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30TH ANNIVERSARY

Solutions to New Challenges in Advanced Vertical Guide Plates

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Summary

Introduction

Motivation : A need in the market for higher current Probe Cards

A Simple Mechanical Model

Manufacturing Challenges

Results of 1st Trial

Results of 2nd Trial

Discussion

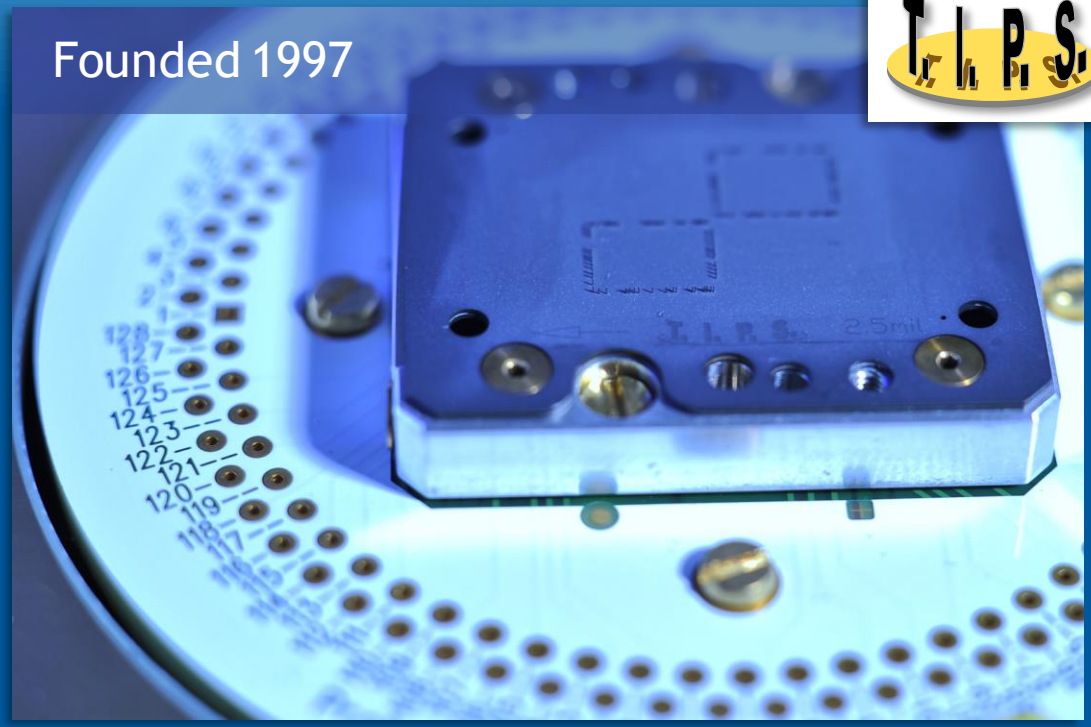
Follow-on Work

Conclusion

Introduction

Specializing in the manufacture of guide plates:

- Over 20 years experience in guide plate production
- World Class subcontract micromachining facility
- Manufacturer of production laser tools



Specializing in the design and manufacture of test interfaces for semiconductor test:

- High Power Applications
- Probe Cards for Sensor Devices
- Automotive RADAR

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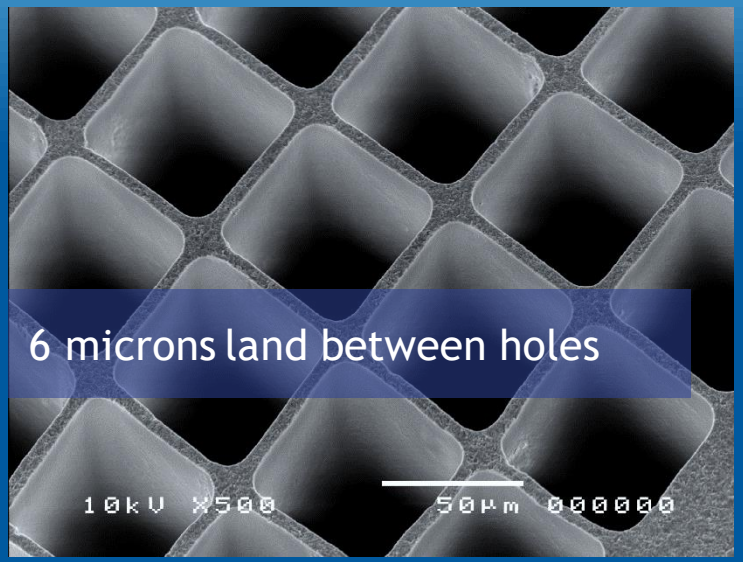
Introduction

Trends in Vertical Probe Cards :

1) Smaller Holes

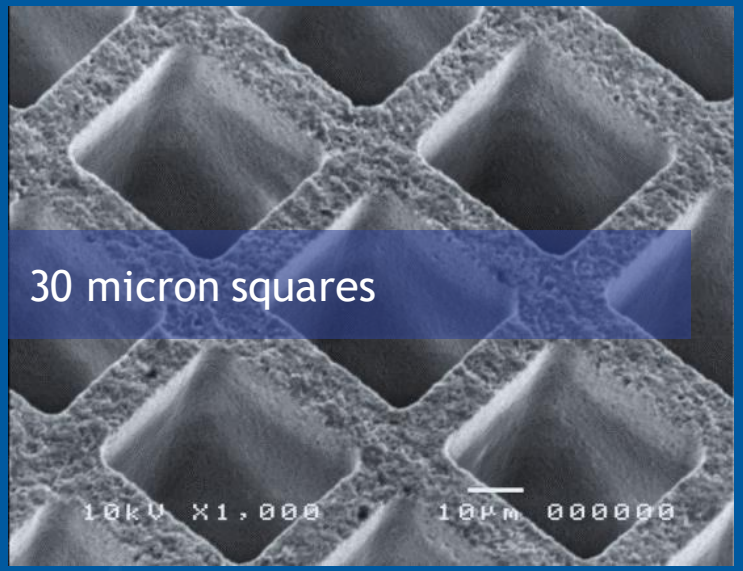
2) Tighter Pitch



The focus of this presentation is on tighter pitch :

