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# Evaluation of Low Pressure MEMS Probes

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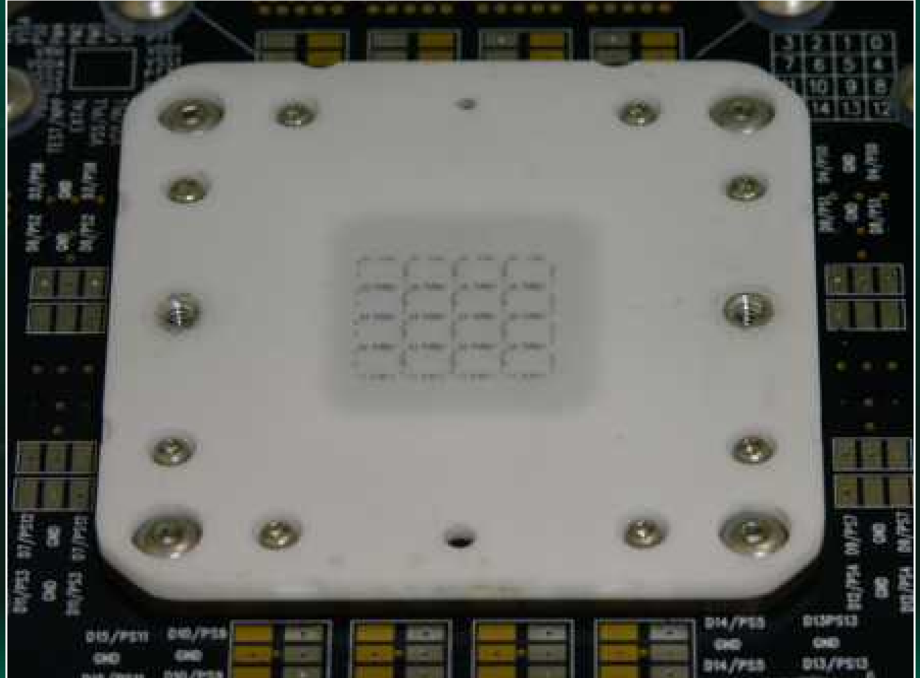
# Outline

- **Design Review**
  - Specifications
  - Resultant Design
- **Design Evaluation**
  - Force vs deflection
  - Life Tests
  - Scrub
- **Conclusion**

# Design Specification

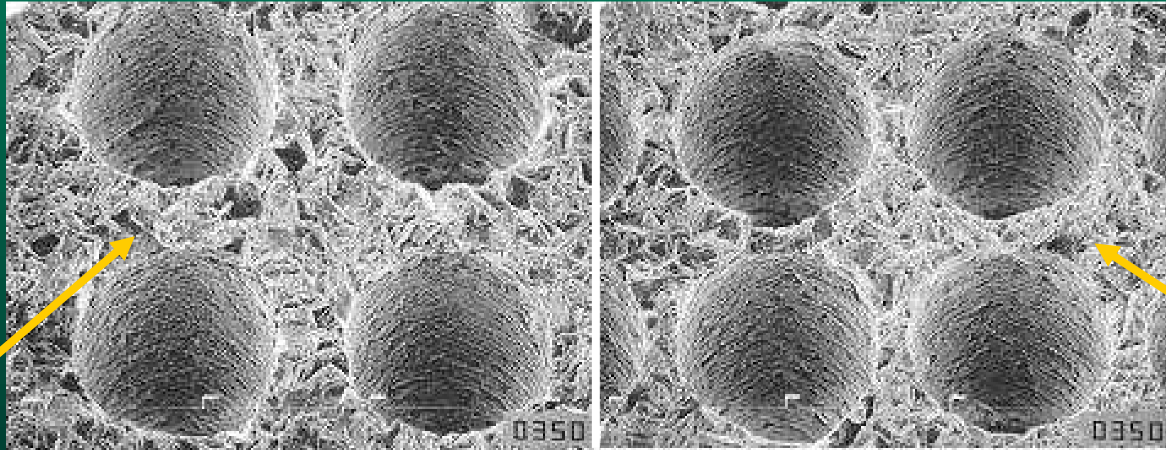
- User replaceable probes
- Compatible with existing technology
- Reliable solution
- Chose a buckling beam type design
- Precision ceramics



