POSTER SESSION # 1

SW Test Workshop

Development of Latest Generation Hole Geometries for Probe Card Applications

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Introduction and Motivation

OpTek Systems is a provider of precision laser drilling either through subcontract manufacturing services or turnkey machines tools. OpTek has been supplying precision drilled holes to the wafer test industry for more than 10 years and supports the market from its locations in Asia, Europe and USA. For vertical probe cards, there is an ongoing challenge to position more holes closer together on a tighter pitch with narrower walls; and including non-round hole geometries such as square and rectangular holes, whilst simultaneously reducing the price per hole.

This poster introduces OpTek's recent Research and Development combined with process optimization to achieve acceptable hole quality with acceptable structural integrity whilst considering drill speeds.

Special attention is given to techniques for high speed and high quantity machining of square holes whilst minimizing both corner radius and taper. Laser performance and the relevance of latest generation ultra short duration pulsed parameters are considered for this application.

Analysis of results achieved in various configurations are reviewed combined with recommendations.

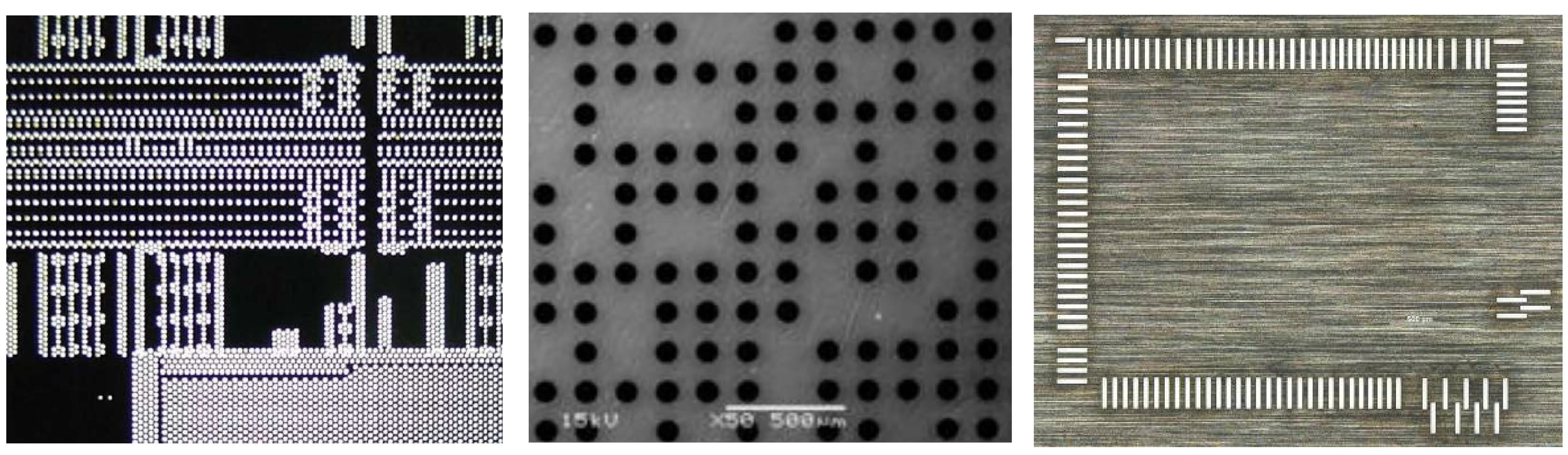


Figure 1 – Typical Vertical Probe Card Arrays

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.

Laser Type	Beam Delivery	Positioning (X-Y Motion)
<30ns pulsed	Direct write	CNC air bearing stages
<10ps pulsed	Galvo scan	Galvo scan
<900fs pulsed	OpTek trepan head	

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

Figure 2 – OpTek MM6500 Workstation

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.