- two years ago, we focused on achieving tighter pitch

- here, with T.I.P.S, we will show a practical example



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Motivation

T.I.P.S have noted an increasing requirement for high current probe cards :

- Requests for 3000A and more
- Vertical probe cards allow much higher current densities compared to cantilever probe cards
- High pin count and high needle density required:
  - Reducing needle pitch to increase overall current
  - Mechanical stress in ceramic guide plates could be a limiting factor

Investigation of **minimum** feasible **hole pitch** in ceramic guide plates

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Our Approach

Development of a basic mechanical model to obtain statements about the mechanical stresses in the ceramic guide plates

Conduct an experimental investigation - considering the findings from the mechanical model

- Discuss feasible wall thickness (Oxford Lasers and T.I.P.S.)
- Experimental setup with specified hole patterns (Provided by T.I.P.S.)
- Manufacturing of the ceramic guide plates (Oxford Lasers)
- Durability testing of the assembled vertical probe head (Conducted at T.I.P.S.)

Revisit the mechanical model with outcome from experimental investigations

Goal:

- **Establish guidelines for designing needle arrangements for given current and pad size / shapes**

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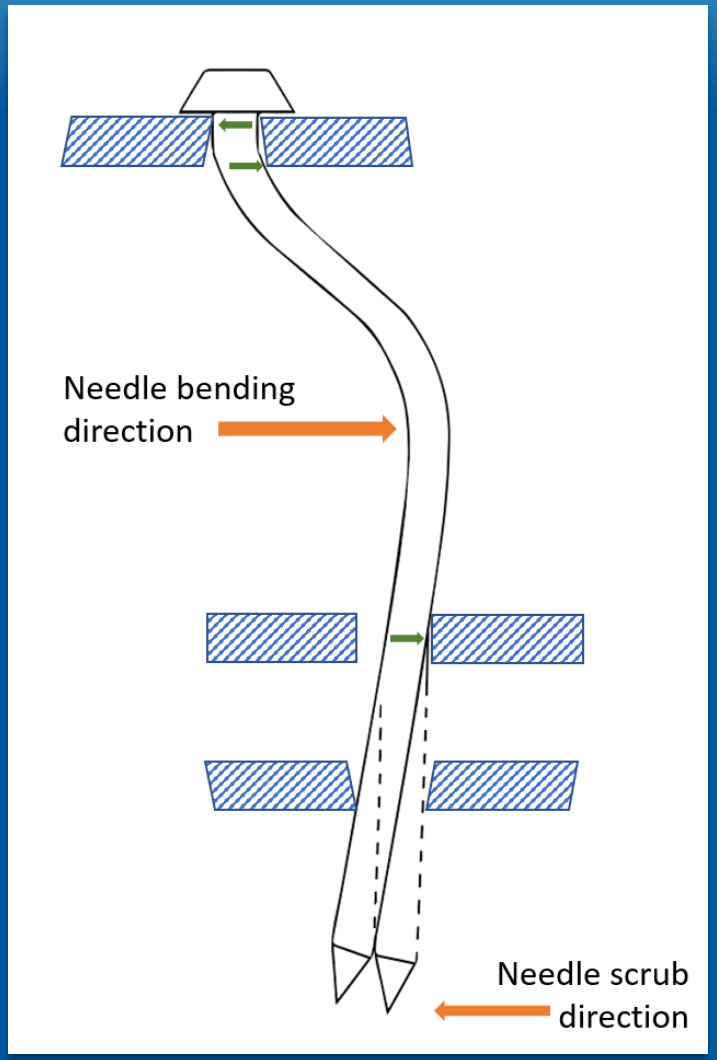
A Simple Mechanical Model

Mechanical model – Needle forces

Bending forces can be calculated from bending line of needle, dependent on:

- Needle diameter and length
- Distance between ceramic plates
- Overtravel
- Young's modulus of needle material



