



SW Test Workshop
Semiconductor Wafer Test Workshop

Innovative Laser Processing and Drilling Techniques for Future Probe Card Applications



Chih-Chang Hsu, PhD
Hung-Lung Chen, CMO

K-Jet Laser Tek Inc.

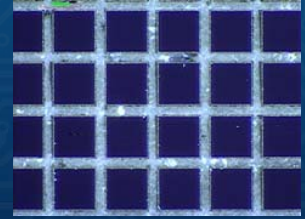
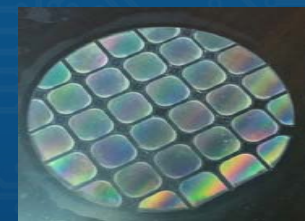
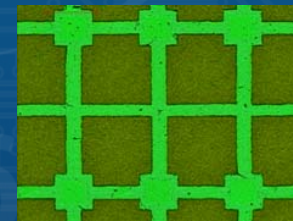
June 5-8, 2016

Outline

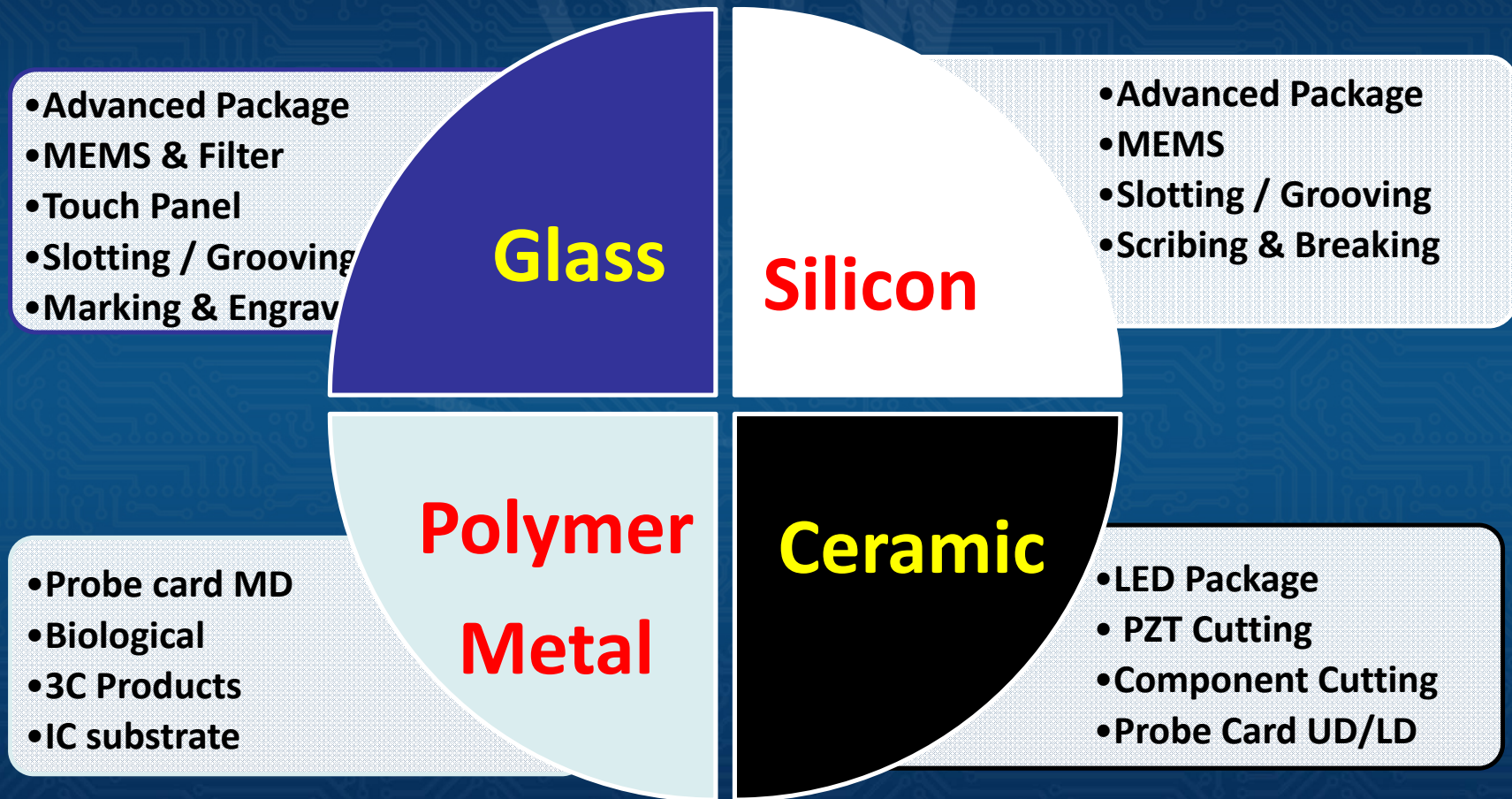
- **Company Profile**
- **Motivation**
- **Opportunities of Laser Processing**
- **Si₃N₄ Probe Head (PH) by Laser Process**
- **Solutions**
- **High Aspect-Ratio Micro Hole**
- **Future Work**

Company Profile

- ◆ Founded in 2001, Located in HsinChu Science Park, Taiwan
- ◆ Over 15 Years Experience in Laser Machining Equipment and Process Development
- ◆ Products: Laser Turnkey System and Production Equipment
- ◆ Service: DPSS and Excimer Laser Job Shop