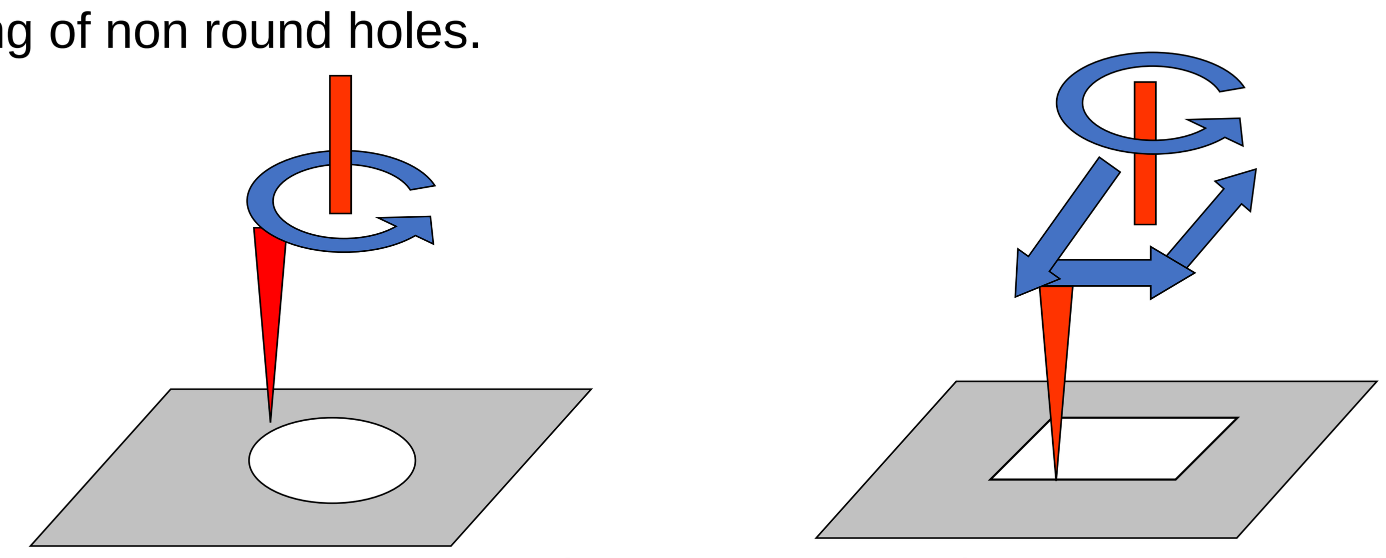


Figure 3 – Trepanning

The CNC stages were then used to position the material under the laser beam locating the holes in the X-Y array locations.

Materials Tested

The materials considered for assessment were identified through OpTek's interaction with users and customers in this field. They include:

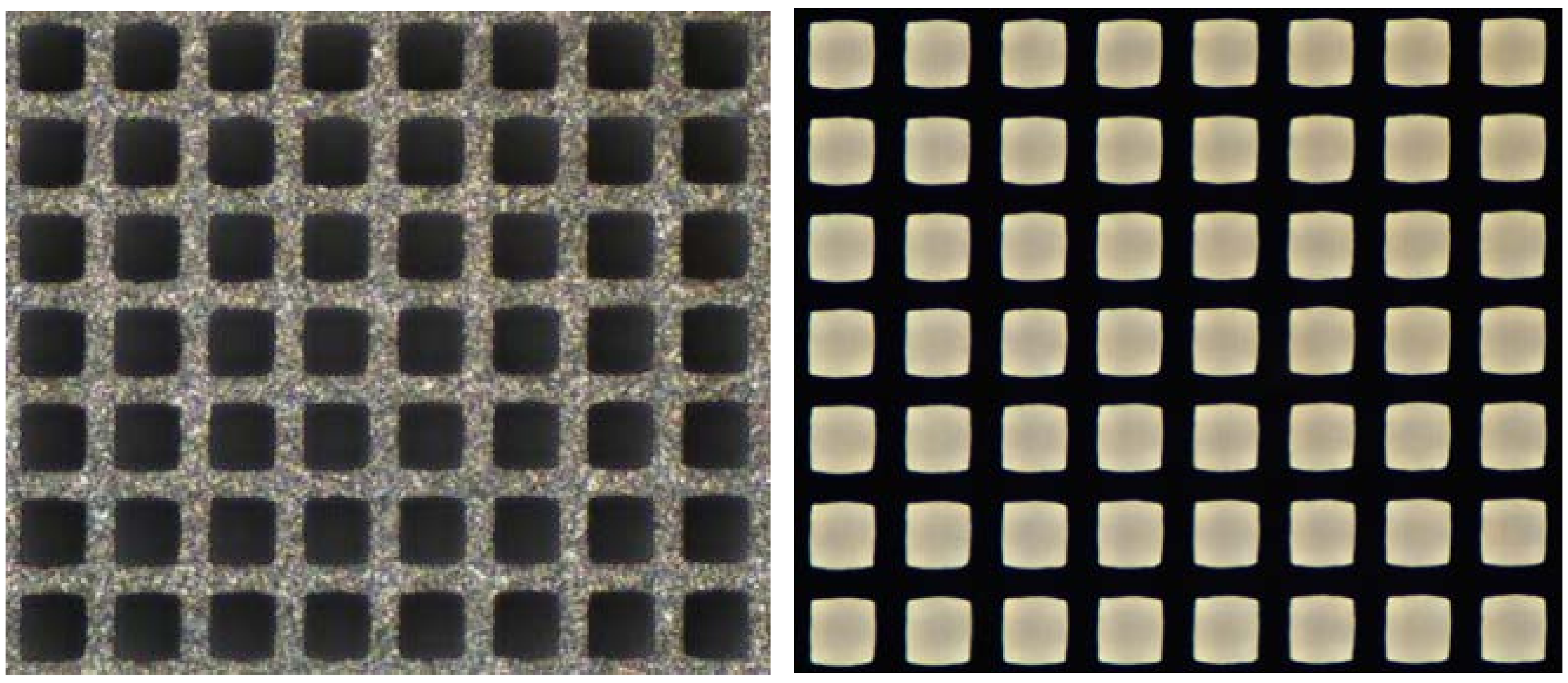
Ceramic	Polymer	Thickness
SiN	Cirlex	125
PVII	Mylar	250
Macor	PEEK	350
Alumina		450
		600
		750

