POSTER SESSION #2

SW Test Workshop

Improvements in Laser Drilled Hole Geometries for Probe Card Applications

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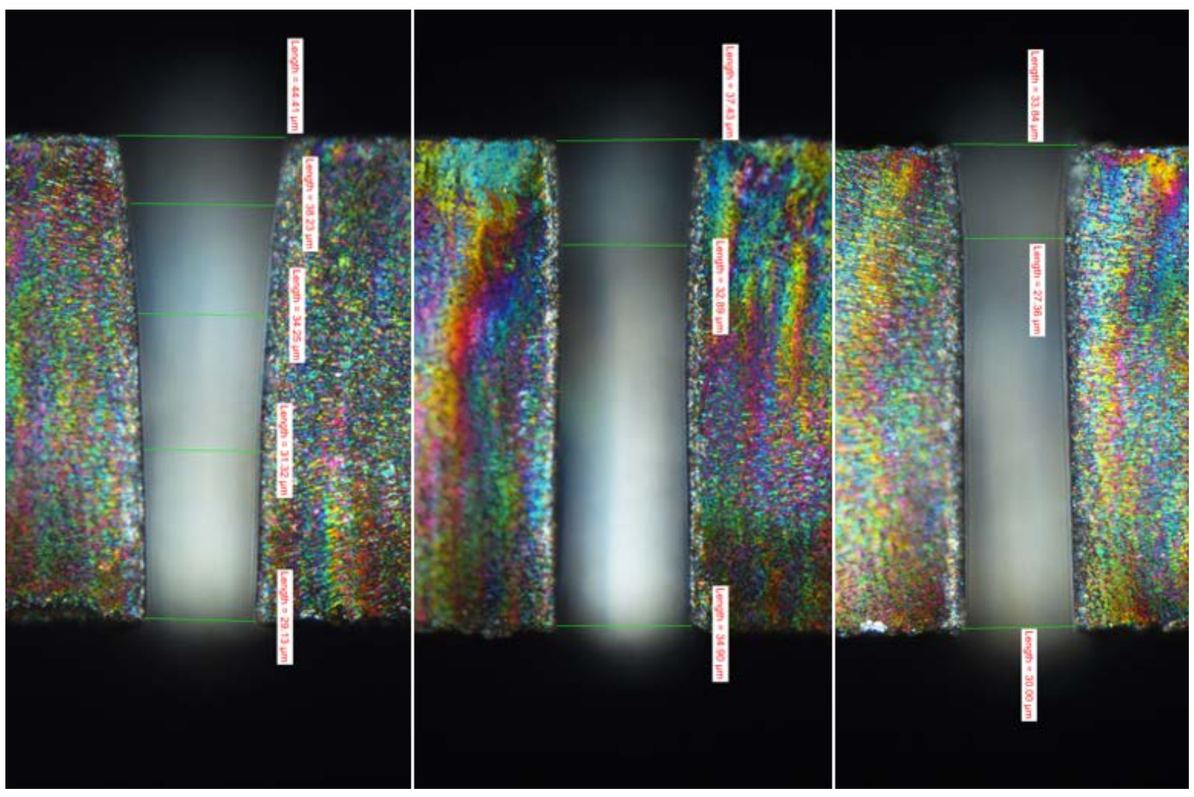
Introduction and Motivation

OpTek provides precision laser drilling to the wafer test industry and in particular manufacturing of guide plates featuring thousands of precision micro holes used in vertical probe cards. The capability is provided in several formats including development of new processes, contract manufacturing services and providing of fully integrated workstations. In addition to the guide plates, OpTek is involved in manufacturing of peripheral components that have micro scale dimensions.

There are ongoing improvement aspects to guide plates that challenge how the parts are manufactured including hole size, shape, position and quantity. This presentation focuses on the aspect of shape and in particular taper and how this influences guide plate drilling.