# Machinable Ceramics Review

- Hole Shape: Critical for fine-pitch hole integrity and reliability

Standard

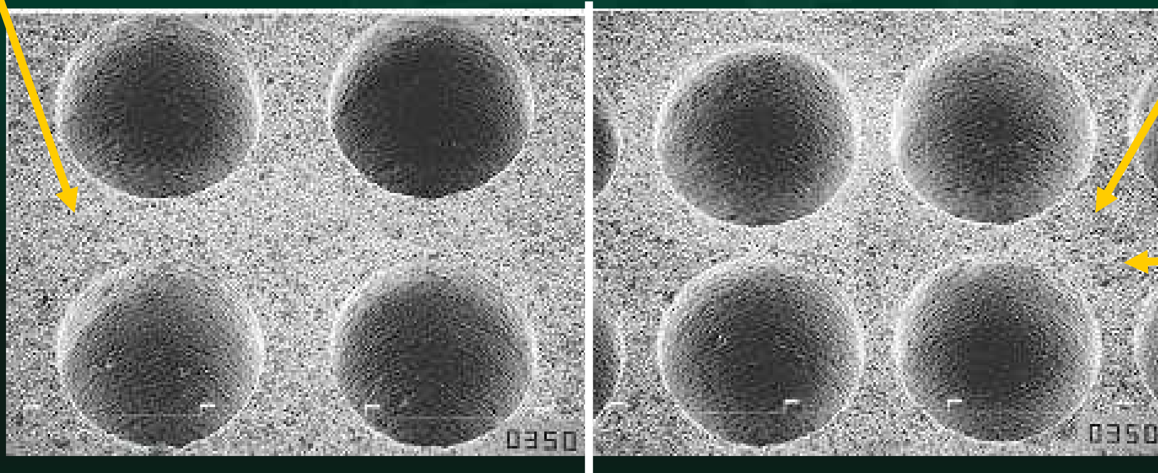



Hole Pitch: 0.15mm

All Hole Diameters: 0.11mm

