SW Test Workshop
Semiconductor Wafer Test Workshop

Innovative Laser Processing and Drilling Techniques for Future Probe Card Applications

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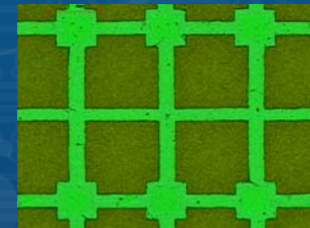
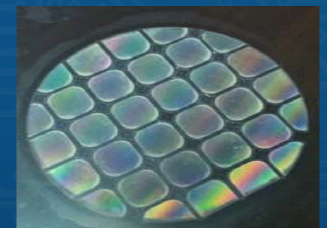
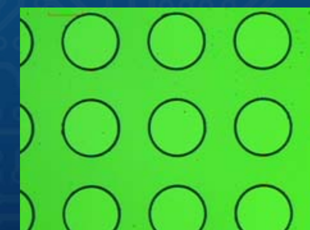
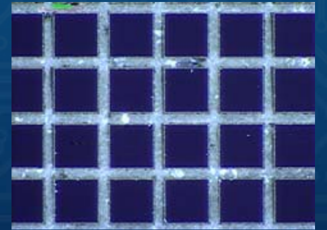
June 5-8, 2016

Outline

- Company Profile
- Motivation
- Opportunities of Laser Processing
- Si_3N_4 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

Glass

- Advanced Package
- MEMS & Filter
- Touch Panel
- Slotting / Grooving
- Marking & Engrav

Silicon

- Advanced Package
- MEMS
- Slotting / Grooving
- Scribing & Breaking

Polymer
Metal

- Probe card MD
- Biological
- 3C Products
- IC substrate

Ceramic

- LED Package
- PZT Cutting
- Component Cutting
- Probe Card UD/LD

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

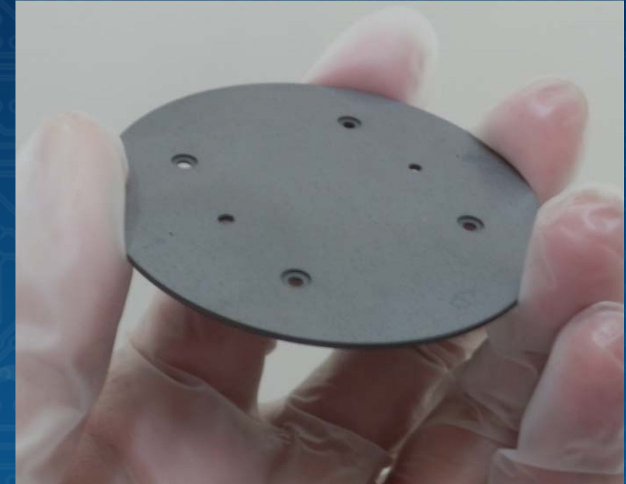
- **High Pin Count**
  - Longer mechanical drilling time
  - Lower yield rate and higher cost
- **Fine Pitch**
  - Material strength
  - Collapse between holes
- **Rectangle or Irregular Hole Shape**
  - Traditional mechanical drilling unavailable
- **New Material for Probe Head**
  - Harder material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