In addition to hole quality, OpTek is sensitive to the process times achieved as in addition to requiring closer spacing with higher hole counts, the cost per hole cannot increase making drill times an important parameter.

Delivery and motion of the laser beam over the substrate being processed is being considered. At Southwest Test in 2017 OpTek touched on taper control and presented the following images:



Material Type:	SiN
Thickness:	125µm
Time/hole:	<2s
Taper:	Left +6.8°, center 0°, right -1.8°

Figure 1 – Taper control presented in 2017

The presentation this year further considers the process with analysis of latest results achieved combined with recommendations.

Equipment and Methodology

The drilled holes being analyzed in this report were created on lab based equipment located in-house at OpTek Systems. Multiple laser types with varying performance were considered, but in this case the laser remains a constant with the beam delivery and in particular the trepanning properties being optimized.

Laser Type	Beam Delivery	Positioning (X-Y Motion)
<30ns pulsed	OpTek Trepanning Head	CNC air bearing stages

Depending on specific customer needs and to facilitate processing of different material types, ultrafast lasers with Picosecond or Femtosecond pulse durations could be employed.

The workstation used 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

Figure 2 – OpTek MM6500 Workstation

Trepanning heads are commercially available for purchase, but to facilitate greater control and better integration with existing OpTek hardware, OpTek has developed and built a custom module that is being assessed in this report. Different to using CNC stages (moving material) or galvo mirror scanning (deflecting beam), trepanning is a technique for offsetting the beam in a circular motion to precisely mill holes to the required diameter. Control and sequencing of the device enables different machining strategies such as spiraling to the required diameter or high speed trepanning of non round holes.

Materials Tested

Various types of ceramics and polymer based materials are used for guide plate applications, but for the purpose of this report and to reduce the number of variables in the analysis of the processing only Silicon Nitride is assessed.

Test Procedures

Arrays of sample holes simulating typically required dimensions were determined and then created. Conditions were varied and the impact on the resulting holes considered. Primary assessments being made with microscope based imaging and dimensional measurements.

Results:

The two images below are of exactly the same part, but taken from each side of the same hole array demonstrating the extent of taper controlled and entrance to exit diameter changes of individual holes. Entrance refers to the side the laser enters the material.

