTE: All holes are measured on the laser exit side of the material either optically or with pin gauges.

All tolerances are specified in inches and based on 91% to 99.9% Alumina.
All dimensions and tolerances are LPI standards. Consult with LPI when more stringent tolerances are required.
LPT also offers diamond sawing services in addition to laser scribing and machining. Diamond sawing produces edges of superior quality and high precision for applications such as wraparound printing. Diamond sawing is also the best way to cut substrate arrays into very small parts. We use various blade compositions, blade widths and diamond grit sizes for cutting different materials to optimize cut quality and minimize chipping & pull-outs, therefore obtaining high yields. LPT’s state-of-the-art diamond sawing capabilities offer an economical solution for the most stringent design requirements.

**EQUIPMENT CAPABILITIES**
- Table Travel: 8.0"
- Effective cut length: 8.0" X 8.0"
- Accuracy and repeatability: ±0.0001" (2.5 microns)
- Optics resolution: ±0.0001" (2.5 microns)
- Blade diameter: 2.3" & 4.6"
- Smallest part size: 0.020" X 0.020" X .010"
- Substrate thickness: .005" to .200"
- Kerf widths: .004" to .020"
- Mounting of parts: wax, adhesive or UV tape
- De-ionized water wash

**STANDARD TOLERANCES**
- ± .001" finished part dimensions
- ± .001" squareness and perpendicularity
- ± .001" alignment from fiducials or internal features
- Kerf width tolerance ±0.0004"
- Tighter tolerances are available upon request

**SERVICES**
- Prototype to high volume production
- Qualification samples at no charge
- Rapid turnaround
- Packaging in waffle packs, custom trays, shrink-wrap or bulk

When applications require a combination of process technologies, LPT’s optical alignment systems provide tight tolerance registration from internal features within each substrate. This allows us the option to provide Laser Drilling, Laser Machining and Diamond Sawing on each component.
We process jobs quickly, precisely, on a reasonable cost basis.

Ability to prototype or manufacture small quantity jobs without the expense and leadtime required for complex tools, dies or punches.

Character generation (laser marking) is available for serialization or identification with a part number, name or logo on almost any surface.

Typical thickness for various types of mild steel and alloys range from .001" to .078". In plastics or acrylics, thicknesses of up to .500" can be laser cut or drilled.

Standard tolerances of ± .005" are easily achieved, although, depending on the thickness of the material, some taper in the cut will be present.
LPT has recently acquired custom equipment with improved, state of the art, high speed laser cutting technology. Markets keep demanding that features become smaller and closer together. With our new laser capability, LPT can provide leading edge technology to accommodate these demands.

The new laser technology allows higher cutting speeds without sacrificing quality. This equipment was custom fabricated for LPT to not only produce parts at higher speeds but to improve quality and allow features to be spaced more closely, a 4X benefit.

Normally, design guidelines limit feature spacing to be equal to material thickness, a 1:1 ratio. With the new laser system we can space features at half the material thickness. This can be achieved without creating micro-fractures with new technology that allows the heat-affected zone (HAZ) and the taper inherent in the laser machining process to be significantly reduced.

LESS LIMITATIONS

HAZ limits how closely thin and thick film metallization can be deposited around the features. In addition, it limits the spacing between features on other materials such as laminates, Kapton, metal foils, plastics, and other exotic materials. Our new laser cuts these limitations by 50%.

Another benefit of reduced HAZ is that the scribe pulses can be produced using a tighter gap between them. Smaller and cleaner pulses can be achieved allowing for more uniform snapping of the substrate.
Please note that these materials are the standard items that LPT has in stock on a regular basis. If other sizes, thicknesses or surface finish are required, LPT can obtain the required material and/or stock it for our customer’s specific applications. If you have a special need for custom materials, please contact our sales department.

LPT’s qualified suppliers for 96% alumina substrates are CoorsTek, Ceramtec and Kyocera.

### 96% Alumina (As Fired)
- .010” - 3.3’’ x 3.3’’
- .010” - 3.5’’ x 3.5’’
- .015” - 4.5’’ x 4.5’’
- .020” - 4.5’’ x 4.5’’
- .025” - 4.5’’ x 4.5’’
- .025” - 4.5’’ x 6.5’’
- .030” - 4.5’’ x 4.5’’
- .030” - 5.5’’ x 5.5’’
- .035” - 4.5’’ x 4.5’’
- .040” - 4.5’’ x 4.5’’
- .040” - 4.5’’ x 6.5’’
- .050” - 4.5’’ x 4.5’’
- .060” - 4.5’’ x 4.5’’
- .080” - 4.5’’ x 4.5’’

### 99.6% Alumina (As Fired)
- .010” - 4.5’’ x 4.5’’
- .015” - 4.5’’ x 4.5’’
- .020” - 4.5’’ x 4.5’’
- .025” - 4.5’’ x 4.5’’

### 91% Alumina (CoorsTek ADOS-90R)
- .020” - 4.5’’ x 4.5’’
- .040” - 4.5’’ x 4.5’’

### 99.5% Beryllium Oxide (BEO)
- .025” - 2.3’’ x 2.9” (lapped)
- .040” - 2.062’’ x 2.062’’ (as fired)

### Aluminum Nitride (170 w/Mk)
- .025” - 4.5’’ x 4.5’’
- .040” - 4.5’’ x 4.5’’
Company downsizing has left man businesses without the resources to find suppliers and manage their programs to receive finished products with an on-time delivery. In order to provide turnkey solutions for our customers, we at LPT have established a resource network to provide a multitude of services. Our resource base is comprised of companies that are experts within their fields and produce the highest quality products.

LPT provides the following services to help our customers with their turnkey requirements:

- Sonic milling
- Ceramic grinding
- Chemical etching
- Plating
- Via hole fill
- Lapped and polished substrates
- Thin and thick film metallization
- Brazing
- Micro machining
- Other laser services such as Excimer, YAG and UV
- Specialized or exotic materials
- Water jet cutting
- Metal cutting and forming

LPT assumes 100% liability for the quality and delivery of the products. Please contact us if you have special applications where our resources could best fit your needs.