Applications



Motivation

- **Market –Sales of Probe Cards**

- Market growth from \$1.4 Billion in 2015 to \$1.7 Billion in 2020 (VLSI Research Reported)
- Advanced Probe Cards (Vertical, MEMS)

- **Industry Tendency for Vertical Probe Card**

- High Pin Counts
- Fine Pitch
- Rectangle or Irregular Hole Shape
- New Materials for Probe Head

Challenges

- **High Pin Count**
 - Longer mechanical drilling time
 - Lower yield rate and higher cost
- **Fine Pitch**
 - Material strength
 - Collapse between holes
- **Rectangle or Irregular Hole Shape**
 - Traditional mechanical drilling unavailable
- **New Material for Probe Head**
 - Harder material need brand new machining technique

Opportunities of Laser Processing

- **Advantages of Laser Drilling**

- Much higher throughput
- More consistent yield rate
- Non-contact drilling benefits tight hole pitch
- Arbitrary geometry available
- Wide range of materials, like Si_3N_4 , Sapphire, Zirconia...

- **Si_3N_4 is next generation material for VPC, but its hardness makes it difficult for mechanical. Laser process just happens to be the best choice.**

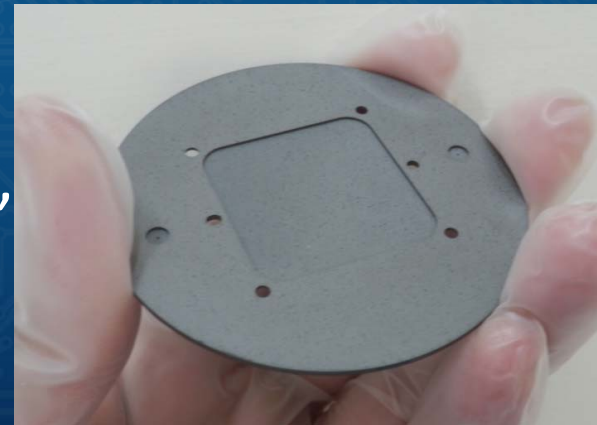
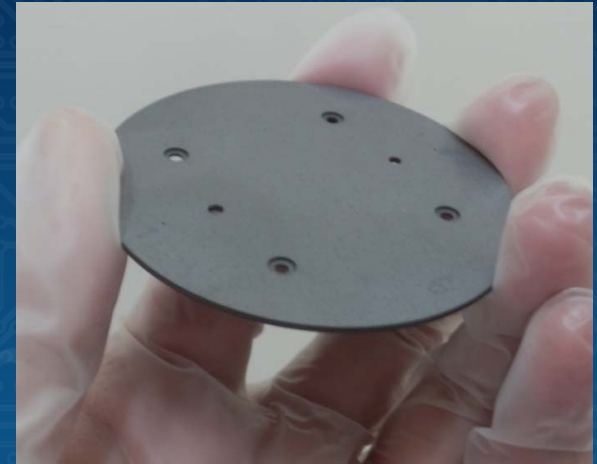
Si_3N_4 PH by Laser Process

- **Non-Laser Process**

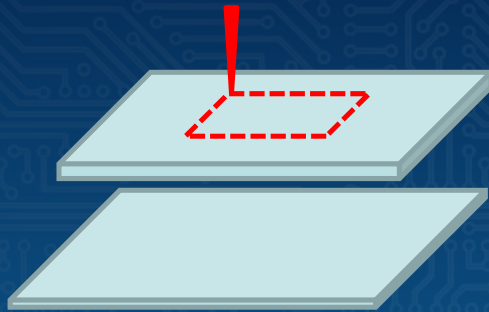
- Material Thinning/Polishing
- Lamination

- **Laser Process**

- Laser Cut
Pocket Slot, Card Contour
- Laser Drill
Counter-Bore Holes, Screw Holes,
Micro-Holes, Align/Pin Holes
- Laser Mark
Serial No./Logo

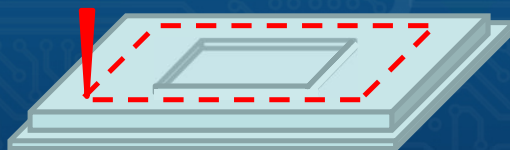


Pocket Formation



Thinning and polishing material into specific thickness($\pm 10\mu\text{m}$) and surface flatness