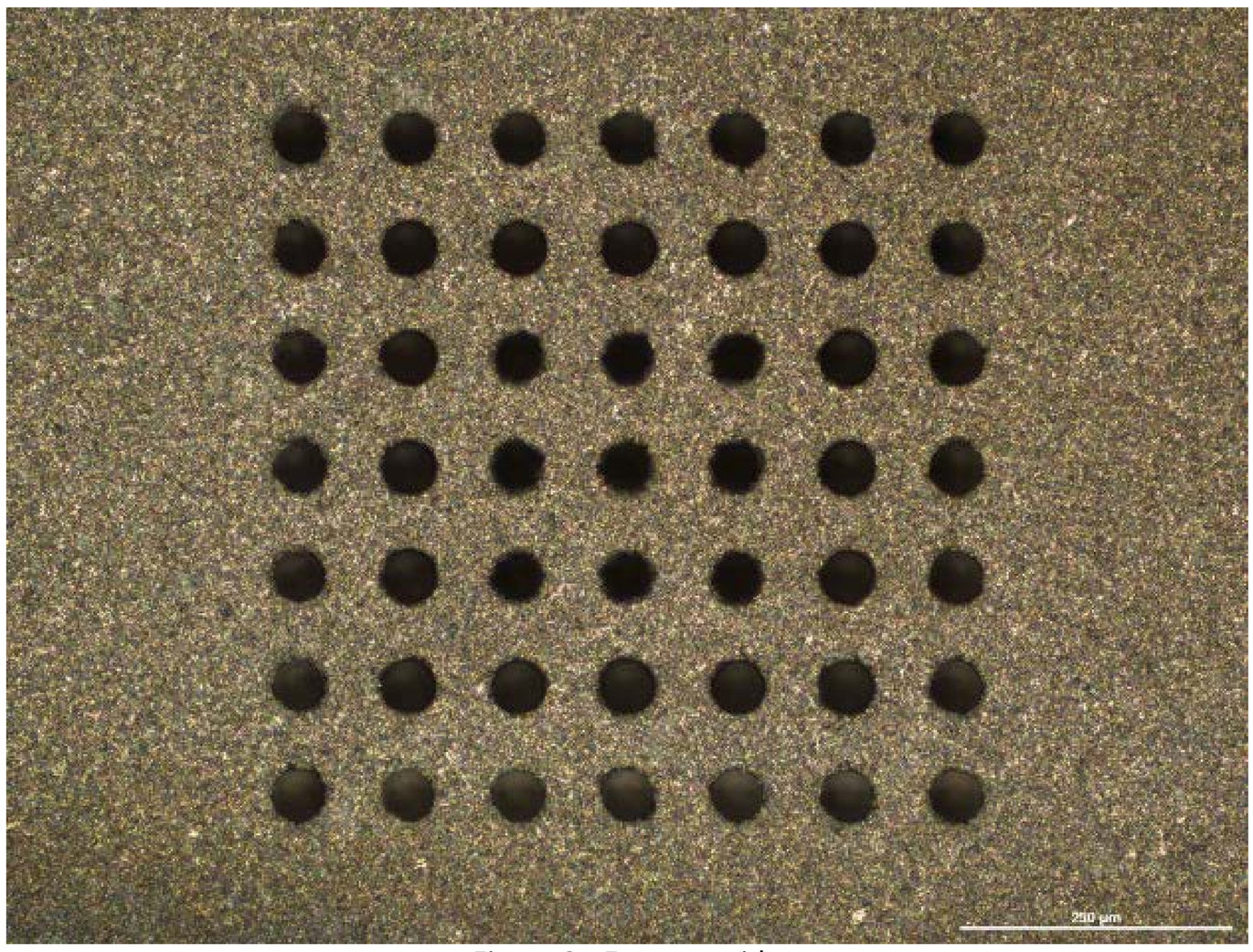


Figure 3 - Entrance side

