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Laser Scribing Ceramic Substrates

Laser scribing ceramic substrates has been increasingly popular since its introduction to the industry nearly 50 years ago. The process involves pulsing the CO2 laser through an optical configuration, into a focusing lens, focusing the beam through an air assisted nozzle assembly, and finally onto the substrate work surface. Most Laser scribing systems utilize a CNC or PC based motion control system, moving the substrate below the fixed beam assembly at speeds as fast as 10 in./sec, or faster. Each pulse of the Laser provides an efficient and effective evacuation of molten and ablated ceramic substrate particulates. Well executed scribes allow for subsequent controlled breaks or "snapping" of the substrate to the final size.

Laser Scribing in History: In 1964 Kumar N. Patel Invented the CO2 LASER while working at Bell Labs.

Critical Parameters for Maintaining Proper Control of Laser Scribing:

- Laser beam quality
- Consistent Focus to the entire work surface area
- Air assist flow and pressure
- Pulse depth (average penetration of each individual pulse into the substrate)
- Pulse to pulse spacing

Is Laser Scribing Right for Your Application?

Consider the following factors when determining if laser scribing is the best option.

- Achievable tolerances
- Edge Quality
- Subsequent Processing
- Surface Quality
- Appearance & Cleanliness
- Singulation Technique
- Cost

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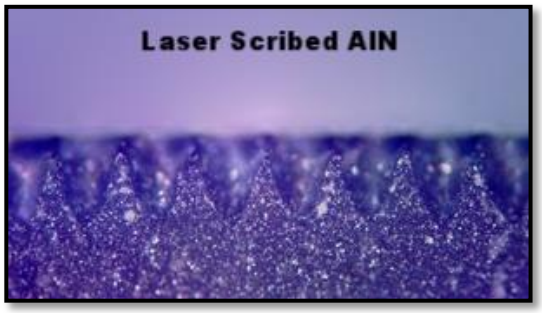
Achievable Tolerances for Scribing:

While Length and width tolerances as low as +/-.001'' for laser scribed and subsequently singulated substrates can be achieved, the most common tolerances that can be consistently achieved are:

- +/-.002'' for .015'' thick or less
- +.003/-.002'' for .016'' to .030'' thick
- +.004/-.002'' for .031'' to .040''
- +.005/-.003 for .041 to .050 thick
- +.006/-.003 for .051 to .060'' thick
- Wider tolerances for most ceramic materials above .060'' in thickness

Edge Quality of Scribed Parts:

A laser scribed edge is not smooth, as at least one side of the edge is scalloped. If any kind of substrate particulate that could break away from a Laser Scribed edge has the potential to be detrimental to the part or its eventual environment, then a Laser Scribe is not recommended.



If a smoother edge is required, consider a diamond sawn edge or laser cut and subsequently annealed or clean fired edge for higher edge quality.

Compatibility with Subsequent Processing:

Due to the many factors pertaining to the subsequent processing of substrate materials, I suggest speaking with an expert to determine if Laser Scribing is a fit for your specific application.

Surface Quality:

A Laser Scribed surface has a heat affected zone local to the scribe, so careful consideration is recommended if there are critical areas on the substrate surface within .005'' of the scribed edge.

Surface Protection:

Laser slag or molten ceramic particulates on the surface can be minimized using a protective coating; a water soluble emulsion is typically used. To be certain that "all" laser slag/particulate is removed from the surface, a subsequent "scrubbing" of the work surface is often needed to provide optimal surface conditions for most applications.

Scribing for Singulated Substrates

When scribing for immediate singulation of substrates, the average scribe depth for a clean and successful "snap" is in the 30% to 50% range of the substrate thickness. When the materials are greater than .040'' or 1mm thick, a slower scribe that achieves greater than 50% penetration, or a "double scribe" may be used to make eventual singulation more successful. Pulse spacing is suggested to be tighter for shallower scribe depths and further apart for deeper scribes. In general, .003'' to .005'' spacing is suggested for materials up to .020'' thick, .005'' to .007'' for materials from .021'' to .040'' thick, and for materials above .041'' thick .007'' to .008''

Considerations for Singulated Substrates:

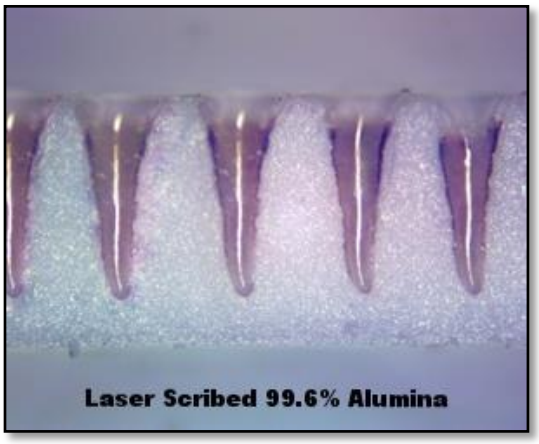
- Smaller Parts (less than 0.4'' or 1 cm in dimension) are easier to achieve when utilizing a deeper scribe and tighter pulse to pulse spacing.
- Will parts be separated by hand or in an automated or semi-automated system? Automated systems can handle a more robust substrate and pulse depth can be specified on the shallower side, or even less. However, with shallower scribes, it's important to have tighter spacing.

Scribing for Arrayed Substrates

Using a multi-up configuration allows the customer to snap the substrates to size after they have completed building and processing the component. When scribing a substrate in a multi-up configuration, it is important to control the scribe parameters to an even greater degree. While the average scribe depth for a clean and successful "Snap" is still in the 30% to 50% range of the substrate thickness, making certain that pulse spacing is properly aligned with materials thickness becomes of greater importance. If pulse spacing is too tight or if pulse depths are too deep, then the substrate may break prematurely with subsequent processing of the substrate material.

Example: Multiple screen print and firings of conductive, dielectric, and resistive materials on the substrate may result in premature breakage.

Appearance and Cleanliness of Scribed Materials:

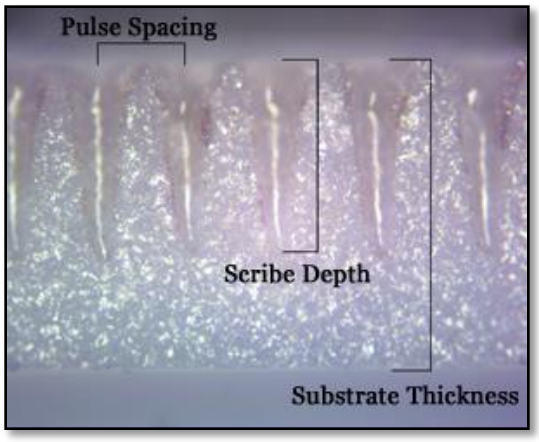


Often a Laser Scribed substrate appears yellowish, gray, or even black on the substrate surface. For many, this is not an attractive part of the Laser Scribe process. In many substrate materials, the scribe can appear far more "clean," or less oxidized via utilization of proper assist gases. Oxygen, Nitrogen, Co2, and other gases or blends of gases and shop air can help to achieve a cleaner looking scribe.

Clean Firing of the substrate materials, where substrates are loaded or cycled through a furnace at elevated temperatures over an extended period of time, can also "clean" the scribes along with the substrate surface.

In critical applications a subsequent "annealing" of the substrate can be performed, but I strongly suggest consulting a professional if annealing is a consideration, as annealing introduces a need for a revised set of laser scribe parameters in order to achieve success.

Criticality in Establishing and Specifying the Ideal Laser Scribing Parameters



Pulse spacing and pulse depth, which are labeled on the 96% alumina substrate to the right, can and should be controlled very tightly. Each application of the Laser Scribing process has the potential to yield ongoing "exact" results when controlled properly. Tighter controls will produce better and far more consistent results

- Pulse Spacing can be controlled to within +/- .0002''
- Pulse Depth can be controlled to a tolerance of +/-10% of the materials thickness.

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Cost Effectiveness of Laser Scribing

The Laser Scribe is the most cost effective method for sizing ceramic substrate materials, other than tooling up for a “Green Scored” ceramic substrate, which adds the upfront cost of tooling from the manufacturer.

Laser Scribing Your Next Project

Take advantage of the many benefits of laser scribing or machining for your next application. There are a lot of things to consider before having your substrates laser scribed, so don’t hesitate to contact us. Start the conversation with us today and we can work together to figure out the right process for your needs.

Are you wondering where to find the right materials? There are several manufacturers of ceramic materials and all offer standardized substrate sizes. Centerline Technologies inventories many different sizes of most major manufacturers’ substrates. We are also able to provide custom sized substrates with a rapid turnaround.