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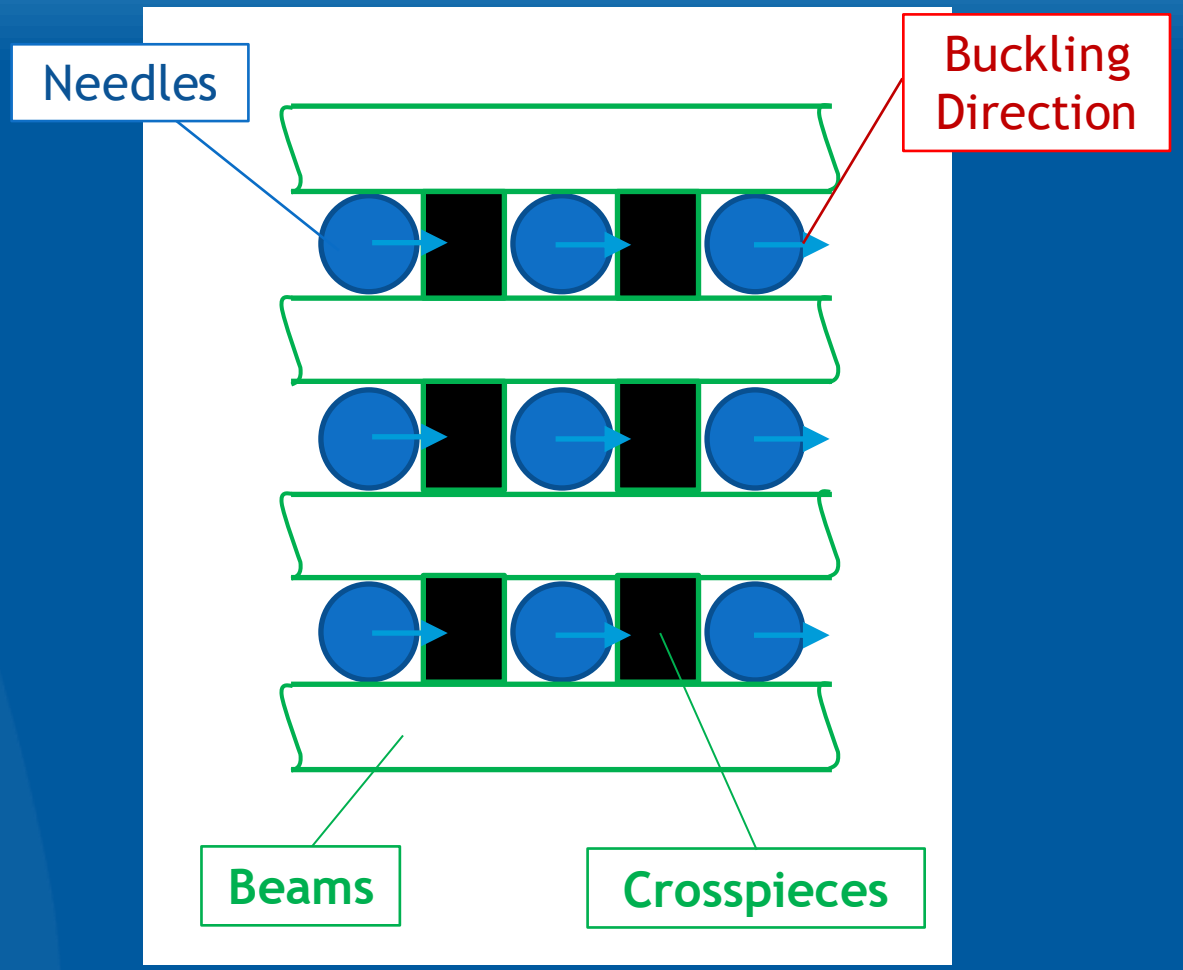
A Simple Model

- Simple hole pattern in ceramic plate
- Material between holes to be considered cuboidal
- Buckling direction parallel to beam alignment



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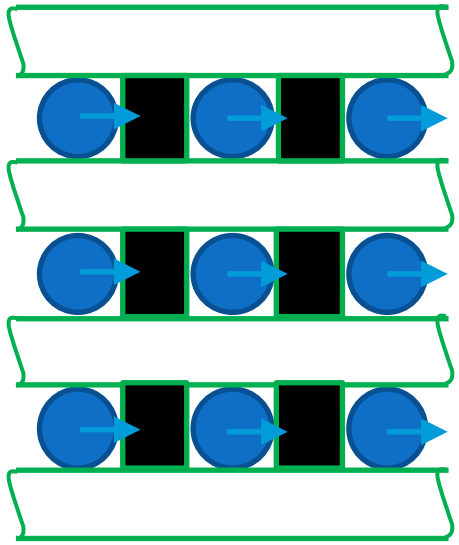
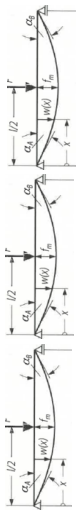
A Simple Model

Crosspiece

Beam

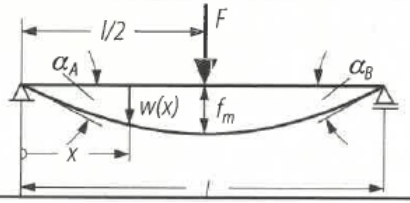
Calculated as "beam in bending"



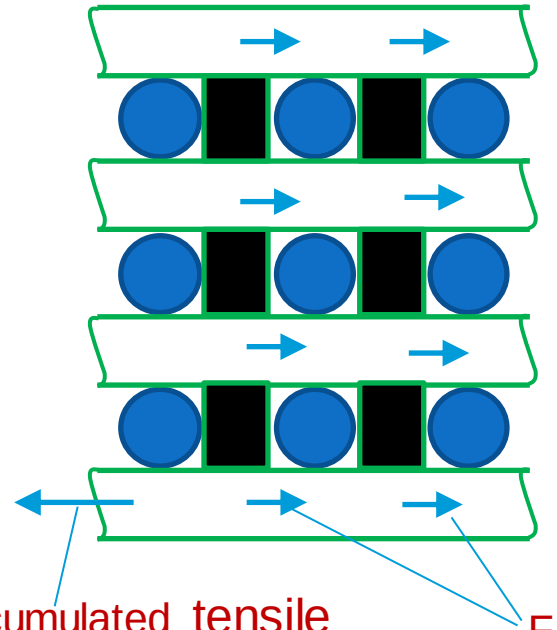


C 22 Festigkeitslehre – 2 Beanspruchung stabförmiger Bauteile

Tabelle 5a. Biegelinien von statisch bestimmten Trägern mit konstantem Querschnitt

Belastungsfall	Gleichung der Biegelinie
1 	$0 \leqq x \leqq l/2$: $w(x) = \frac{Fl^3}{48EI_y}\left[3\frac{x}{l} - 4\left(\frac{x}{l}\right)^3\right]$