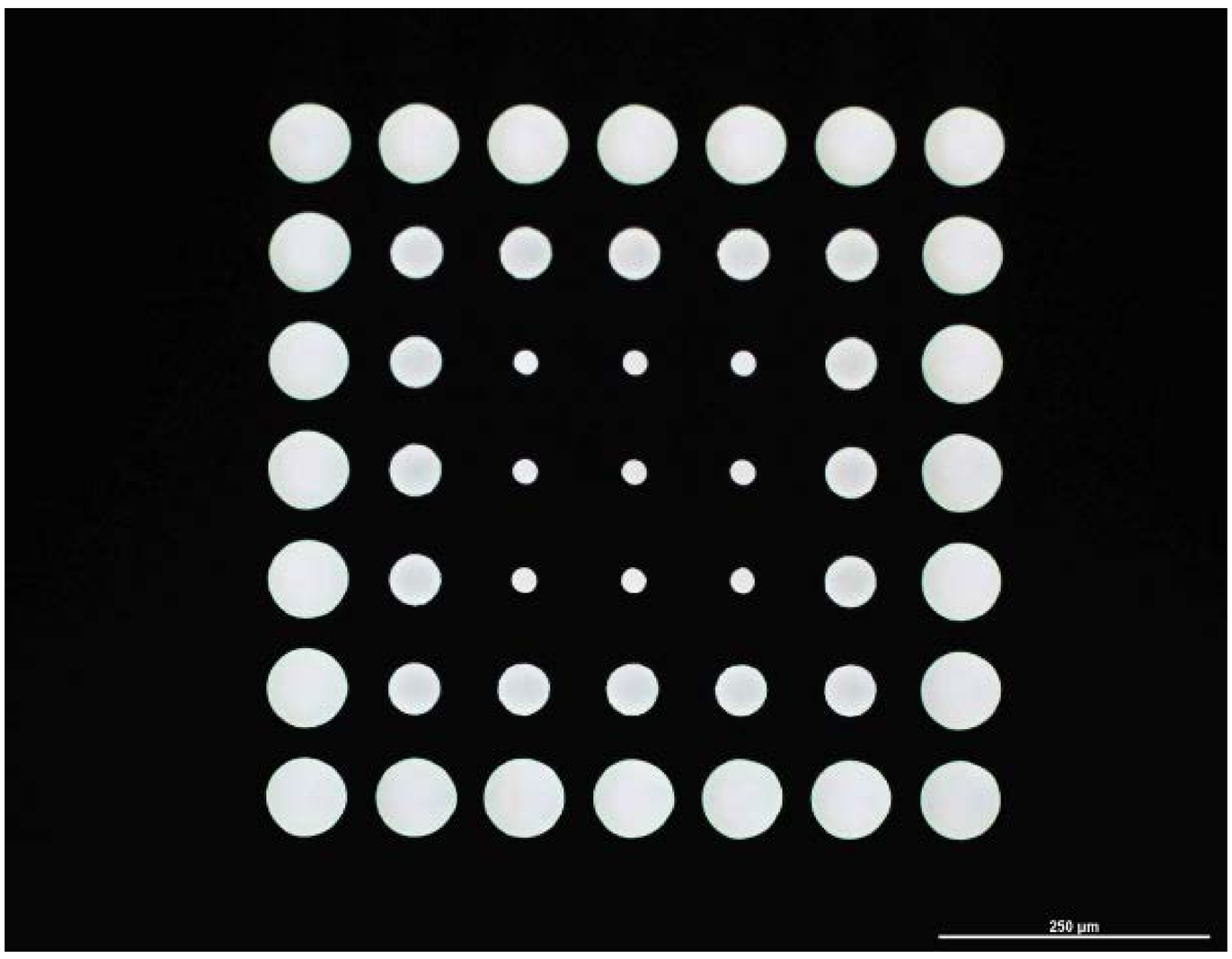
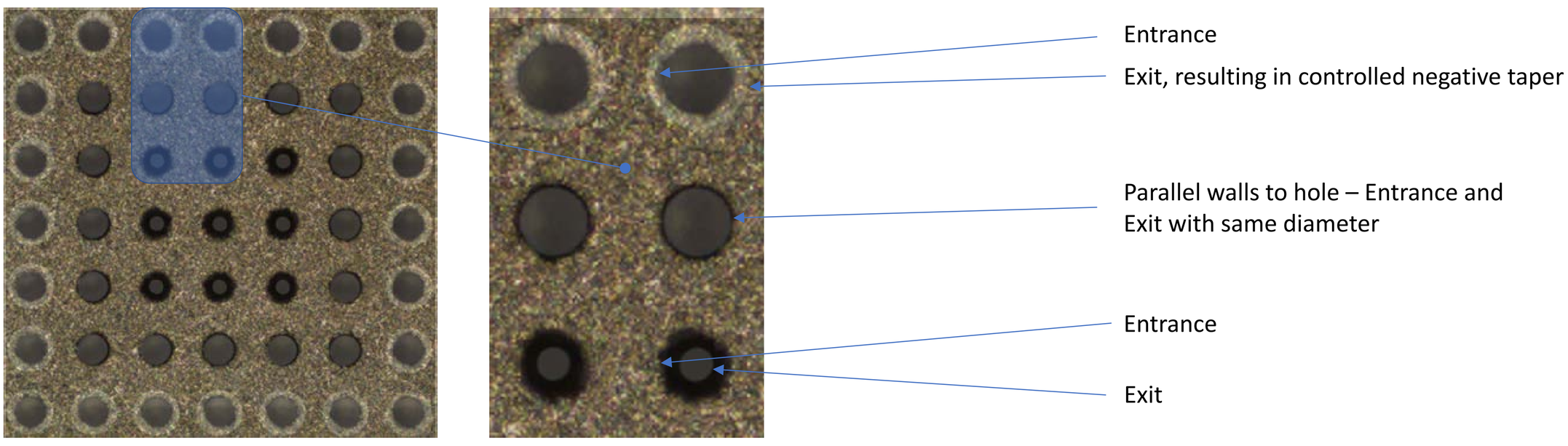