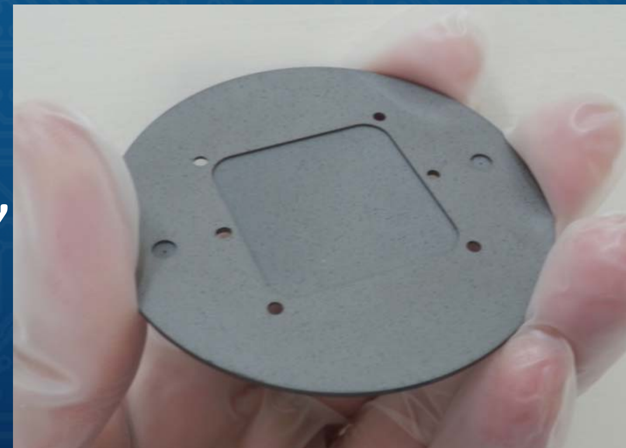
Opportunities of Laser Processing

- **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.**

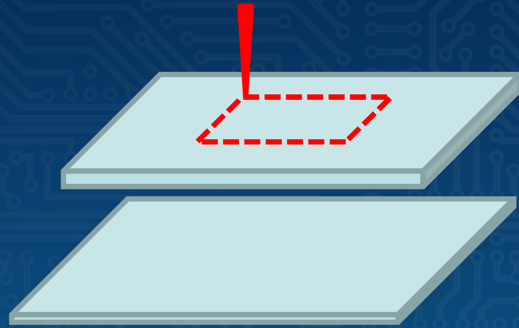
Si_3N_4 PH by Laser Process

- **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



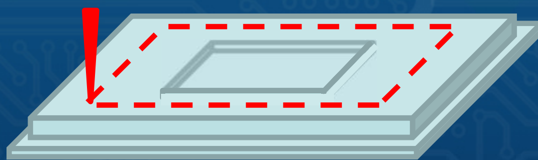


Pocket Formation



Thinning and polishing material into specific thickness(+/-10um) and surface flatness

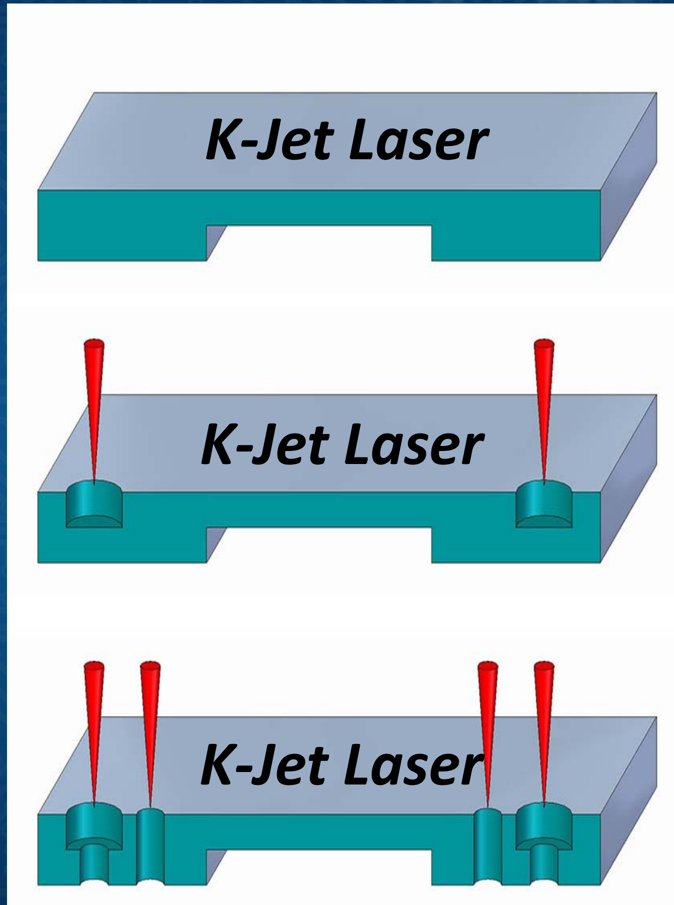
- Laser cutting slot on top material
- Lamination by adhesive of glue



Laser cutting perimeter to specific shape and dimension

3D pocket completed!

Counter-Bore/Screw Holes



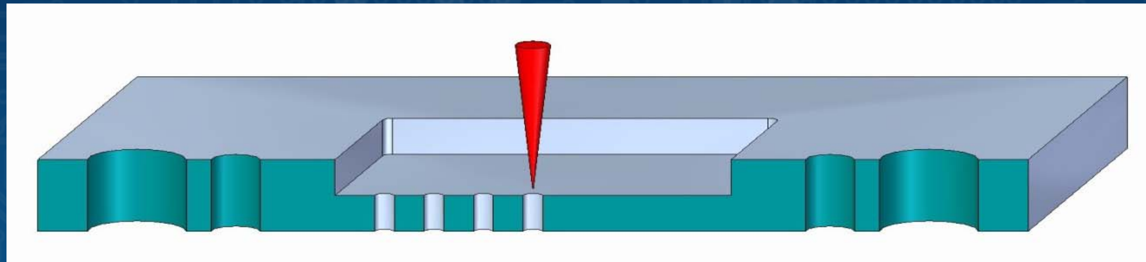
Laser marking logo and alphanumerical texts