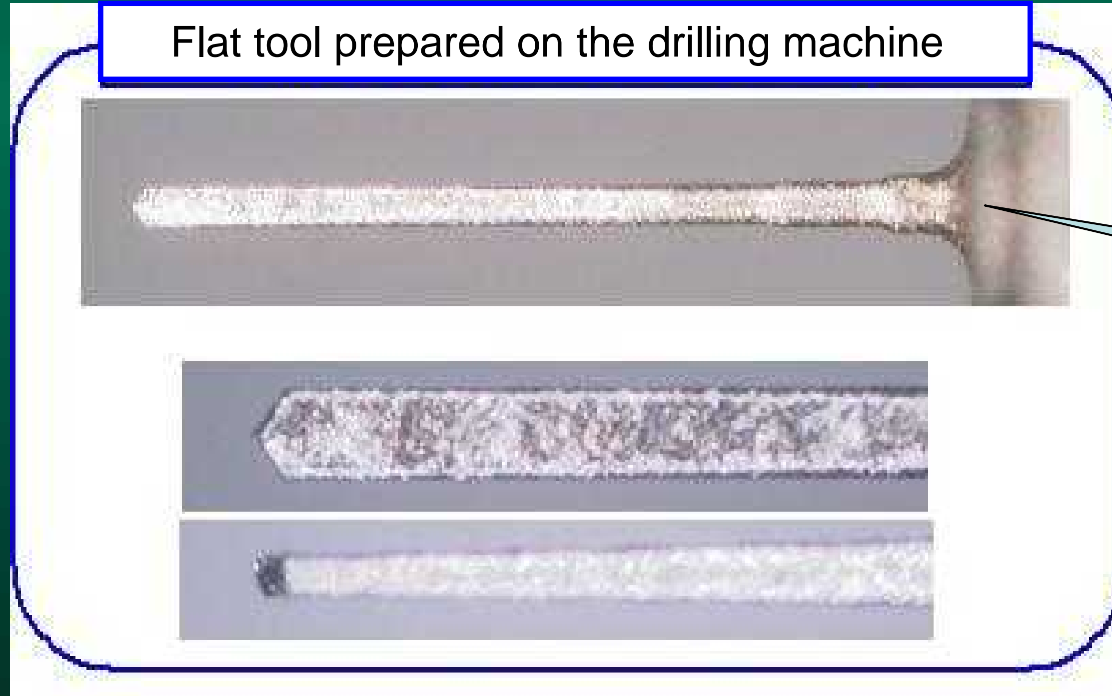
Hole Pitch: 0.13mm

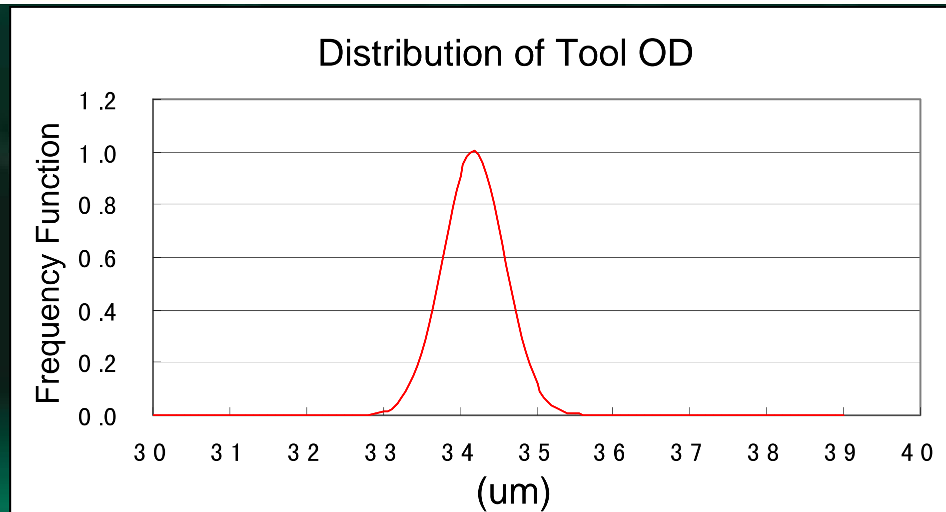
Test Die




Finer grain ceramic

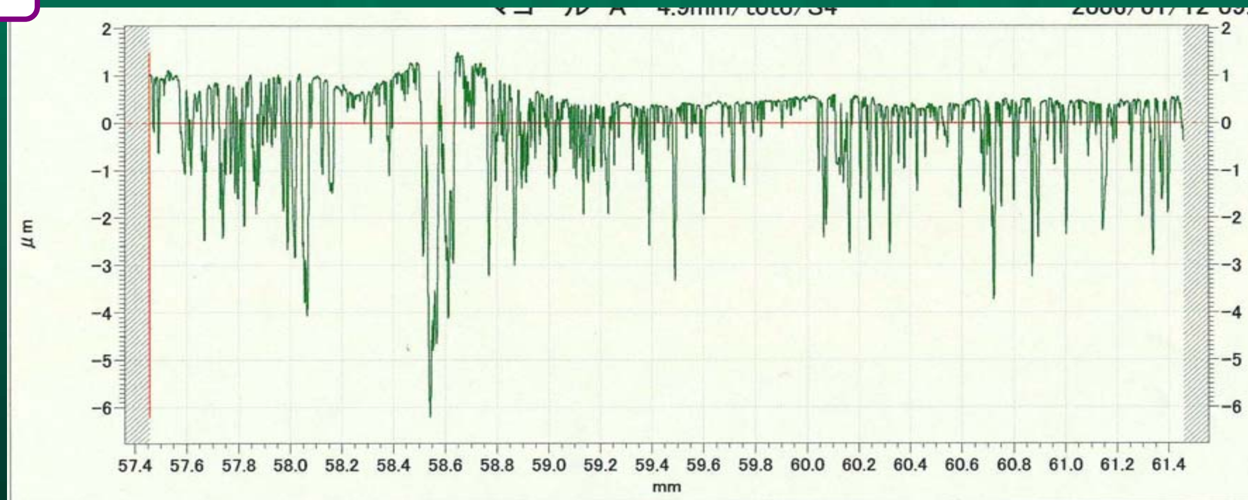
# Polycrystalline Drill Bits – Precision Drilling