- Laser cutting slot on top material
- Lamination by adhesive of glue

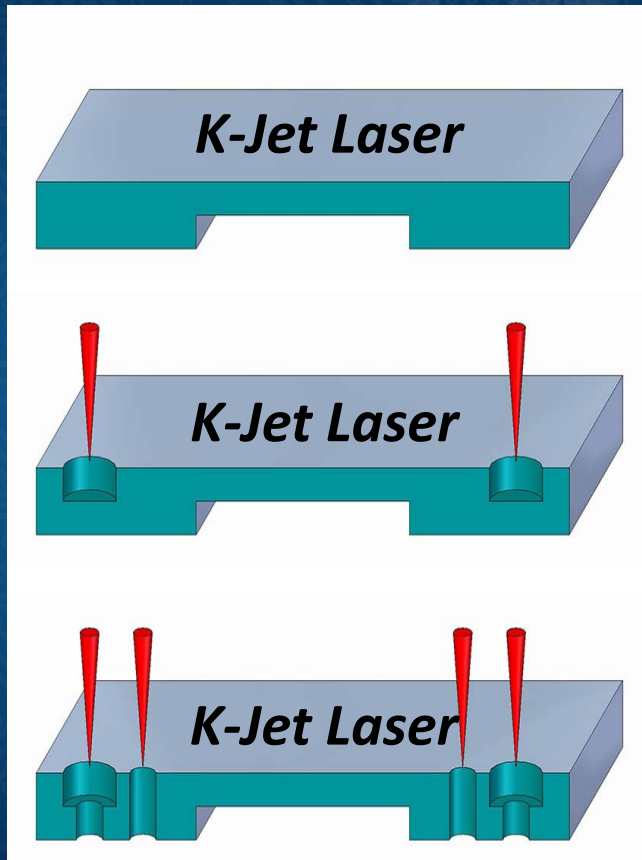


Laser cutting perimeter to specific shape and dimension



3D pocket completed!

Counter-Bore/Screw Holes



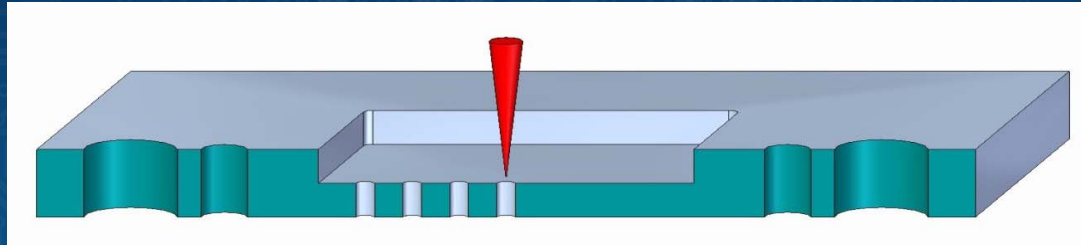
**Laser marking logo and
alphanumeric texts**

**Laser drilling Counter-
Bore with specific depth
(>1mm) and flatness**

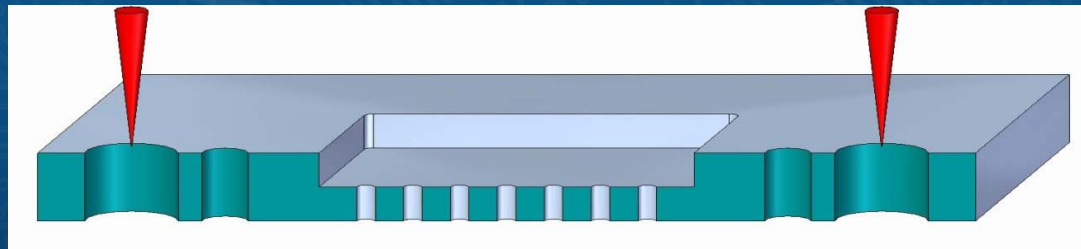
**Laser drilling through
Screw Holes**

Micro and Pin Holes Generation

Laser Micro-Hole Drilling



Laser Pin Hole Drilling



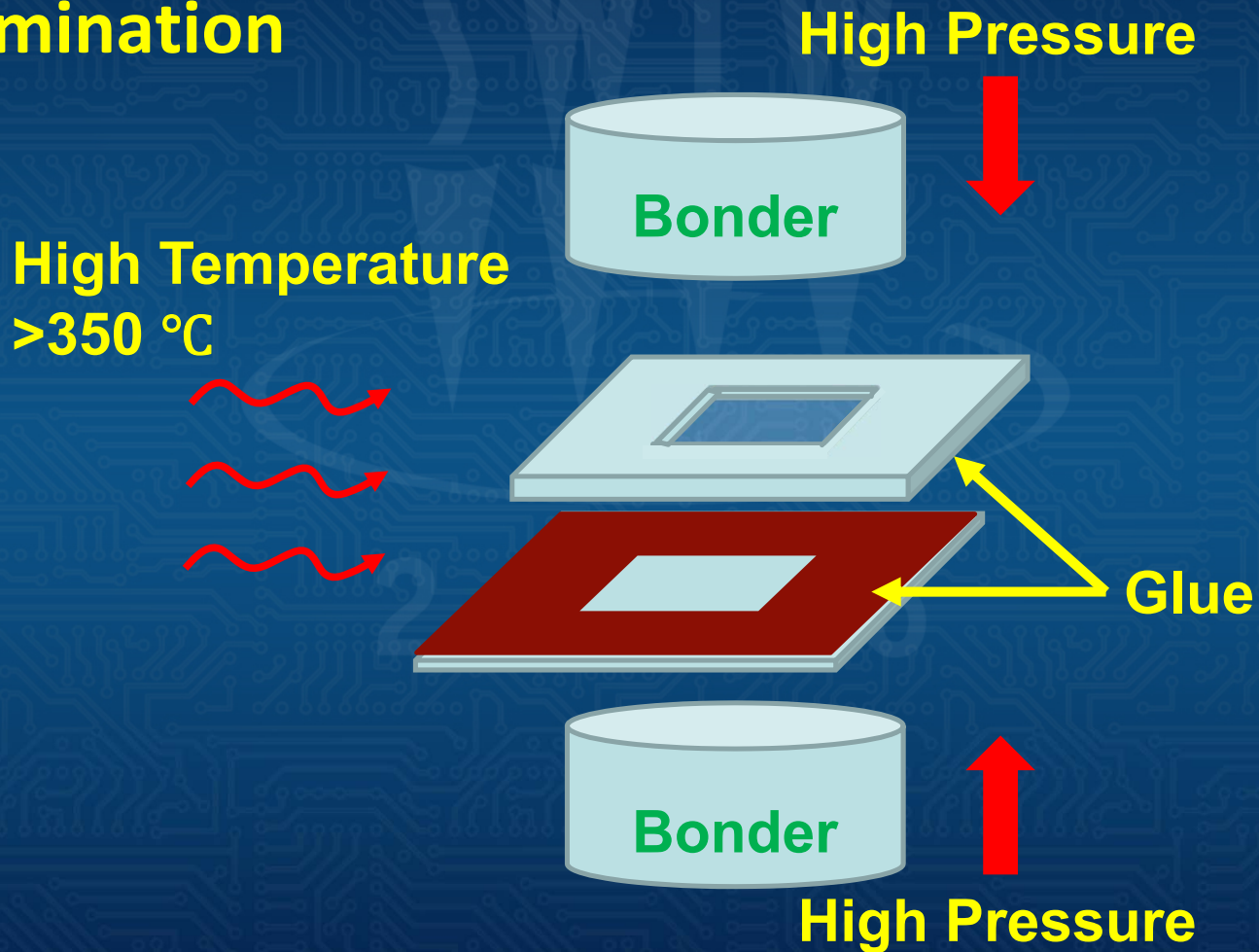
Drilling Micro-Holes and Pin Holes at the same time to ensure position accuracy