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

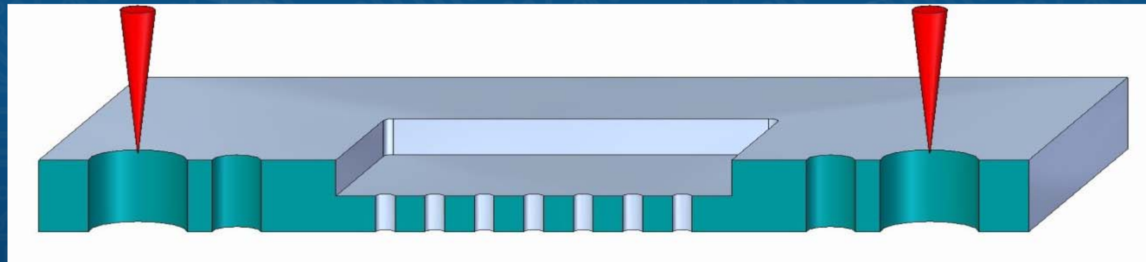
Laser drilling through Screw Holes

Micro and Pin Holes Generation

Laser Micro-Hole Drilling



Laser Pin Hole Drilling



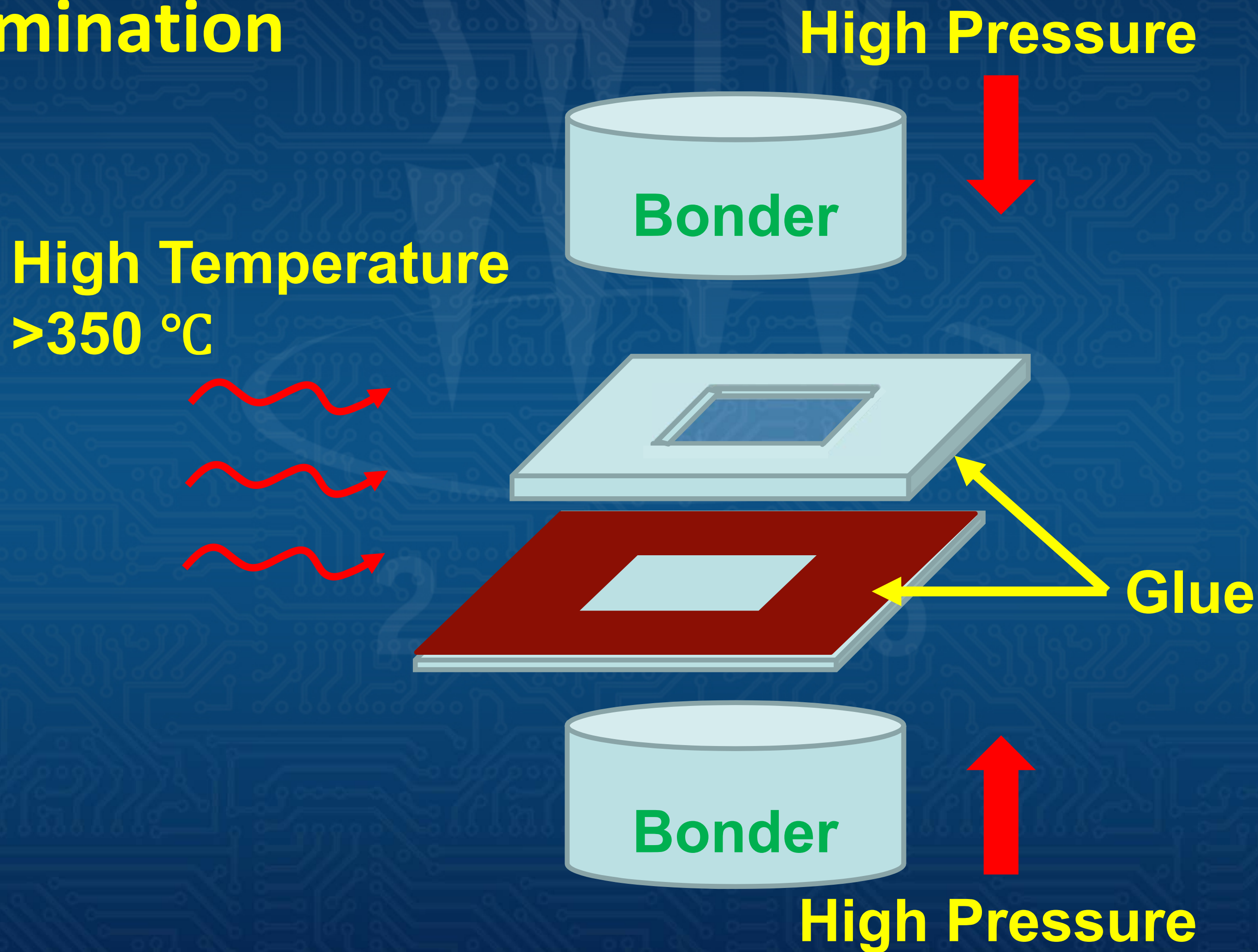
Drilling Micro-Holes and Pin Holes at the same time to ensure position accuracy