Stressed by tensile force of crosspiece



Accumulated tensile force

F

$$\sigma_{max} = \frac{F \cdot nneedle}{A_{beam}}$$

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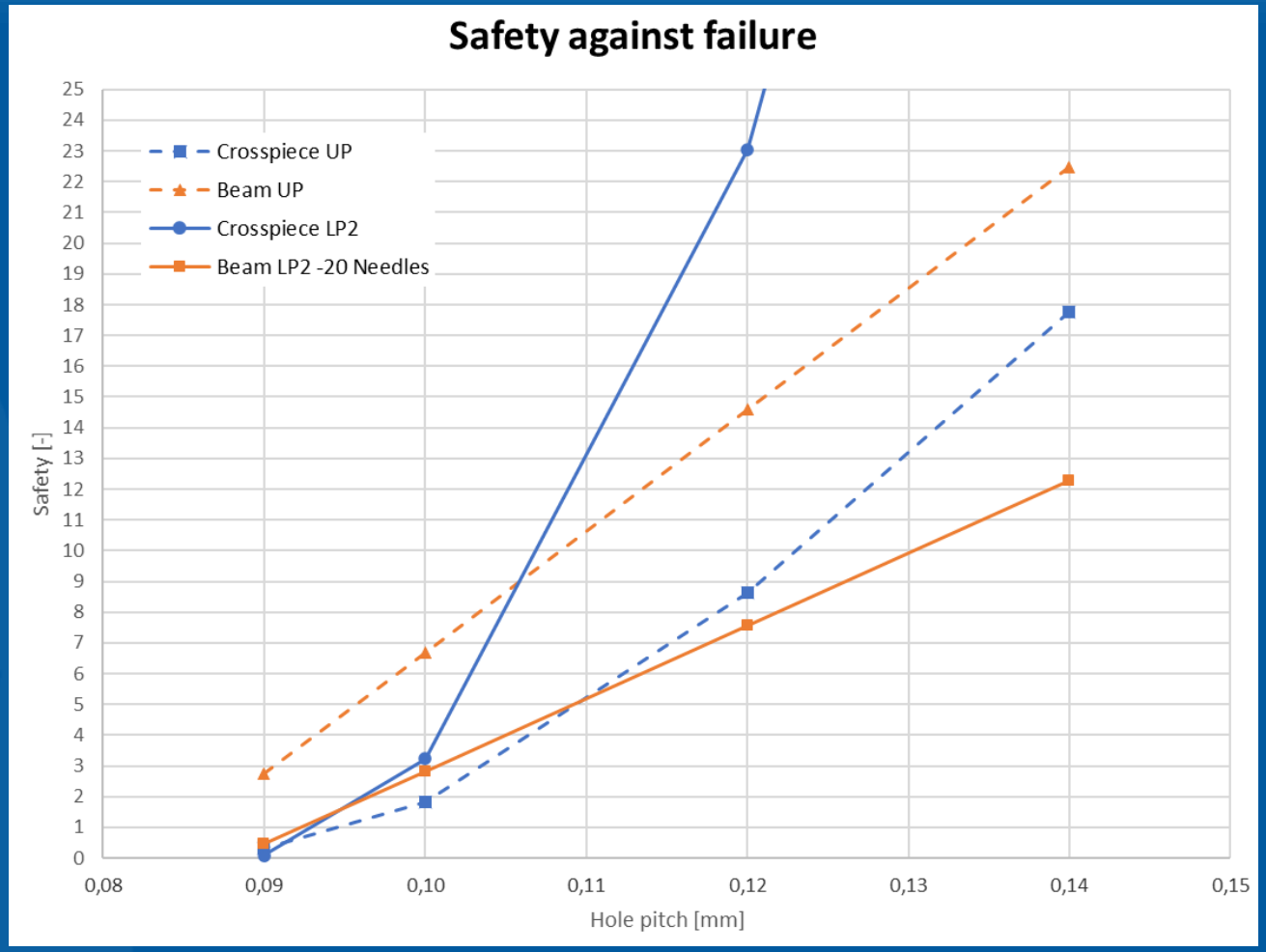
Simple Mechanical Model - Findings

- Simplified model provides basic correlation, but has too many uncertainties
- Absolute values are not that reliable, but
  - **Upper plate:**
    - Crosspiece seems more critical
  - **Lower plate:**
    - Depending on number of needles in buckling direction, beam seems more critical

Experimental investigations needed



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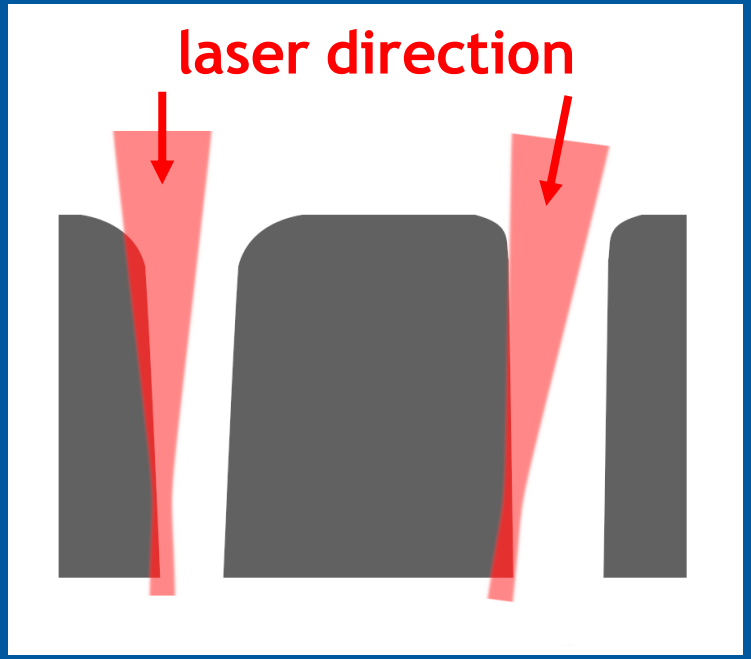
Manufacturing Challenges

