“SMART” Laser Drilling for Advanced Vertical Probe Card Manufacturing

Alan Ferguson, Ph.D
Oxford Lasers

June 5-8, 2016
Overview

Introduction
Advanced Vertical Probe Cards
Historical Review
“SMART” Program
Results
Future R & D Targets
Summary
Introduction

• Guide Plates
  – Are an essential component in Vertical probe cards.
  – Consist of 1000’s micro-holes through which probes are fitted, ensuring accurate location of each probe.
  – Typical probe card uses several guide plates.

• Guide Plate Features
  – Accurately locate probe pins.
  – Pin size and pitch to match DUT.
  – Appropriate current capacity, impedance, contact resistance etc.
  – Appropriate guiding/sliding of pins, scrub, wear, cleaning etc.
  – Mechanically stable substrate.
  – Match CTε to DUT.
Advanced Vertical Probe Cards

- **Advanced Vertical Probe Card Types**
  - Cobra
  - Micro-pogo
  - MEMs

- **Minimum Probe Pitch**
  - Reducing from 120um to <50um.
  - Driven by transition from solder bump to copper pillar.

- **Materials**
  - Ceramics (SiN, Alumina, Macerite, Photoveel).
  - Polymers: Polyimides, (Kapton, Vespel, Cirlex), PEEK.
SW Test Workshop - June 5-8, 2016

Historical Review

2015

Drilling Methods and Materials for Advanced Vertical Probe Cards

Alan Ferguson, Ph.D
Oxford Lasers

2014

Challenges and Solutions in future designs of Vertical Probe Cards

Alan Ferguson
Oxford Lasers

2008

Comparison of Drilling Rates and Tolerances of Laser-Drilled holes in Silicon Nitride and Polyimide Vertical Probe Cards

Dr. Alan Ferguson
Oxford Lasers

2005

Laser Micromachining: A flexible tool in Vertical Probe Card Manufacturing

D. Karnakis, M. Knowles
Oxford Lasers Ltd., Moorbrook Park, Didcot OX11 7HP (UK)
Historical Review

What we have shown and presented:

- Demonstrated the use of Lasers in Probe Card Drilling (2005)
- Demonstrated the Over Coming of Challenges in the Industry (2014)
- Demonstrated a variety of drilling methods and materials (2015)

Now to the next Level:

Project SMART
Smart is a UK Government fund to help companies, to engage in R&D projects in the strategically important areas of science, engineering and technology.

Started December 2015

SW Test Workshop - June 5-8, 2016
Innovate UK Smart – Non Round Holes

Why Square or Rectangular Holes?
More and more requests for rectangular / square micro holes
Probes can achieve softer touchdowns
Probes are of lower cost

Why Laser Drilling?
Can’t make a square hole with a round mechanical drill bit.

What are the Issues?
Rounded / Square corners
Hole Taper
Stability
Speed
Goals of the Project

a) Decrease the corner radius for square holes
b) Maintain taper at under 2μm for all holes
c) Improve the positional accuracy of microholes
d) Improve the roundness of round holes
e) Improve / Reduce hole size variation
f) Increase the drill speed for all holes
Importance of Reduced Corner Radius

While the pin size "d" is the same, the larger corner radii reduces the possible minimum pitch of holes.
Preliminary Results

380um thick Silicon Nitride

SW Test Workshop - June 5-8, 2016
Preliminary Results

250um thick Silicon Nitride

SW Test Workshop - June 5-8, 2016
## Preliminary Results

<table>
<thead>
<tr>
<th>Material Thickness $\text{Si}_3\text{N}_4$</th>
<th>250μm</th>
<th>380μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old Method Range of Radii</td>
<td>6-8μm</td>
<td>7-10μm</td>
</tr>
<tr>
<td>New Method Range of Radii</td>
<td>4-5μm</td>
<td>4.5-5.5</td>
</tr>
</tbody>
</table>
Preliminary Results

Cast of Square Hole

Smooth Hole Profile

Low Hole Taper
What’s Next

Next Production Steps:
A.) Vigorously test and productionise Corner Radius Method

Next R&D Smart Steps:
A.) Reduce Hole Size Variation
B.) Reduce Hole Taper

SW Test Workshop - June 5-8, 2016
Hole Size Variation for 10,000 Holes

60 um by 60 um, 100-200um thick Silicon Nitride

SW Test Workshop - June 5-8, 2016
Hole Size Variation For 20,000 Holes

60 um by 60 um. 200-300 um thick Silicon Nitride

SW Test Workshop - June 5-8, 2016
While the pin dimension “d” is the same, if we reduce the entrance diameter, then this reduces the minimum pitch of the holes.
Summary

- Smart Progress
- Tighter Corner Radius possible
- Research and Development is never complete there are always further improvements to be made