Process Issues

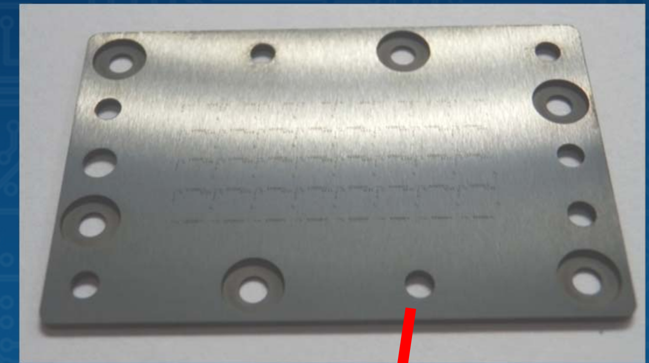
- **Lamination**
  - Adhesion of glue breakdown during high temp. probing environment
- **Screw/Pin Hole**
  - Need smooth side wall and precise/straight hole
- **Counter-Bore Hole**
  - Need flexible bore hole depth capability
- **Micro-Hole**
  - Taper needs to be avoided
  - Prefer higher AR hole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

Solutions

- Lamination

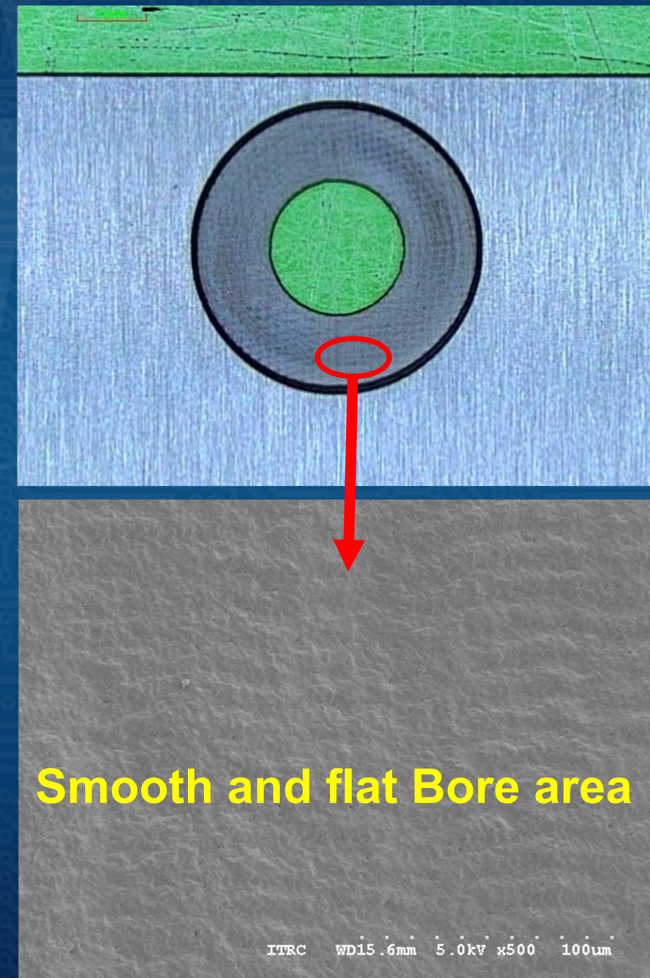


- **Screw/Pin Hole**
  - Drilling Screw/Pin hole after lamination, No align issue
  - Straight hole from top to bottom, less than 20um taper and up to 1mm thickness
  - Hole dimension accuracy within 5um
  - Smooth sidewall without debris



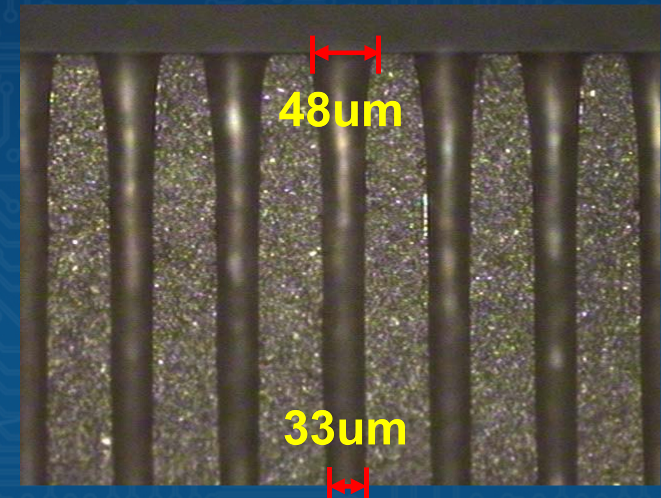
- **Counter-Bore**
  - Directly drilling Counter-Bore hole AFTER lamination
  - No depth limitation on Bore area, more design flexibility
  - Good flatness on Bore plane
  - Arbitrary Bore and Screw hole size