Process Issues

- **Lamination**
 - Adhesion of glue breakdown during high temp. probing environment
- **Screw/Pin Hole**
 - Need smooth side wall and precise/straight hole
- **Counter-Bore Hole**
 - Need flexible bore hole depth capability
- **Micro-Hole**
 - Taper needs to be avoided
 - Prefer higher AR hole to multilayer lamination

Solutions

- Lamination



- **Screw/Pin Hole**

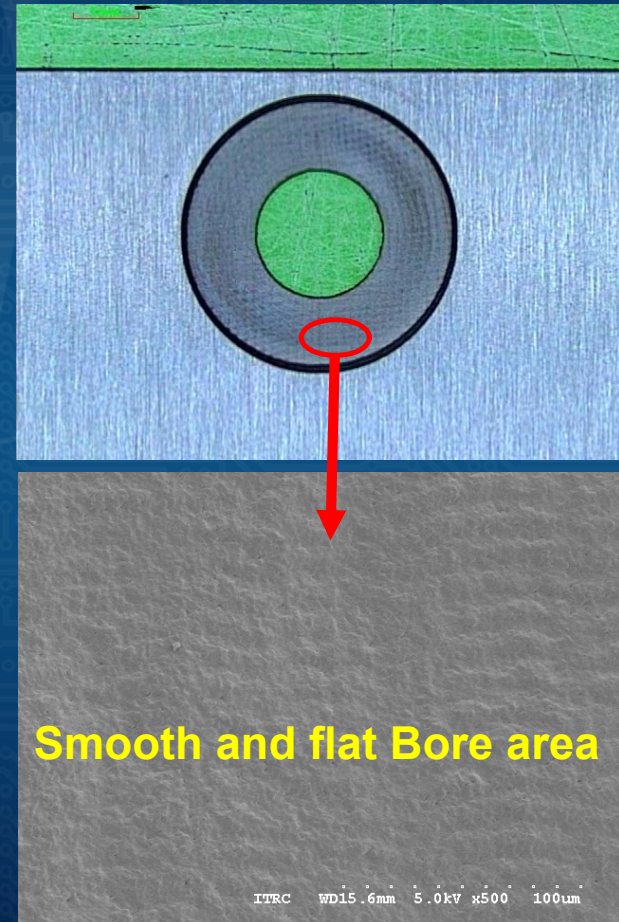
- Drilling Screw/Pin hole after lamination, No align issue
- Straight hole from top to bottom, less than 20um taper and up to 1mm thickness
- Hole dimension accuracy within 5um
- Smooth sidewall without debris



- **Counter-Bore**

- Directly drilling Counter-Bore hole AFTER lamination
- No depth limitation on Bore area, more design flexibility
- Good flatness on Bore plane
- Arbitrary Bore and Screw hole size

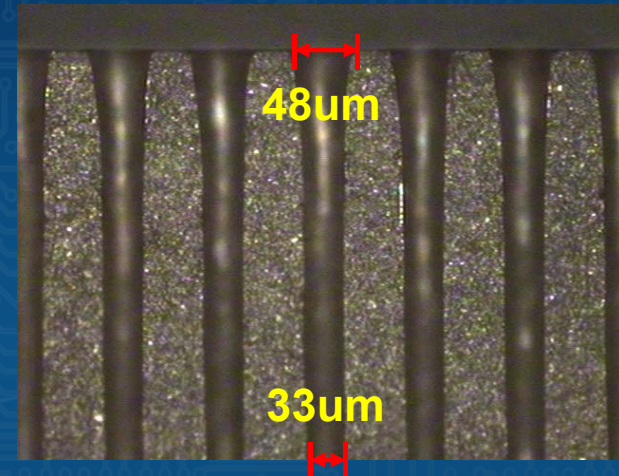
Counter-Bore Hole



High Aspect-Ratio Micro Hole

- Laser drilling high aspect-ratio hole tends to have taper issue

- 5-10um for 300um of Si_3N_4
- 20-30um for 500um of Si_3N_4
- Hole will collapse in Fine Pitch

