Equipment and Methods

The manufacturing of sample holes analyzed for this report were created on lab based equipment located in-house at OpTek Systems. There are many equipment variables and Table 1 outlines the options considered for this processing.

<table>
<thead>
<tr>
<th>Laser Type</th>
<th>Beam Delivery</th>
<th>Positioning (X-Y Motion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30ns pulsed</td>
<td>Direct write</td>
<td>CNC air bearing stages</td>
</tr>
<tr>
<td>&lt;10ps pulsed</td>
<td>Galvo scan</td>
<td>Galvo scan</td>
</tr>
<tr>
<td>&lt;900fs pulsed</td>
<td>OpTek trepan head</td>
<td></td>
</tr>
</tbody>
</table>

All processing was performed with short duration pulsed lasers with the intent to avoid thermal damage to the substrates.

The workstation employed has a flexible configuration in that it can accept multiple laser types and provides a large open space for the beam delivery and motion systems. This type of tool is being used for Research and Development through to Production laser micro drilling and milling.

Figure 2 shows the machine finished in stainless steel for cleanroom compatibility.

To satisfy the demanding hole quality and positional accuracies a combination of trepanning and stages were employed. As illustrated in figure 3 trepanning is a technique for offsetting the beam in a circular motion to precisely mill to the required diameter. Further control and sequencing of this movement enables high speed trepanning of non round holes.

The CNC stages were then used to position the material under the laser beam locating the holes in the X-Y array locations.
Results: The Question of Corners - Radius Minimization

For square and rectangular holes, the key to performance is the corner radius. Minimizing this radius allows the maximum diameter of pin to be inserted in the smallest possible hole. It also allows for adjacent holes to be placed ever closer together without breakdown of the adjoining wall. The images below show 50μm square holes machined through 250μm SiN.

The Question of Corners - Dog Bone Filets

An alternative means of providing clearance in the corners is to add an external radius, the so-called “dog-bone filet”. The rather extreme example below illustrates the process:

A more typical application of this is shown below:
The requirements are increasingly more challenging and when considering the smaller sizes and tighter tolerances, non round holes cannot be drilled using traditional techniques - laser is a proving to be a good fit.

As presented, the advantages of laser drilling include:
- Flexible processing routines
- Avoids mechanical drill failure
- Feature sizes compatible with current designs
- High speed drilling of Non Round Holes now possible.

Conclusions
The requirements are increasingly more challenging and when considering the smaller sizes and tighter tolerances, non round holes cannot be drilled using traditional techniques - laser is a proving to be a good fit.

As presented, the advantages of laser drilling include:
- Flexible processing routines
- Avoids mechanical drill failure
- Feature sizes compatible with current designs
- High speed drilling of Non Round Holes now possible.

Potential issues observed with Laser drilling:
- Accuracy and tolerances require expensive hardware
- Material thickness >1mm result in excessive drill times
- Taper and entrance rounding, but manageable attributes of laser drilling

Similar results can be achieved in round holes with even shorter drill times and greater taper control. Future processing to be performed with ultrafast laser types to explore what additional improvements can be realized.

Questions?
If you have any questions, please contact:
Mike Osborne: **Europe & ROW**: 12-14 Blacklands Way, Abingdon Business Park, Oxford, OX14 1DY, UK. Tel +44 1235 539182
Andy Webb: **USA & Americas**: 12 Pilgrim Road, Greenville, SC 29607, USA, Tel: +1 978 652 8331
Henry Lu: **Asia**: 1008, Bldg A, Dingfeng Intl. Plaza, Dongguan, Guangdong 523000, China, Tel +86 13901187950

Website: www.opteksystems.com
Email: info@opteksystems.com

References
SWT Workshop Proceedings