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

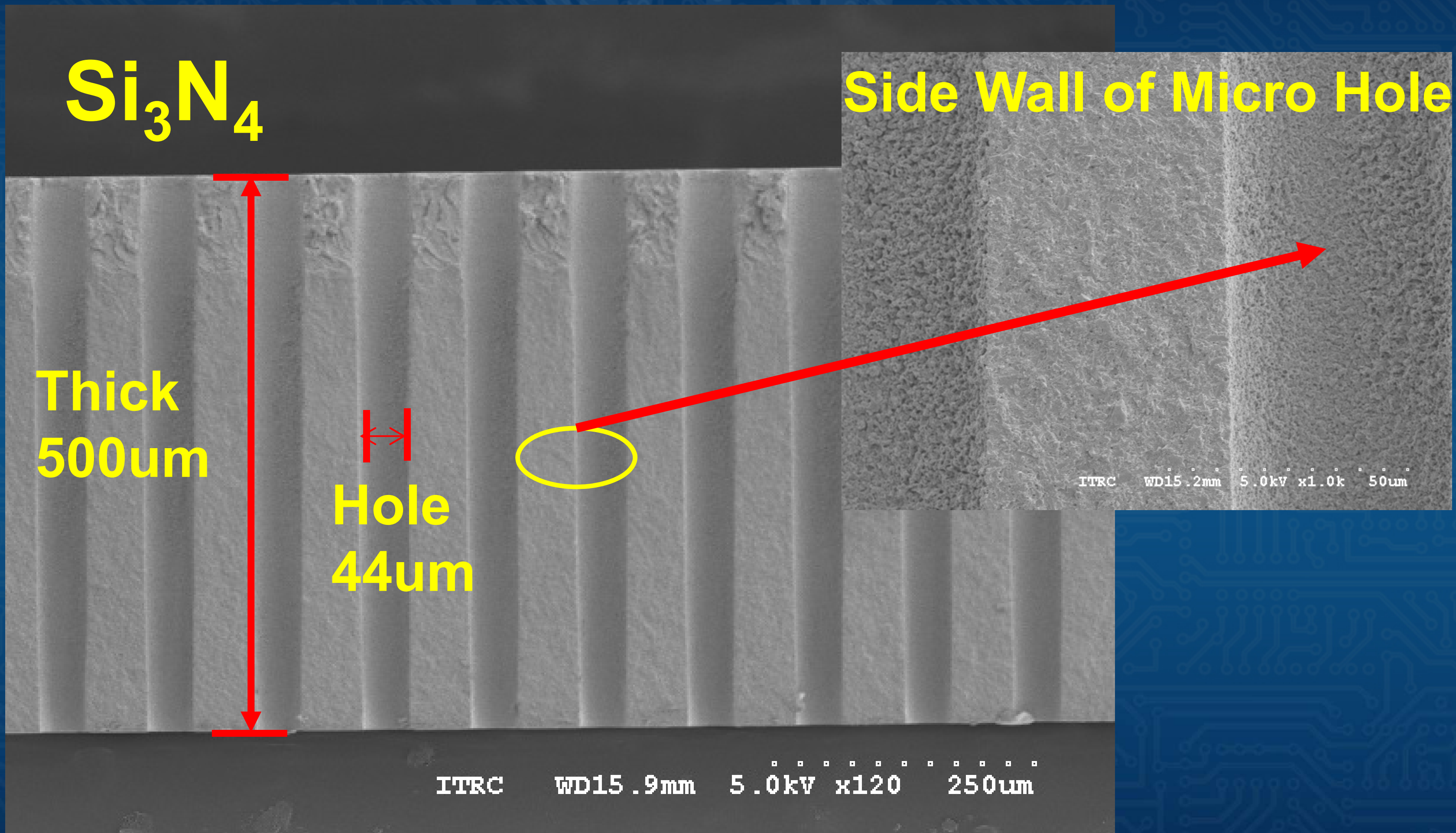


K-Jet developed a state-of-art method - "<u>DeepWell Drill</u>" technique to overcome the taper issue, and implement complete straight micro-hole up to 800 um thickness on Si_3N_4.