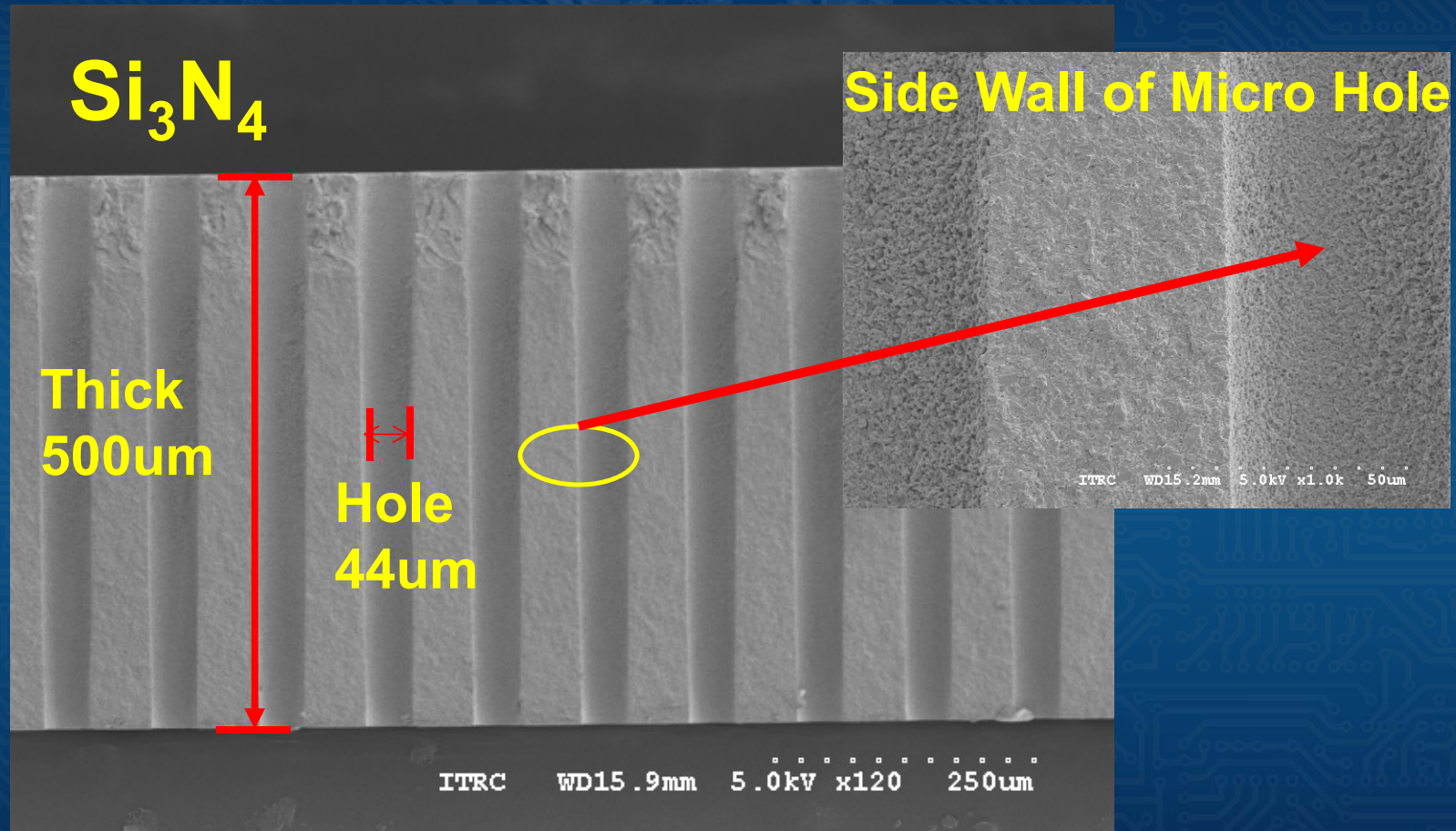


K-Jet developed a state-of-art method - “DeepWell Drill” technique to overcome the taper issue, and implement complete straight micro-hole up to 800 um thickness on Si_3N_4 .