Drilling holes on tighter and tighter pitch

Some factors to be considered :

- Variety of hole diameters in different plates making up each probe head
- Deliberate taper requirements to assist needle movement
- Entry rounding on the laser entry side of the drilled hole
- Structural integrity of wall



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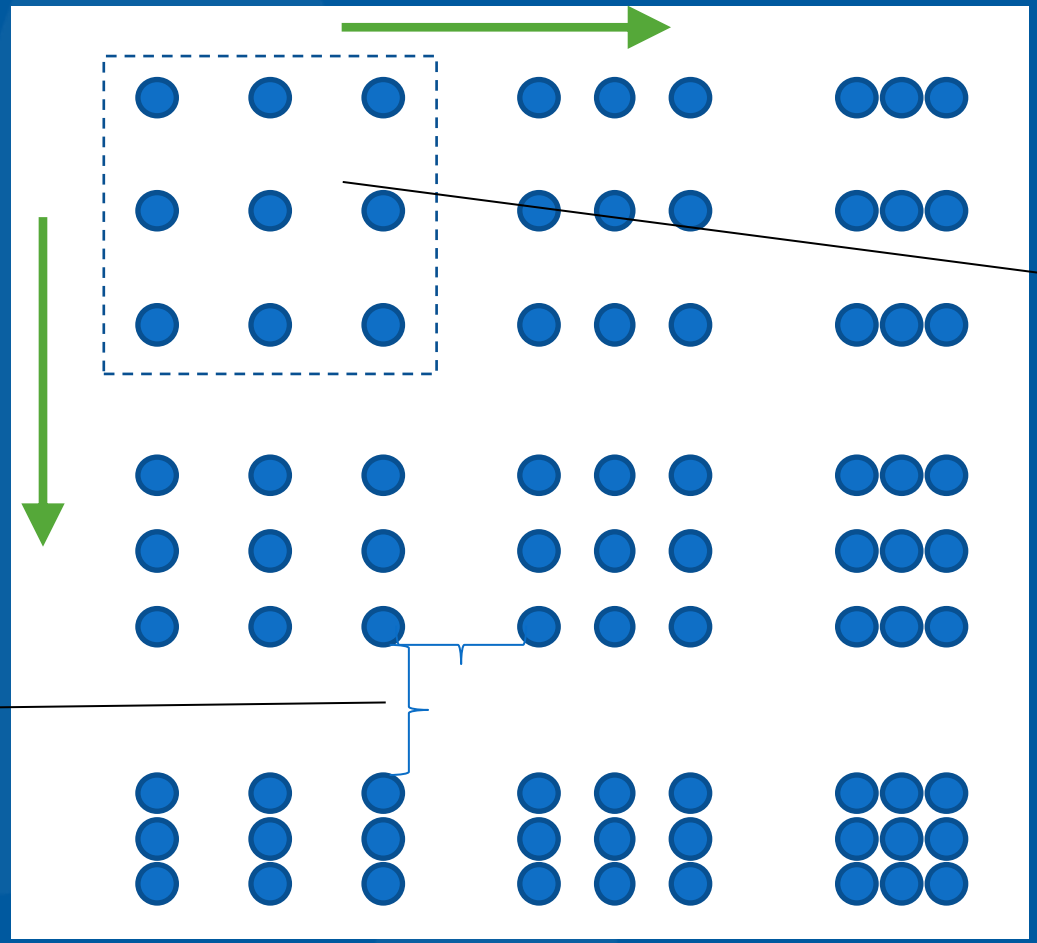
Experimental Work – First Trial