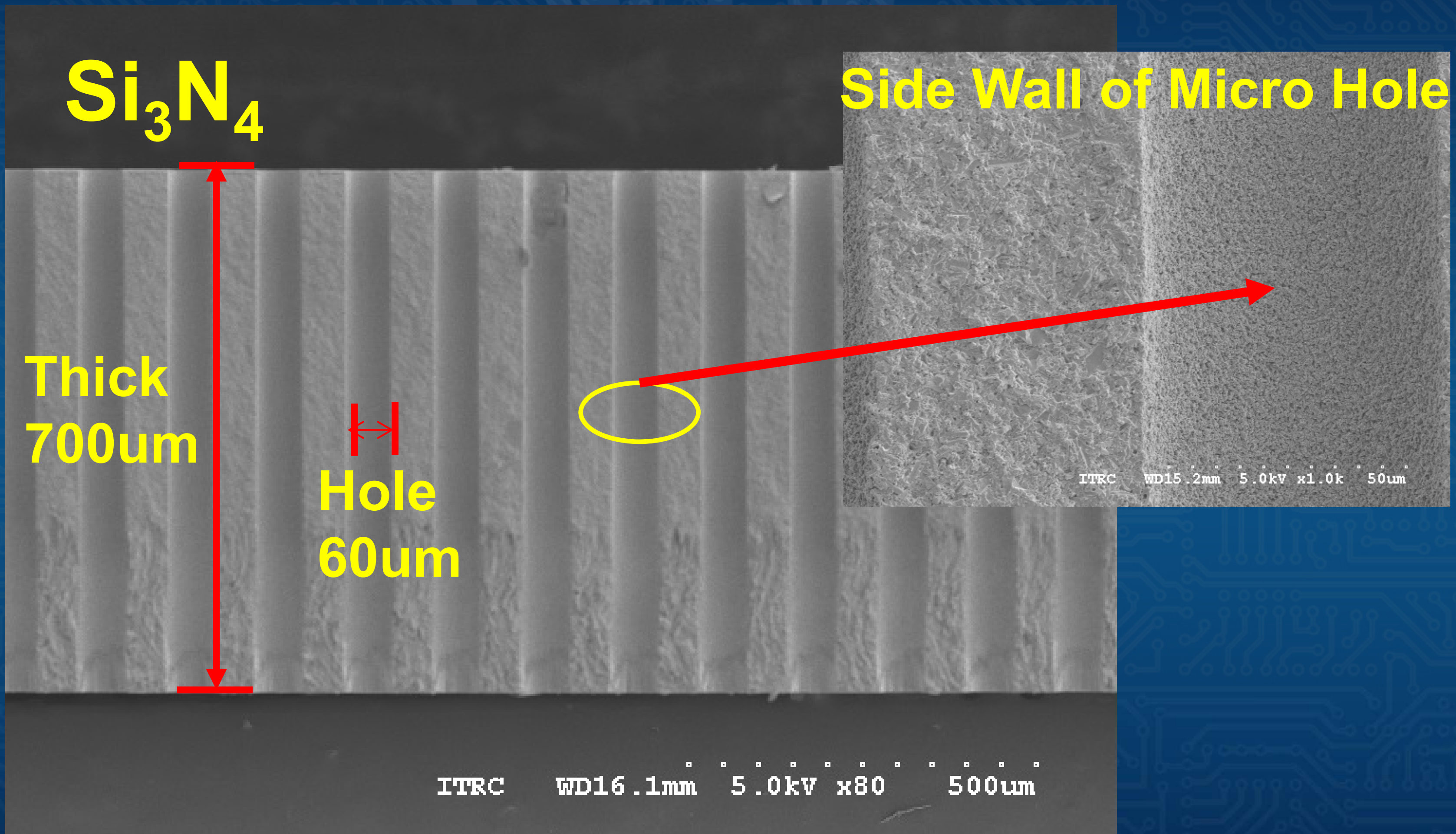
Capabilities of *DeepWell Drill*

- **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

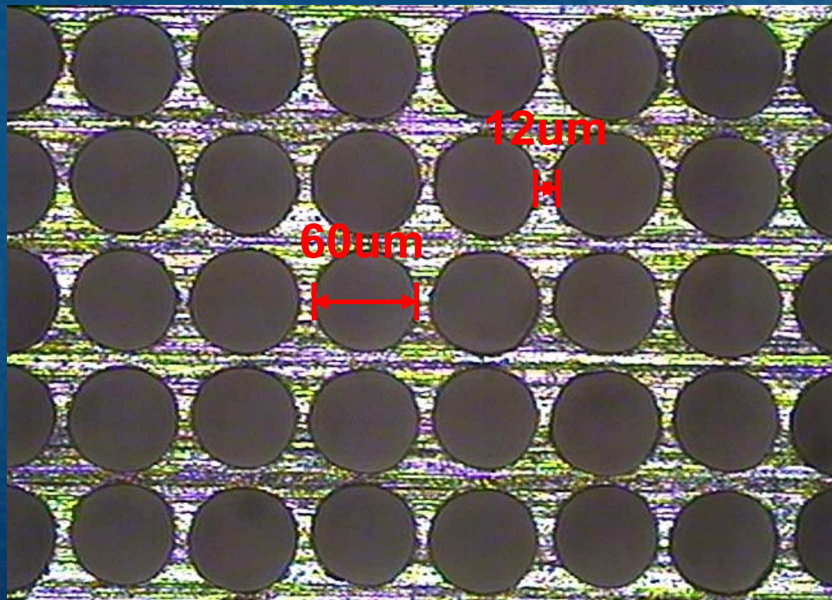


DeepWell Drilled Micro-Holes

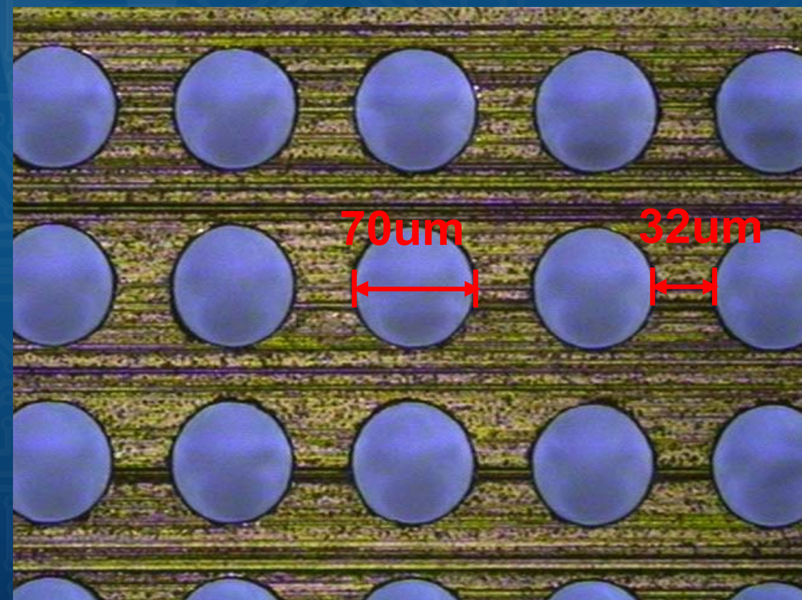


DeepWell Drilled Micro-Holes

Hole: 60um
Spacing: 12um

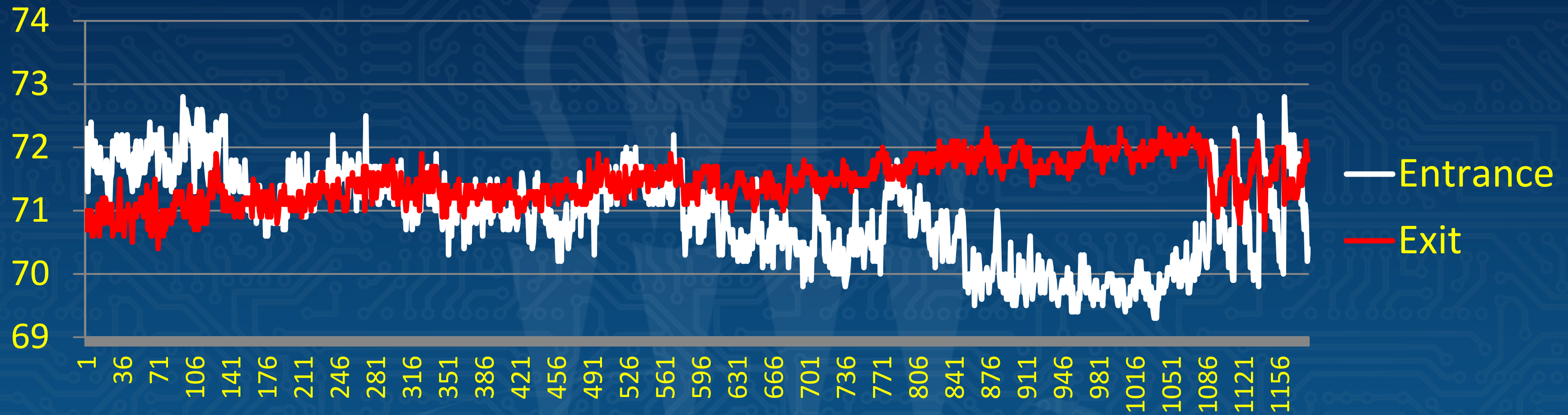


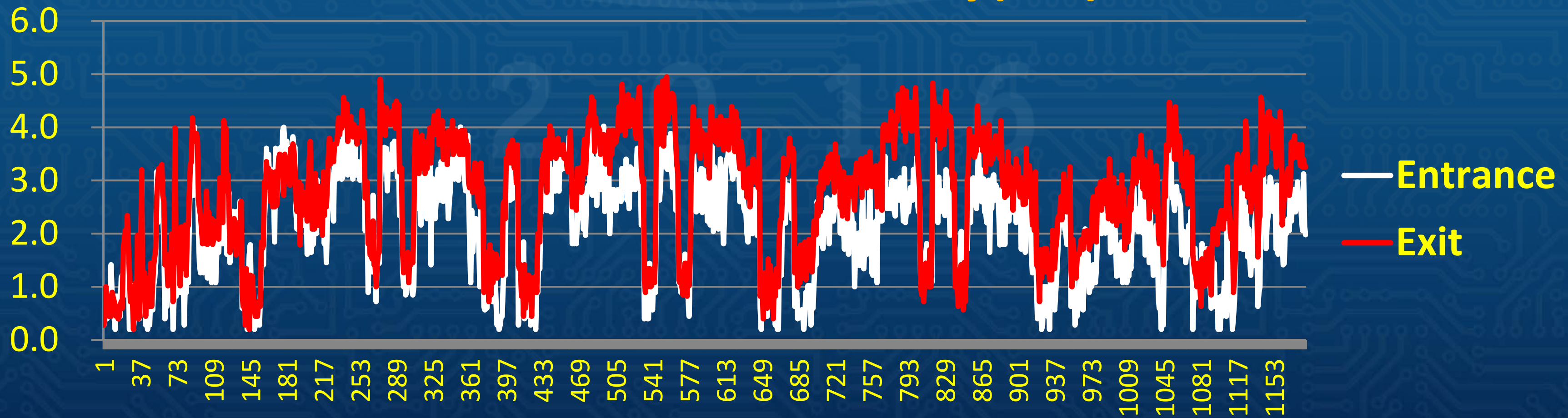
Hole: 70um