Test Procedures

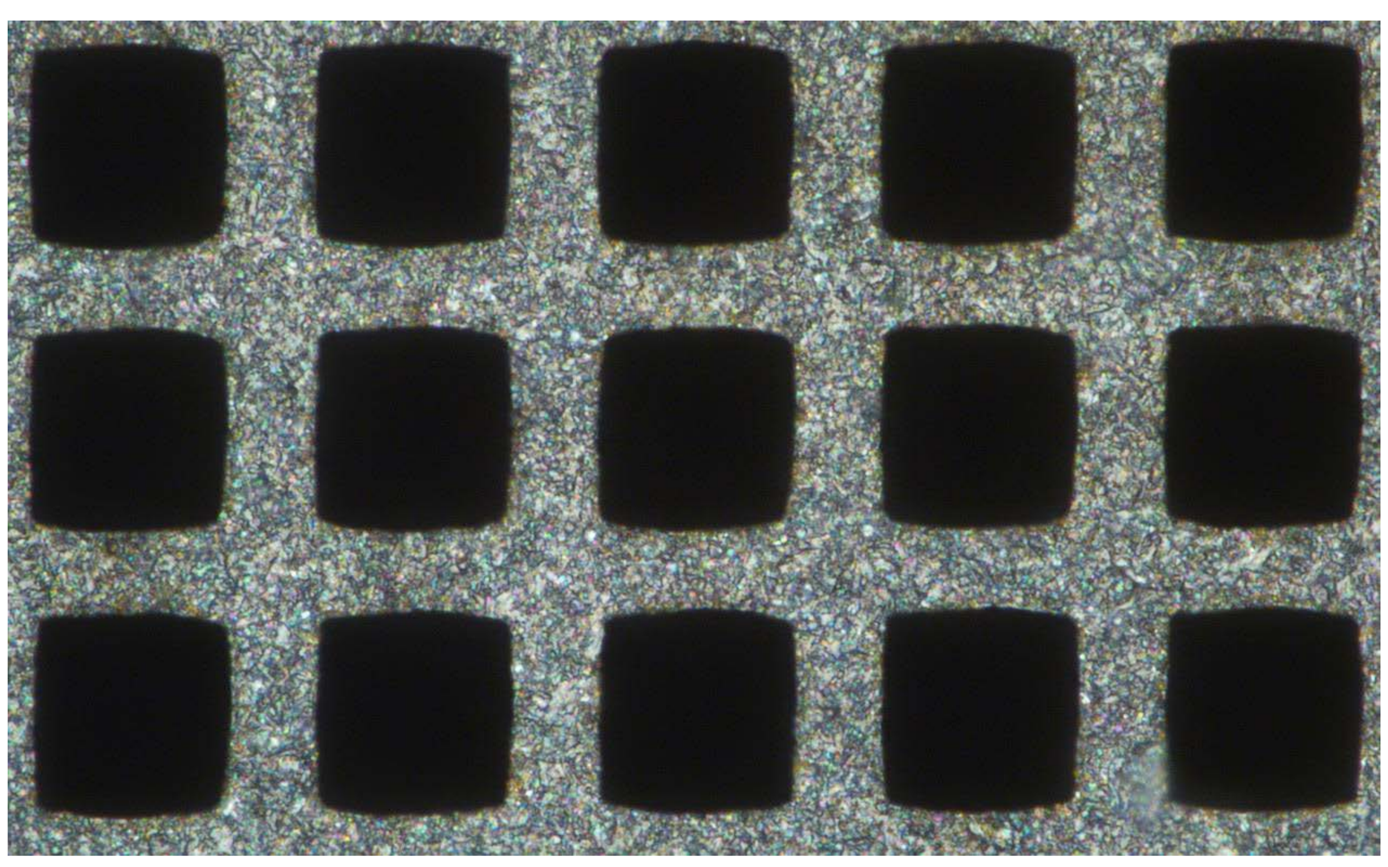
Arrays of holes simulating typical requirements were processed with the resulting drilled holes being assessed through microscope imaging measuring the dimensions, location and visually assessing hole quality.