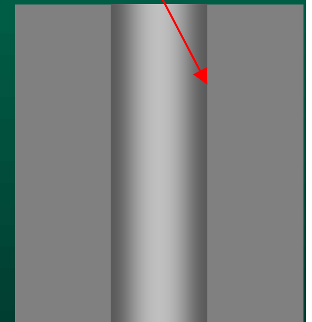



# Surface Roughness of Inner Hole Wall

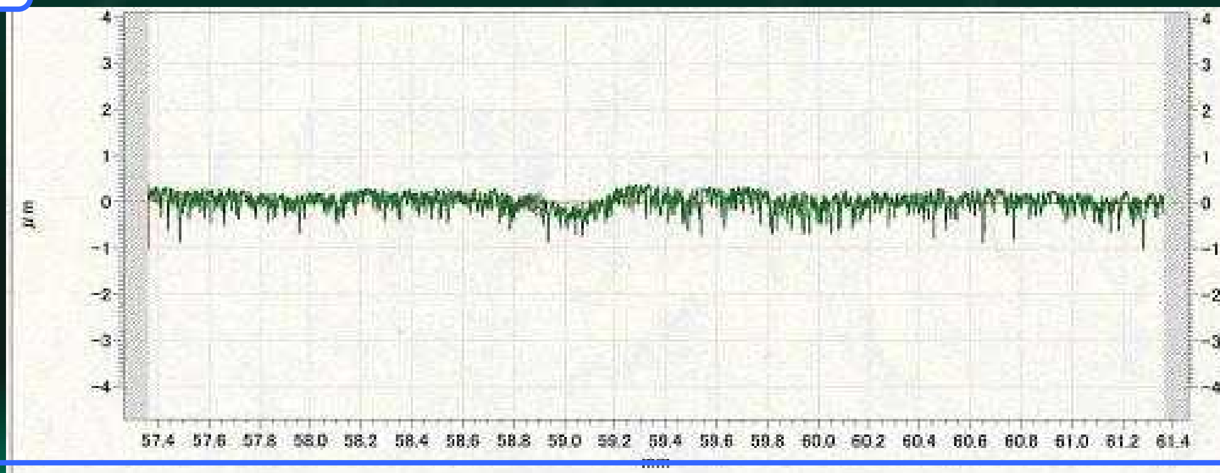
Standard