Spacing: 32um



Evaluation

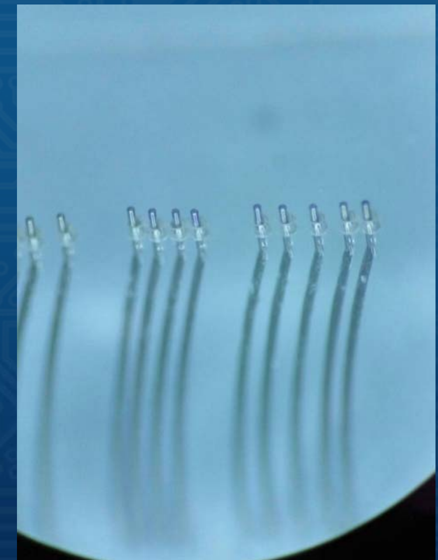
- A Si_3N_4 upper die was fabricated by bonding and laser process to evaluate the performance.
- Micro-Holes were measured by Nikon VMR3200
- Total Thk.: 0.8±0.01mm
- Pocket Thk.: 0.254±0.01mm
- Pin Holes: Φ2/2.5+0.005/0.010mm
- μHoles: Φ71um±1um
- Numbers: 1,184


Micro-Holes Diameter(um)
74
73
72
71
70
69
1
36
71
106
141
176
211
246
281
316
351
386
421
456
491
526
561
596
631
666
701
736
771
806
841
876
911
946
981
1016
1051
1086
1121
1156
Entrance
Exit


True Position Accuracy(um)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
37
73
109
145
181
217
253
289
325
361
397
433
469
505
541
577
613
649
685
721
757
793
829
865
901
937
973
1009
1045
1081
1117
1153
Entrance
Exit

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!