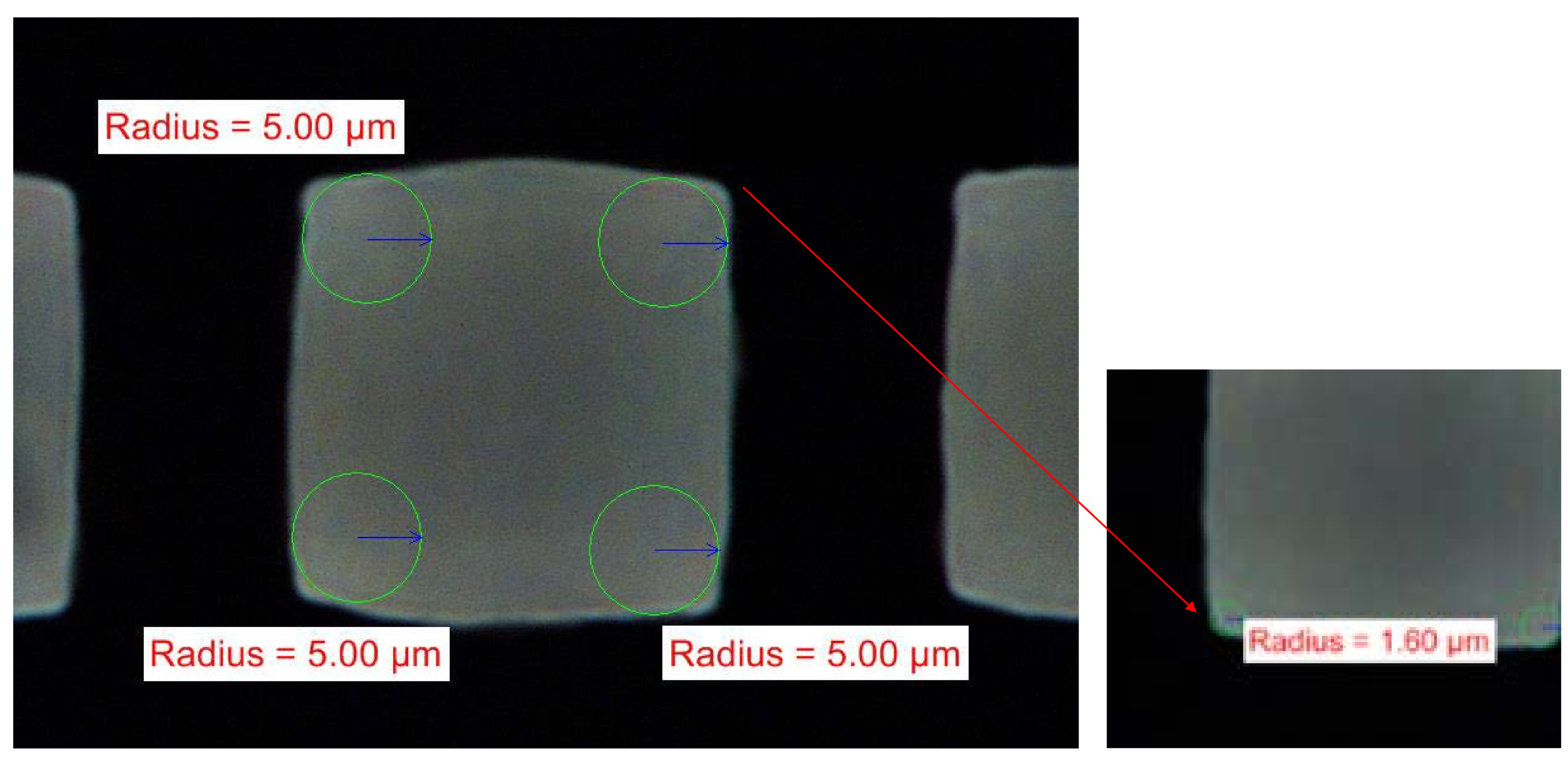
Results: The Question of Corners - Radius Minimization

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.