Variation of hole pitch in both directions to find out critical wall thickness



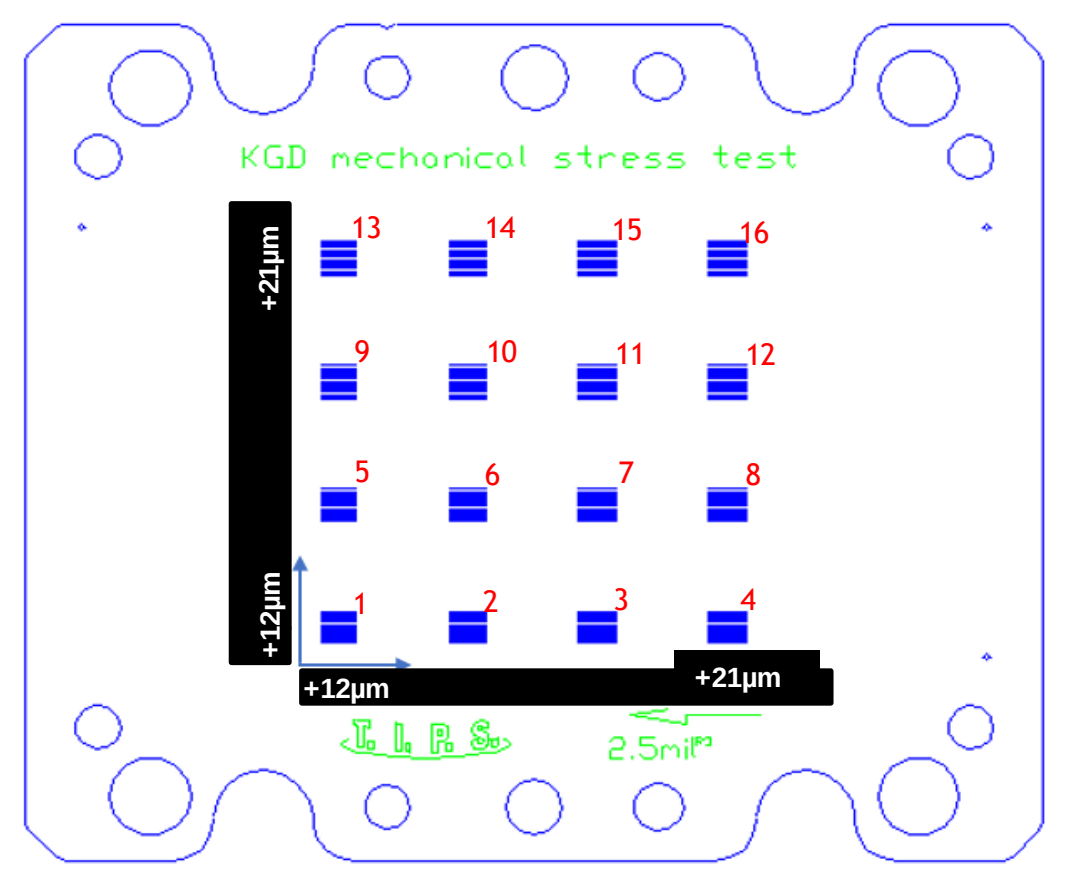
Array "n x n" needles

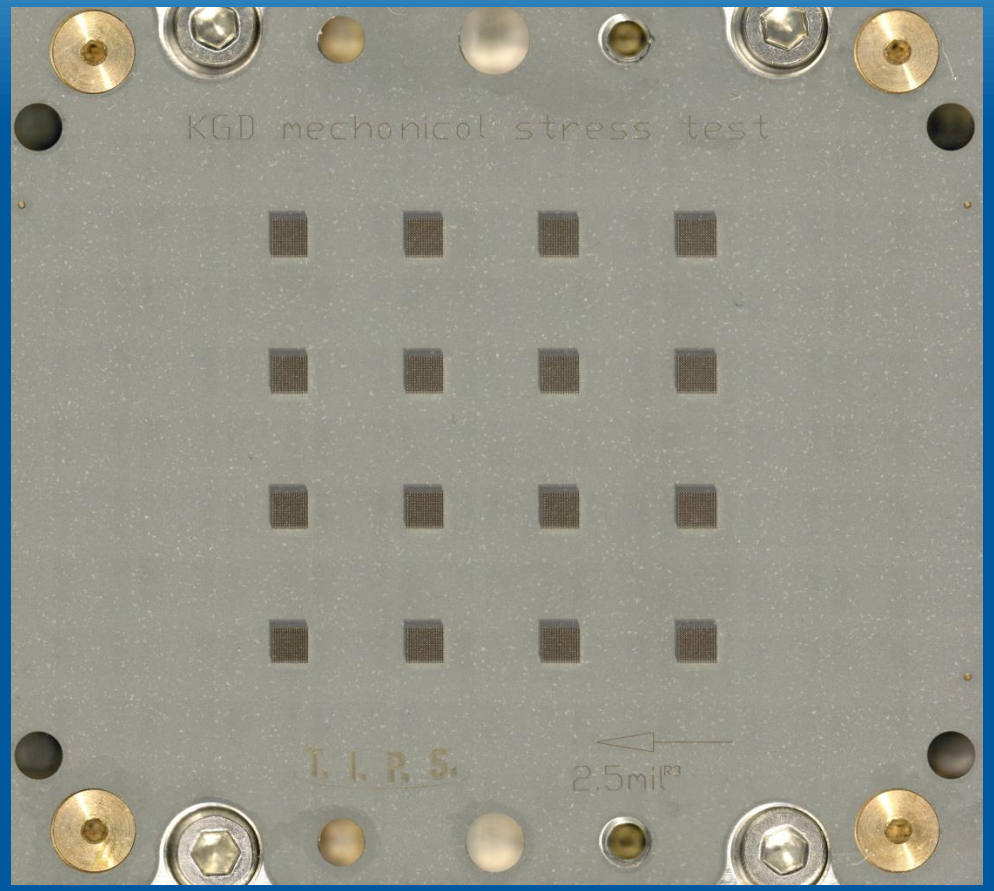
Sufficient distance between arrays avoids interference

Approach:

Destructive test to determine minimum dimensions at which holes start to break out

First Trial





Test Conditions :

Overtravel : Maximum Overtravel
Touchdowns : > 20,000

Test Method :

Disassemble probe head
Check for ceramic plate failure
Repeat

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Results from First Trial

Pleasingly all arrays passed :