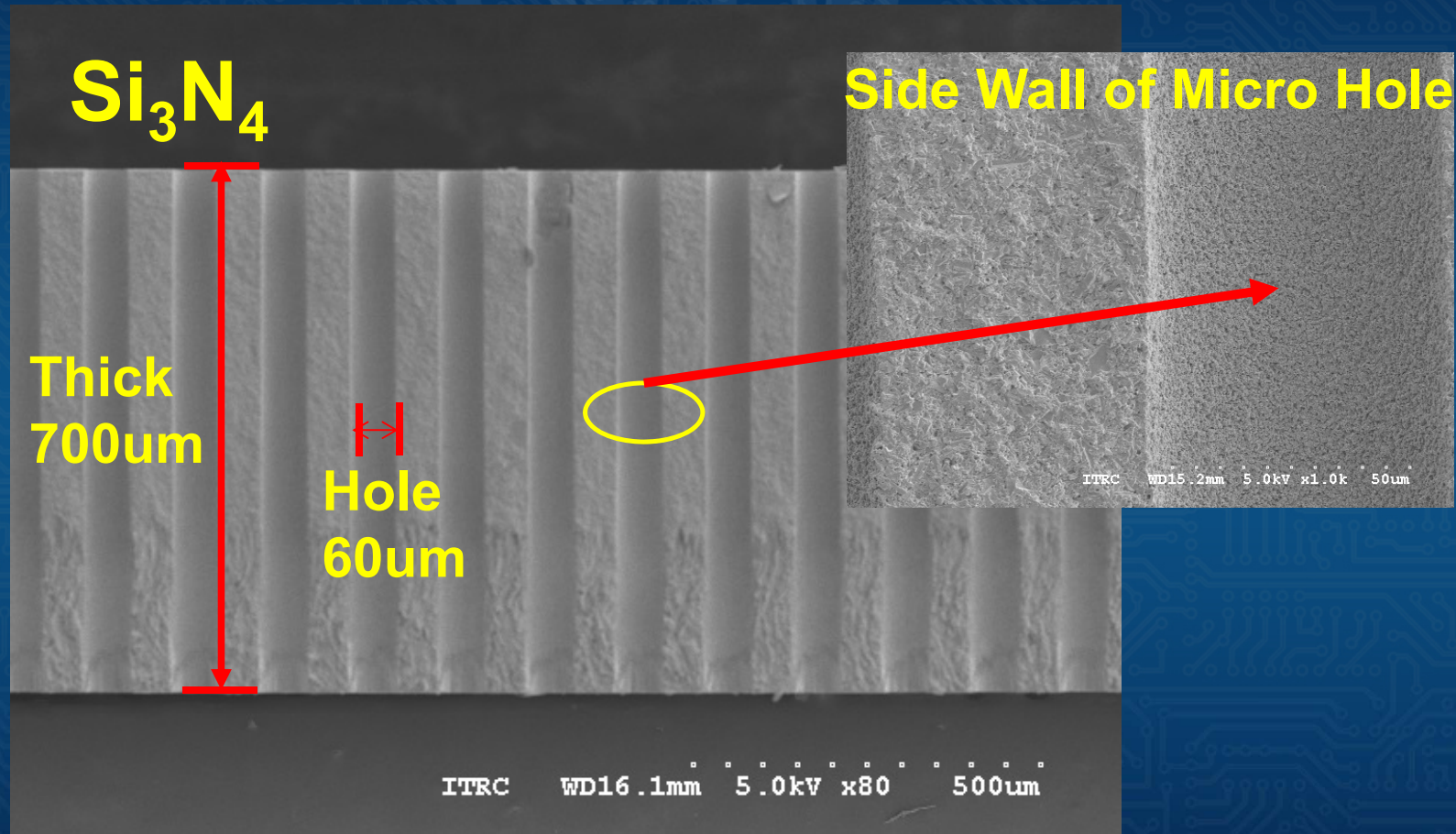
Capabilities of *DeepWell Drill*

- Available Hole Size(Round): 35um – 150um
- Thickness: Up to 800um, move on 1mm.
- Tolerance: +/-2um typically, both ent&exit.
- Spacing: 15um between holes without collapse!
- Materials: Not only available on Si_3N_4 , also work on PhotoVeel, Sapphire, Zirconia, Silicon, Cirlex.
- Application: Not only drill straight round hole, also high AR irregular hole shape is possible.
- *DeepWell Drill* directly cutting MEMS probe is under investigation.