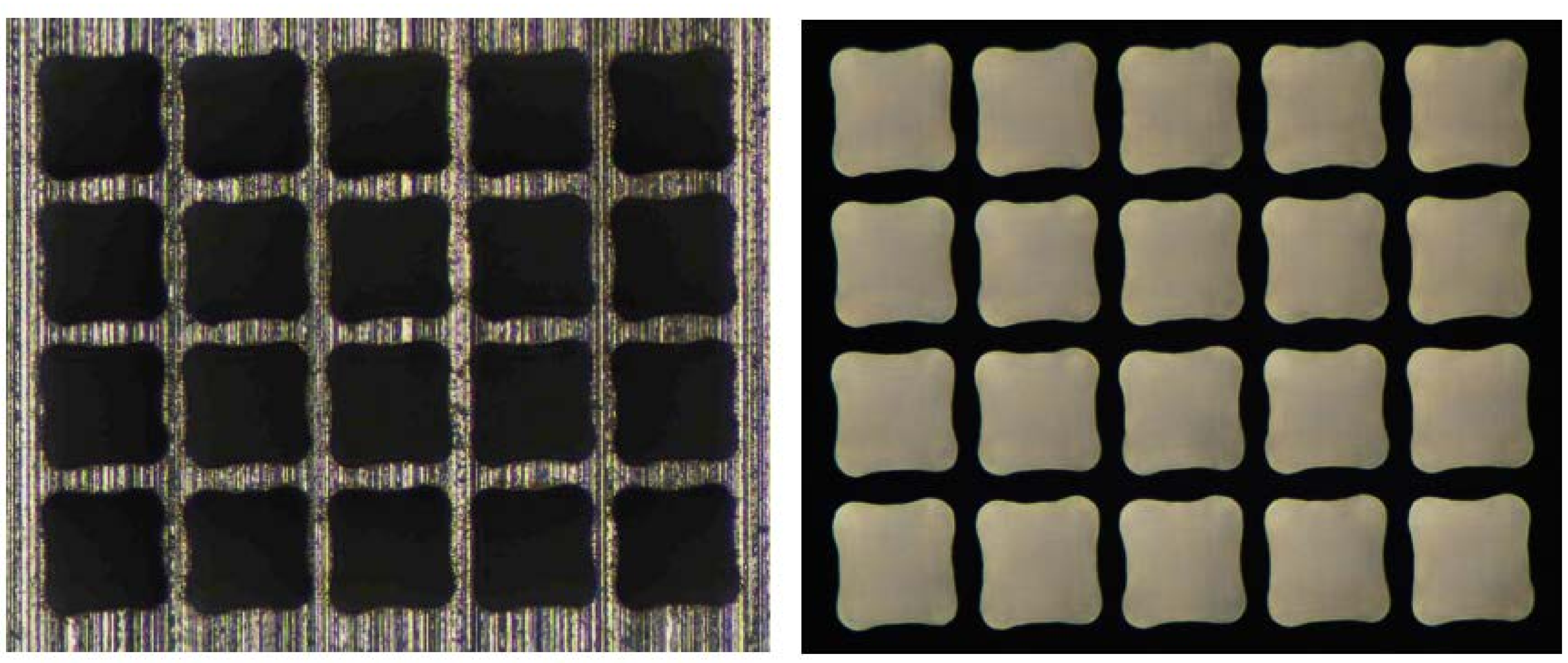
Material Type:	SiN
Thickness:	250µm
Process time per hole:	<10s
Parameters:	Radius < 2µm,
Hole size:	50 x50µm
Comments:	Front and rear illuminated images





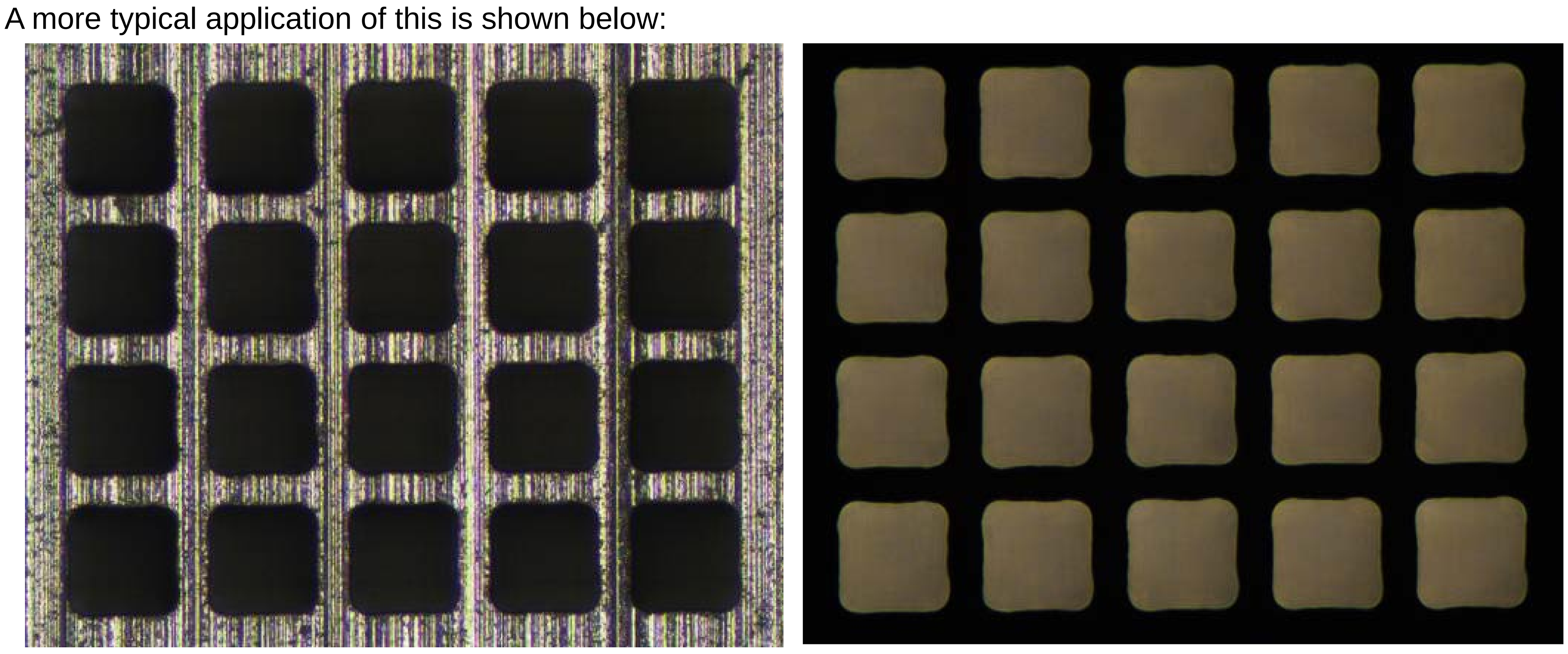
The Question of Corners - Dog Bone Filets