Figure 4 - Exit side of exact same array in Figure 3 above

Dimensionally the entrance diameter is 50 microns and the exits demonstrate 15 microns negative taper, zero taper and 25 microns positive taper. To date, production parts being manufactured using this technique feature 10 microns or less taper. The image below superimposes the two images:



The material drilled was Silicon Nitride with a thickness of 250microns, drill time per hole is <2s.

Hole Shape

For use of these holes in guide plate applications, in addition to measuring the entrance and exit diameter, the internal shape of the hole has to be considered.

If there are artifacts that could change the internal diameter such as necking or undercuts then this could cause friction or undesirable effects between the wall of the hole and the test pin being inserted/used. The image to the right illustrates a sectioned reverse taper hole and how OpTek's trepan head is creating a consistent shape to the hole and not introducing undesirable effects.

The discoloration observed in the image is due to the sectioning and not the laser drilling.

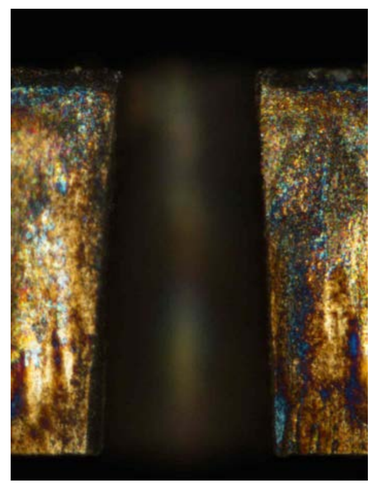
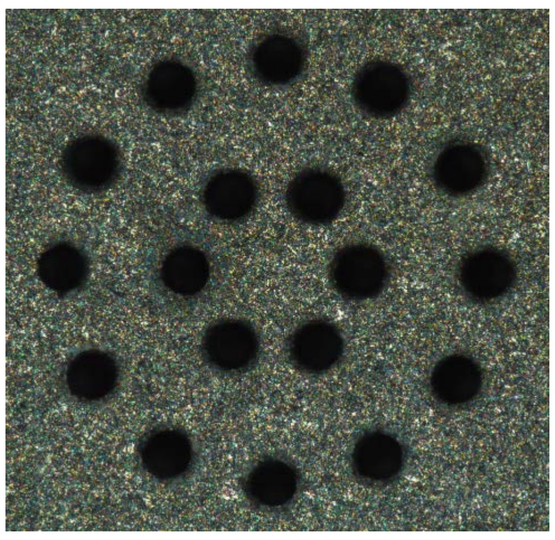


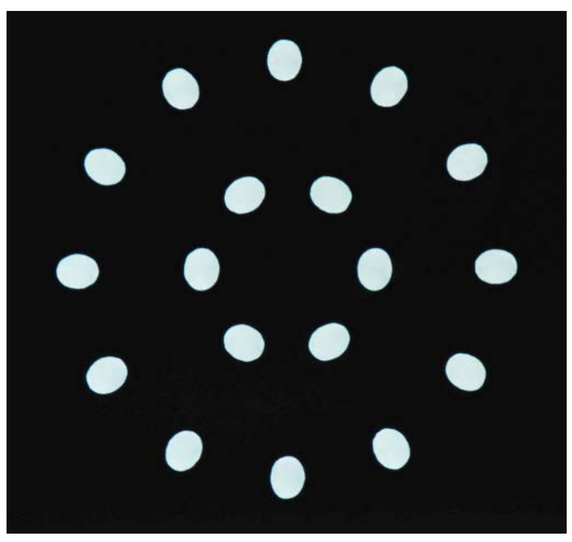
Figure 5 – Cross section reverse taper

Additional Capability

By adjusting the parameters of the OpTek trepan head during drilling and coordinating timing in relation to laser pulses, in addition to controlling the taper alone it is possible to change the shape of the hole just at the exit. This in itself is interesting, but probably not relevant to probe card applications. However, the extension of this is using the trepanning head to machine square holes whilst managing taper enabling tighter pitches of holes.