DeepWell Drilled Micro-Holes

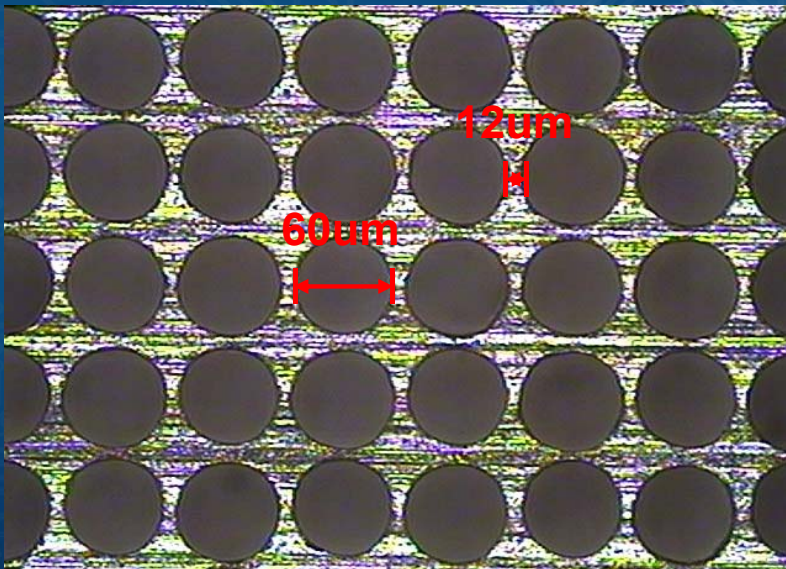


DeepWell Drilled Micro-Holes

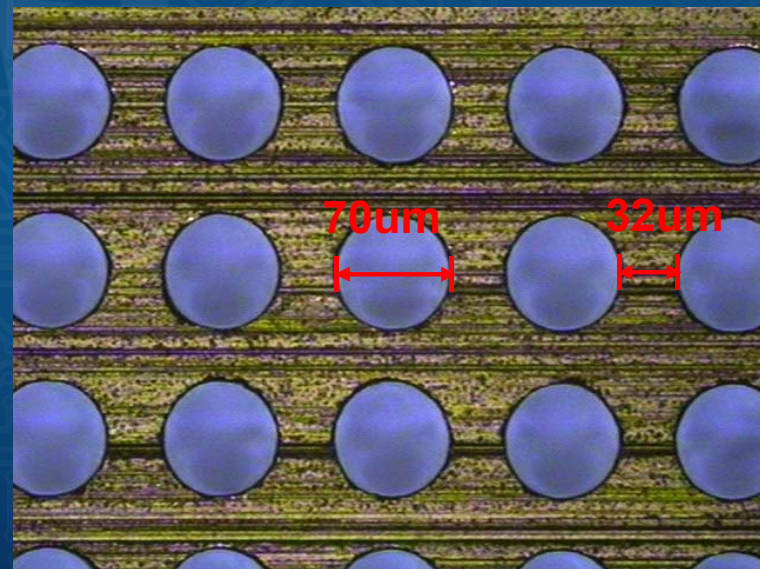


DeepWell Drilled Micro-Holes

Hole: 60um
Spacing: 12um



Hole: 70um
Spacing: 32um

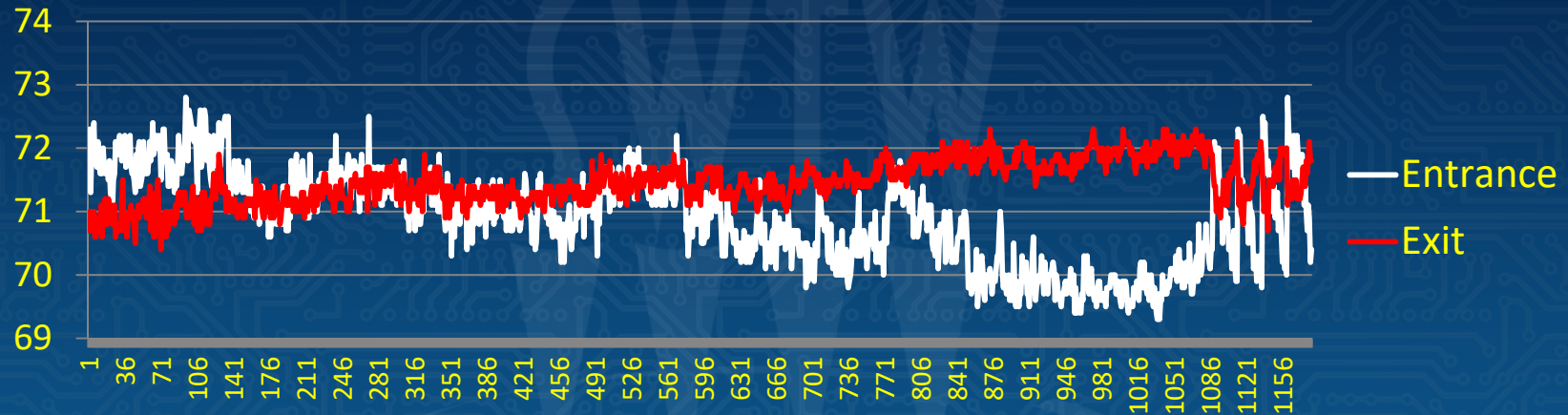


Evaluation

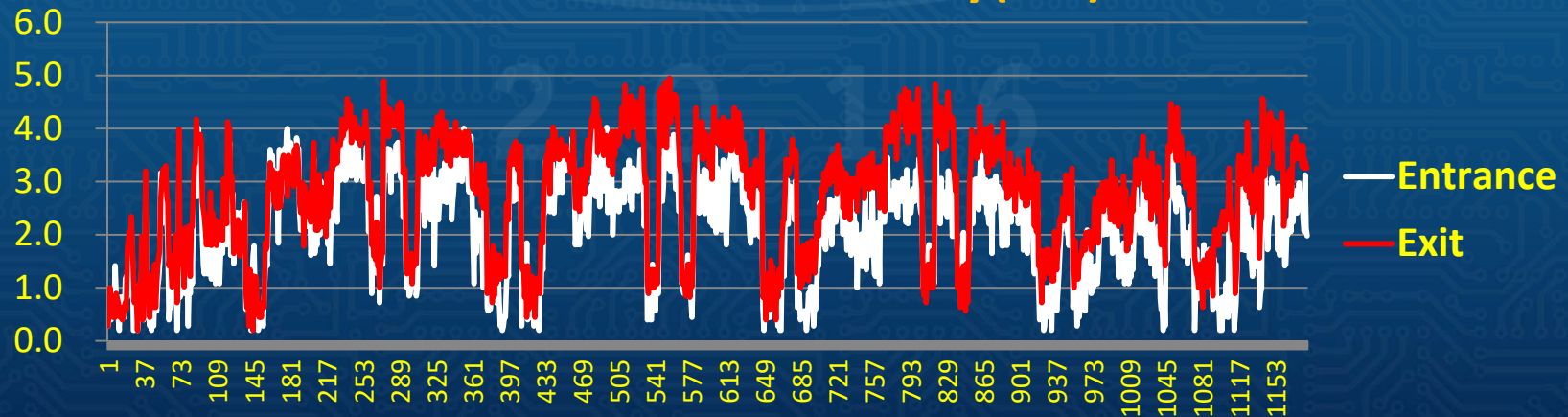
- A Si_3N_4 upper die was fabricated by bonding and laser process to evaluate the performance.
- Micro-Holes were measured by Nikon VMR3200
- Total Thk.: $0.8 \pm 0.01\text{mm}$
- Pocket Thk.: $0.254 \pm 0.01\text{mm}$
- Pin Holes: $\Phi 2/2.5 + 0.005/0.010\text{mm}$
- μHoles : $\Phi 71\mu\text{m} \pm 1\mu\text{m}$
- Numbers: 1,184