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 to process:



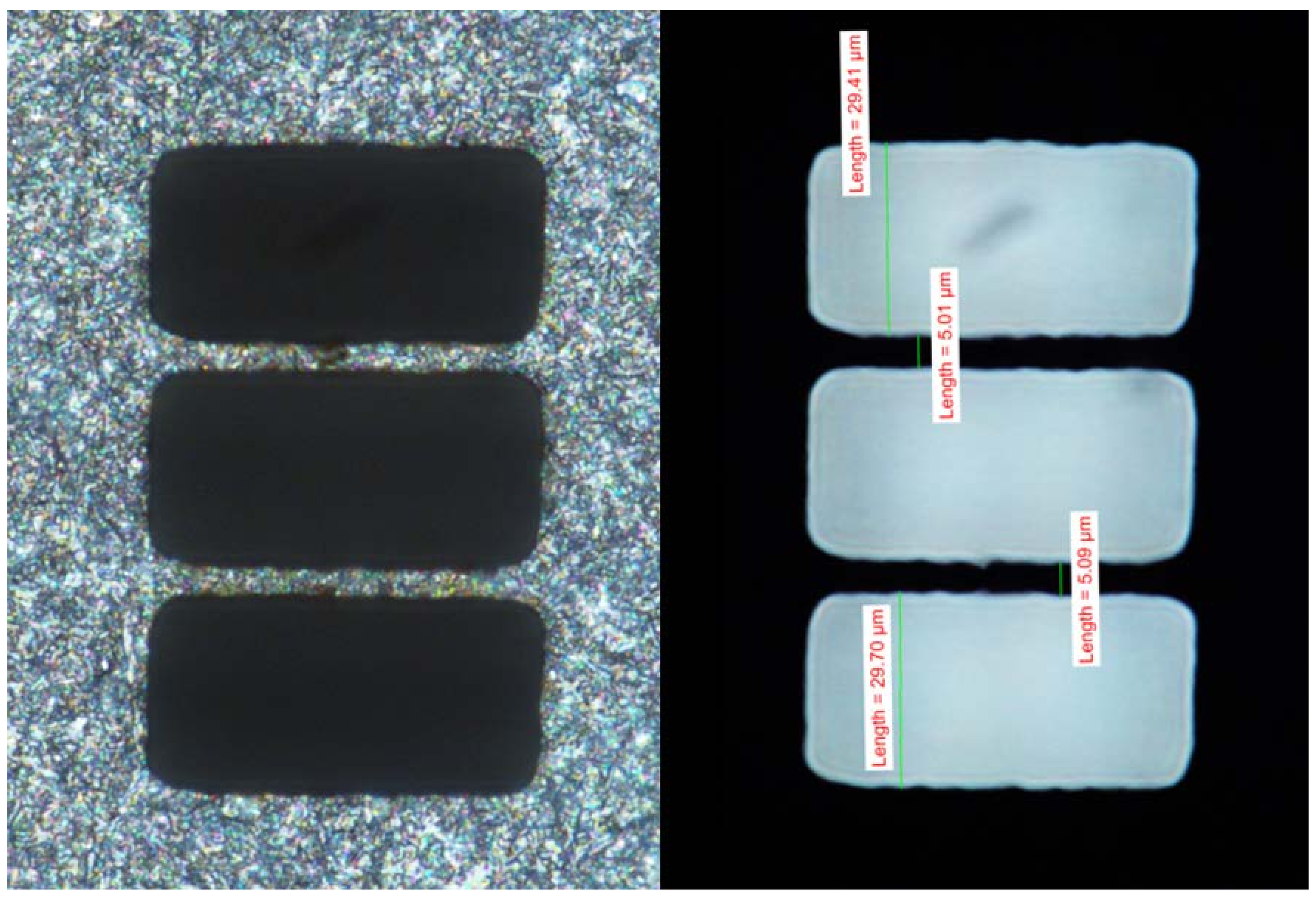
Material Type:	SiN
Thickness:	250µm
Time/hole:	<5s
Parameters:	30x30µm; 8µm radius filet
Comments:	Consideration has to be given to proximity of adjacent holes and the reduction in wall thickness due to corners