Surface roughness of hole inner wall

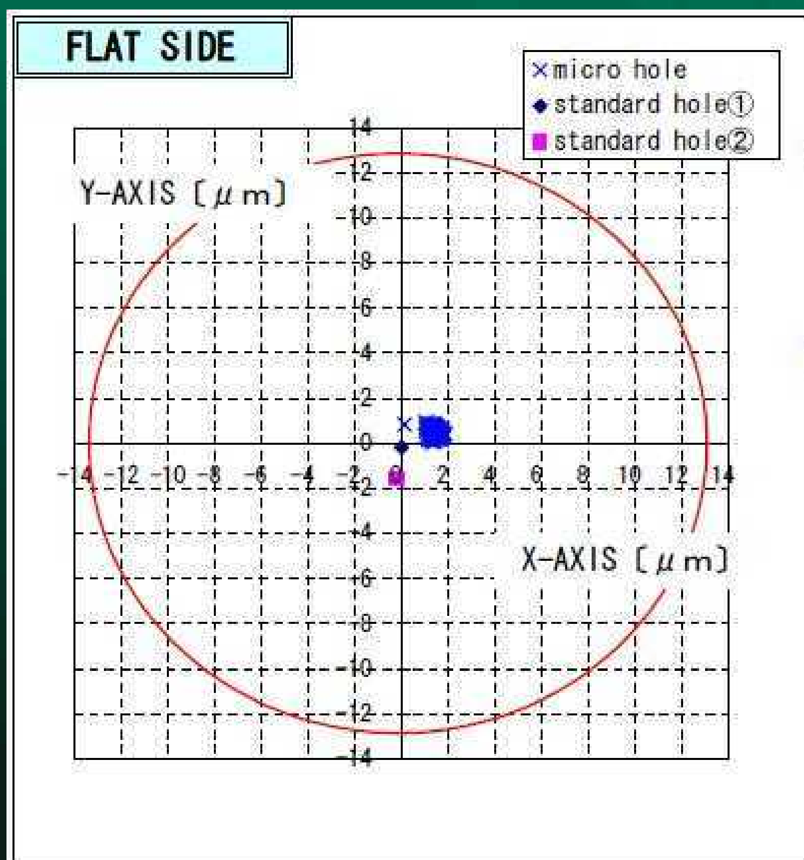


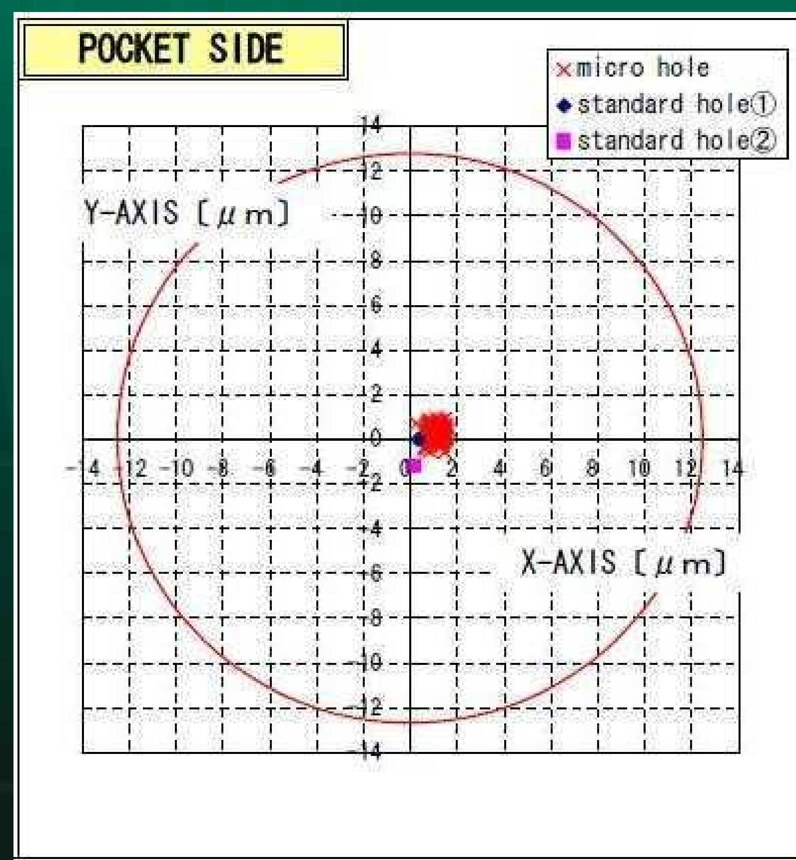
Test Die



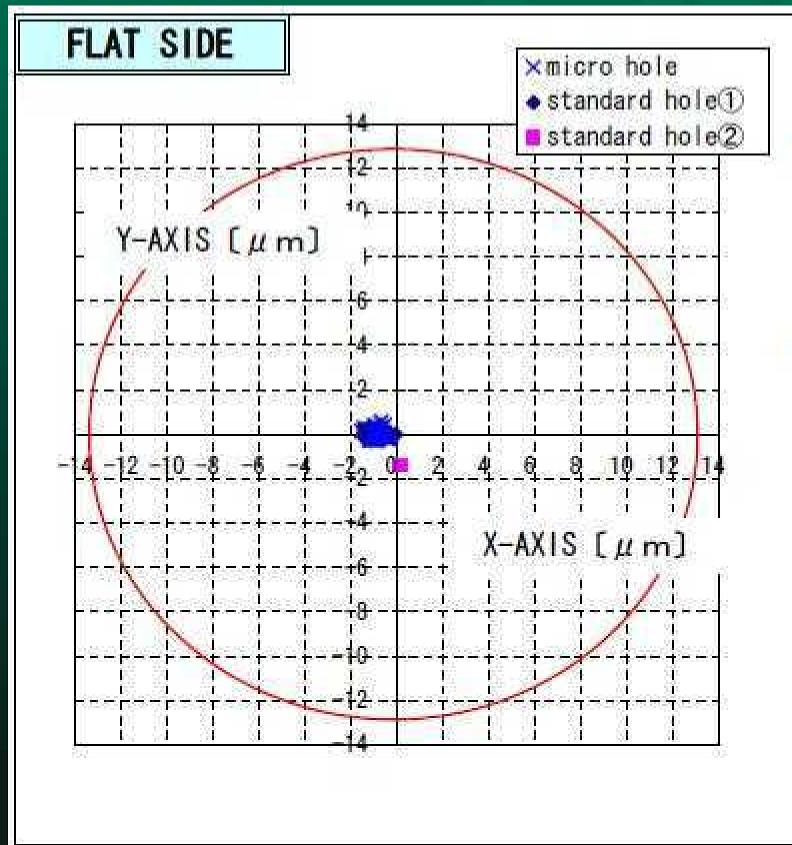