Micro-Holes Diameter(um)

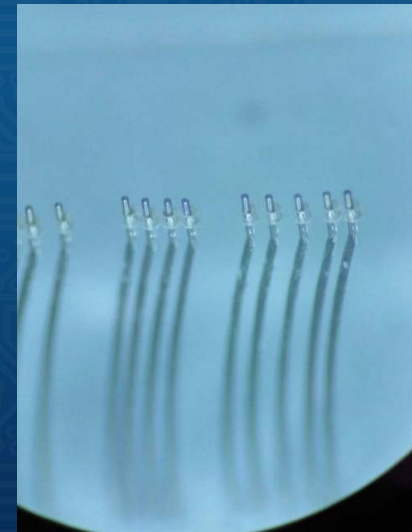


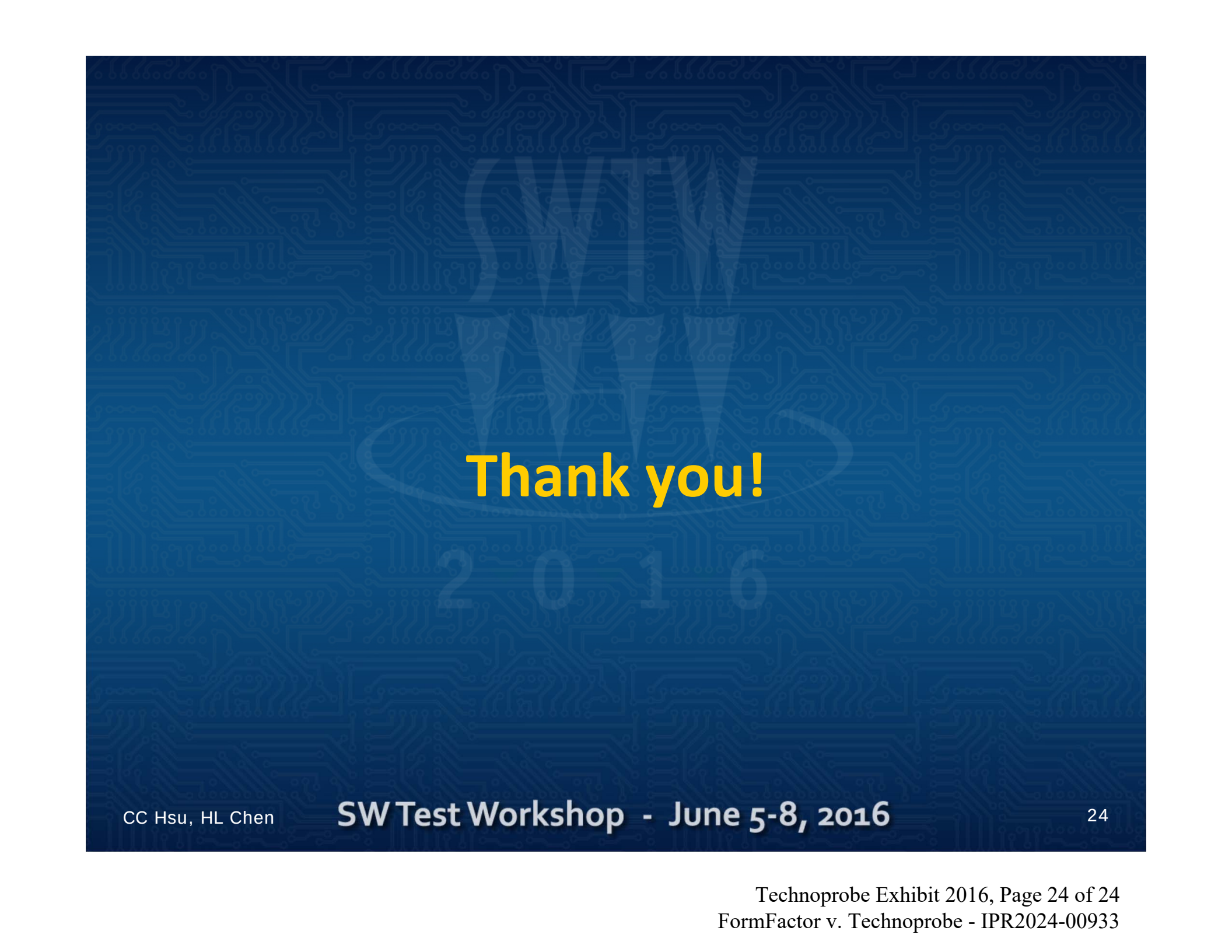
True Position Accuracy(um)



Future Work

- Evaluate Die thickness up to 1mm or more.
- Evaluate micro-hole size down to 25um(1mil).
- Develop high aspect-ratio rectangle and irregular hole, expect up to 500um or more.
- Evaluate alternative material for probe head, especially hard and transparent material like sapphire which might be good replacement for upper die.





Thank you!