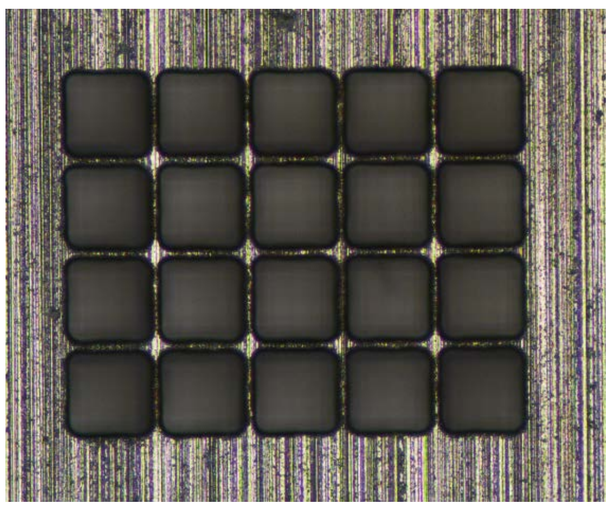


Entrance
32microns diameter

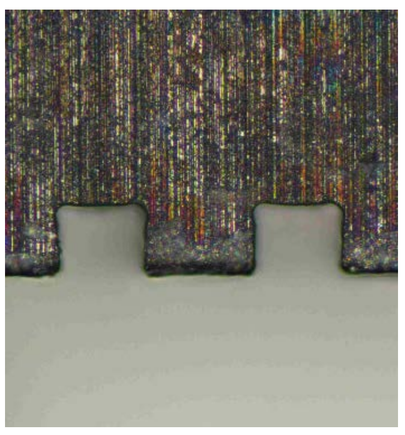


Exit image of same array, note shape of purposely elongated to 28 x 36 microns

Latest developments in trepanning of square holes whilst controlling taper facilitates positioning of holes leaving only a 5micron wall section in between each hole:



62 x 62 microns square holes, taper free with a corner radius less than 7 microns



Sectioned individual holes for assessing corner radius. Ignore damage caused by sectioning

Conclusions

The probe card industry continues to challenge laser drilling contract service providers and equipment manufacturers with hole geometries needed for vertical probe card guide plates. As observed in previous years, hole size, shape and taper require a higher level of precision and accuracy. To help address this, OpTek has developed and manufactures its own design of trepanning head for use in the laser beam delivery system and this presentation reports on the most recent performance characteristics observed.

Advantages of laser trepanned holes include:

- Ability to set the taper angle of walls in drilled holes
- Manipulate differences in hole shape between exit and entrance surface of holes
- Enable very repeatable hole geometries
- Trepan non-round and nominally square holes
- Facilitates high speed drilling

Potential issues observed:

- Not all material types tested yet
- Material thickness >1mm can result in excessive drill times
- Square holes exhibit a slight roundness to the corners
- More complex beam delivery control and programming required
- Device is wavelength of laser specific

Further testing is required so that the performance in different material types commonly used in the probe card industry can be assessed. Depending on the outcome of that testing and potentially enhancing the performance, alternative laser types should also be considered. These include going to shorter pulse durations such as Picosecond or Femtosecond and shorter wavelengths.

OpTek welcomes any guidance from the wafer test industry in relation to hole geometries to be evaluated using this technique.

Questions ?

If you have any questions, please contact:

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References

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