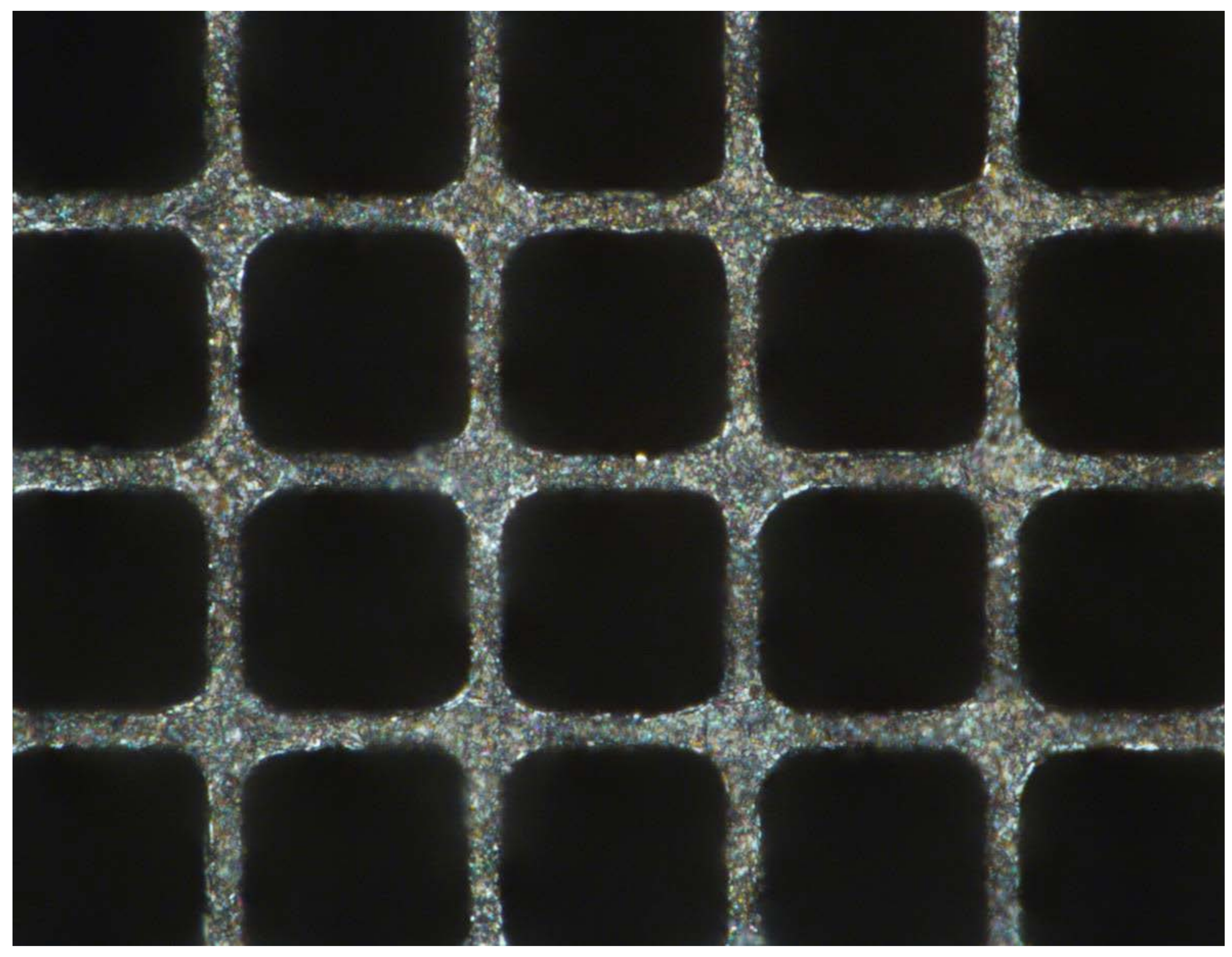
A more typical application of this is shown below:

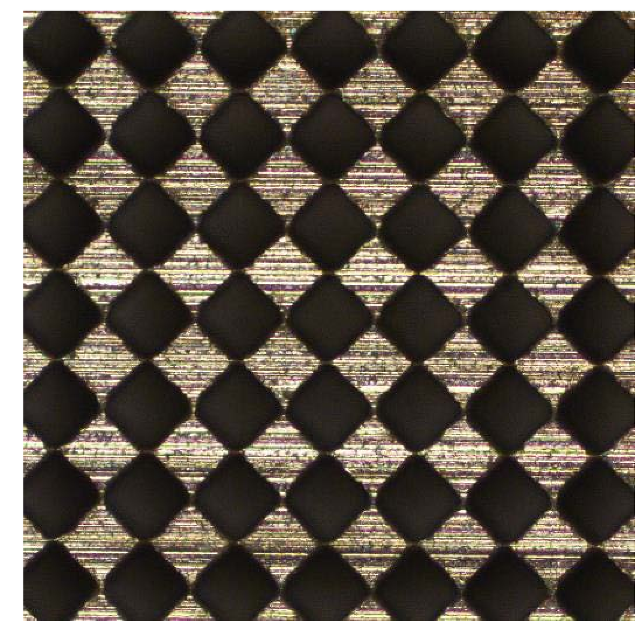


The Question of Walls

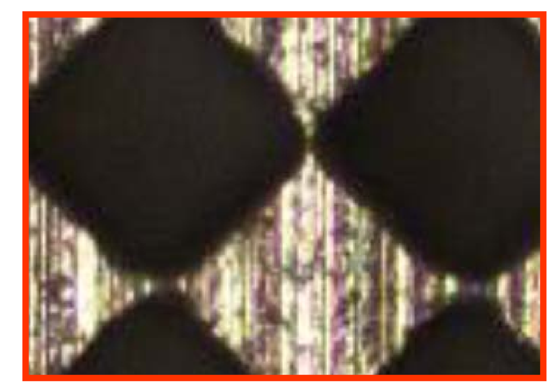
Achieving the tightest pitch can result in damage to the walls between holes and the top flat surface sometimes used for assisting the positioning of pins. Images below illustrate minimum dimensions possible:





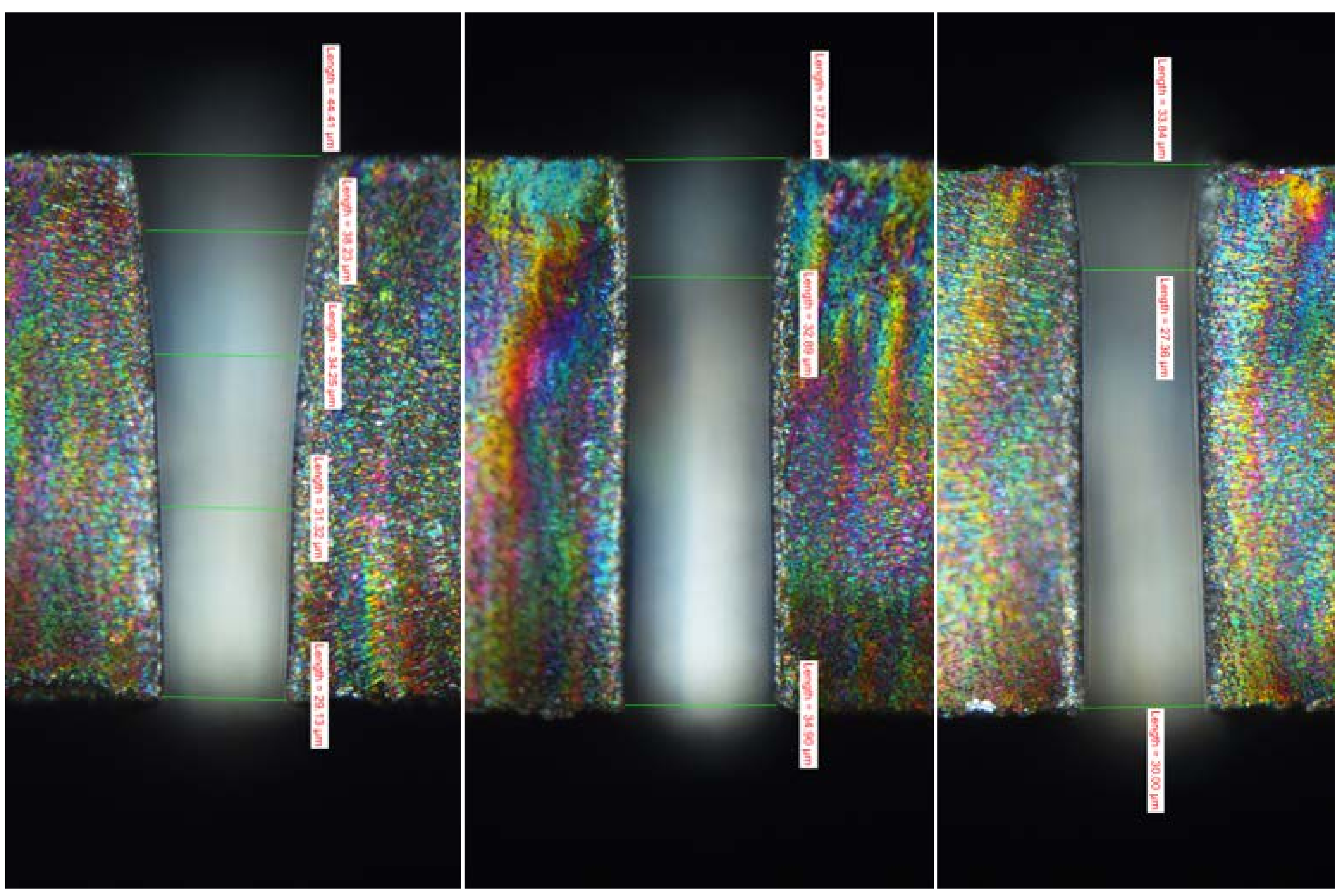


Material Type:	SiN
Thickness:	250µm
Time/hole:	<5s
Parameters:	Rectangular 60x30µm; Walls 5µm
Diamond	40x40µm; Walls <2µm between corners
Square	45x45µm; Walls <6µm



The Question of Taper

Positive (left), zero (center) and negative (right) taper possible. This is important for both assembly of pins into the probe card and reducing wall damage between adjacent holes.



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

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

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

High speed drilling of Non Round Holes now possible.

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:

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References

SWT Workshop Proceedings