- no broken ceramics
- nothing exciting to show

Shows that model is just an indicator

Next step – To reduce the hole pitch further

Test plates with hole to hole wall thickness of 10 microns and 8 microns

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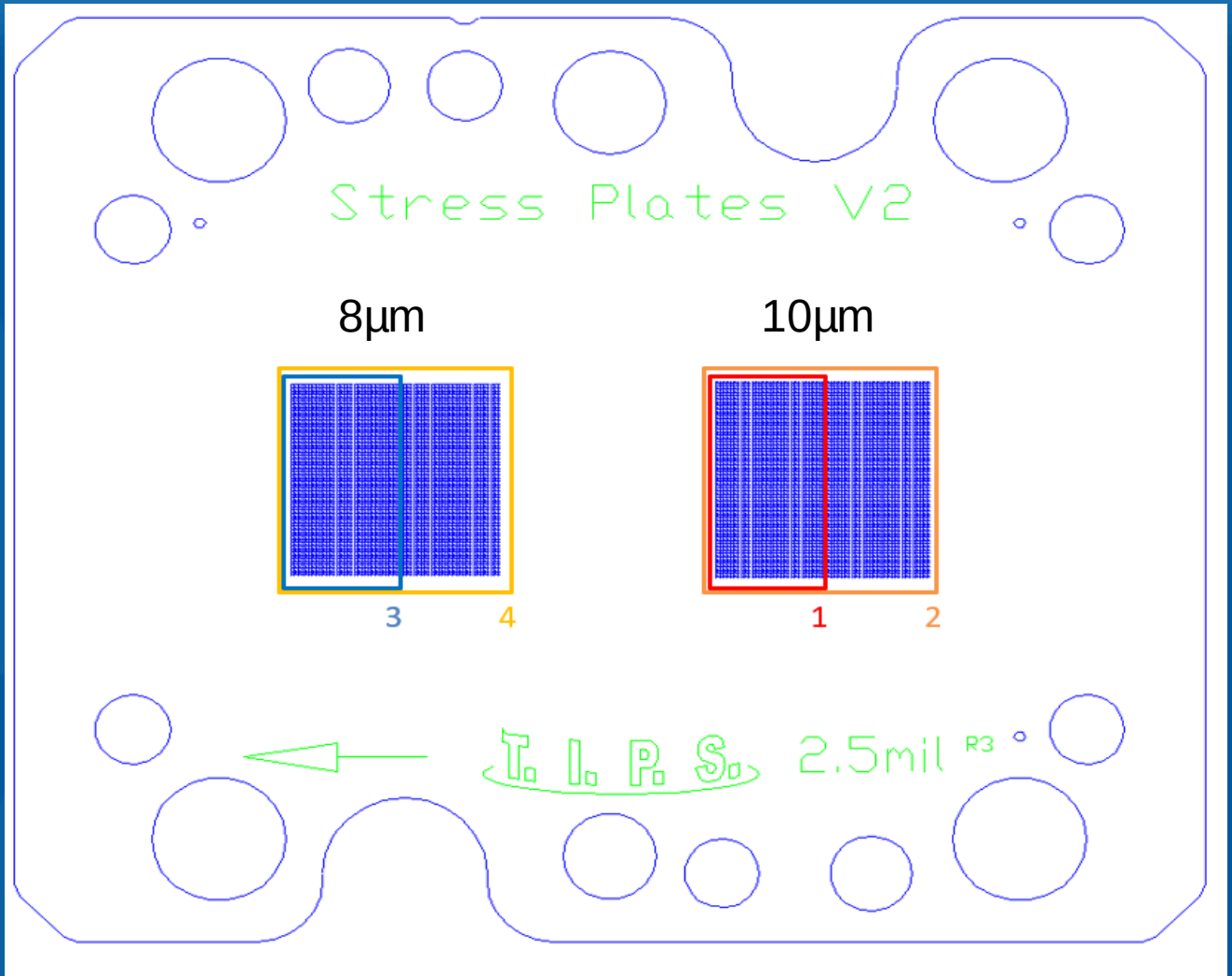
Second Trial

Two further test conditions :

- Minimum wall thickness 10 microns
  - Array 1
  - Array 2
- Minimum wall thickness 8 microns
  - Array 3
  - Array 4

Testing Protocol :

Maximum overtravel
50,000 touchdowns
Disassemble probe head
Check for ceramic plate failure
Repeat



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Second Trial Results

Results from the two further test conditions :

- Minimum wall thickness 10 microns
  - Array 1 ✓
  - Array 2 ✓
- Minimum wall thickness 8 microns
  - Array 3 ✗

Testing Protocol :

Maximum overtravel
50,000 touchdowns
Disassemble probe head
Check for ceramic plate failure
Repeat

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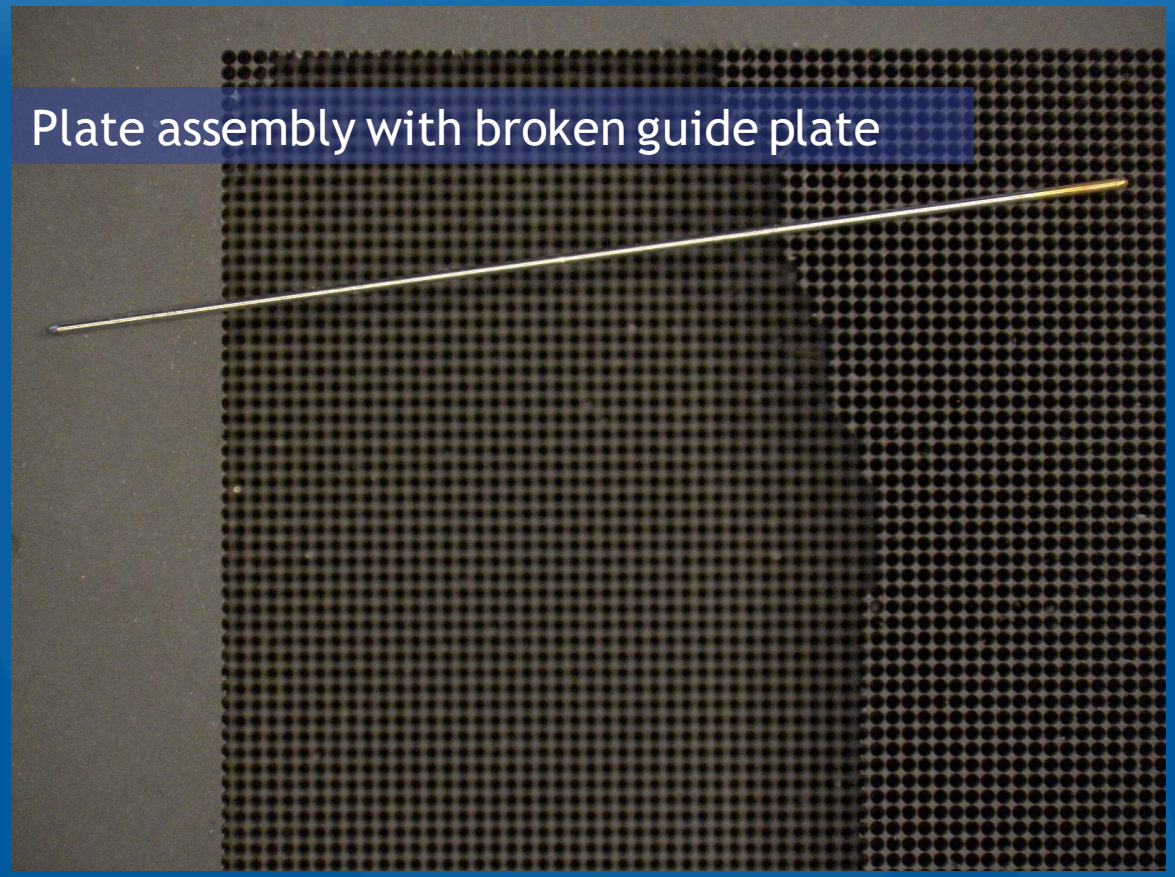
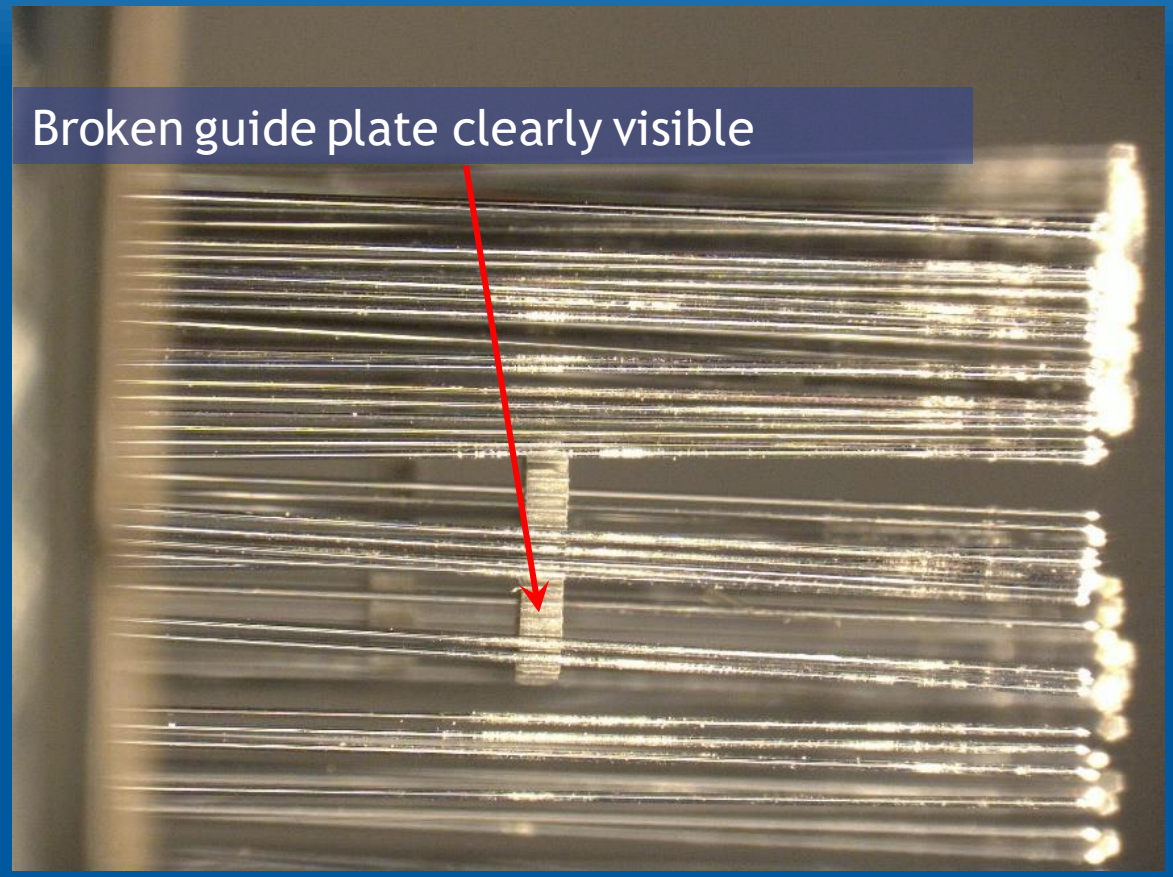
Results from Second Trial





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Discussion

- Simple mechanical model gives good understanding of forces involved
  - Not accurate enough to do predictions
  - Calculations err “on the side of safety”
- Experimental verification gave good insights into actual mechanical stress limits
- Raises questions on the limits of tight pitch in certain circumstances
- Expect to be different for different plate thicknesses and materials

Follow-on Work

- Improve the Mechanical Model
- Check repeatability of this work under a variety of conditions
- Investigate other materials

Conclusion

- Simple model gives some indication, but needs further refinement / experimental investigation – much more complex – but good to get understanding of forces

- Demonstrated an improvement on pitch reduction performance of 26% in both directions
  - Increase of current density of almost 60% on same chip size!

- Possible to design a Probe Card that is both :
  - manufacturable and
  - has a safety margin built in

- Satisfies the customers high current requirements

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Thanks

My thanks for this work go to :

From T.I.P.S :

Dr Rainer Gaggl
Sebastian Salbrechter
Meinhart Jeschke

From Oxford Lasers :

Michael Gaukgroger
Mark Cheverton

Thank you for your Attention