| | Ra (um) |
|---|---|
| Test Die | 0.1059 |
| Std. | 0.4433 |

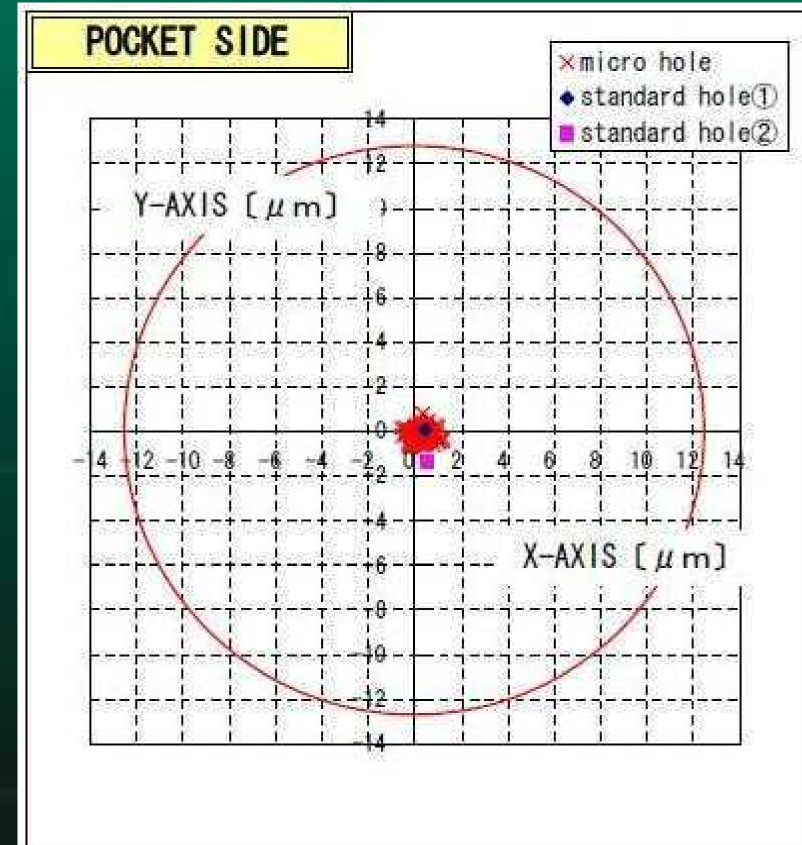
# Upper Die Measurements



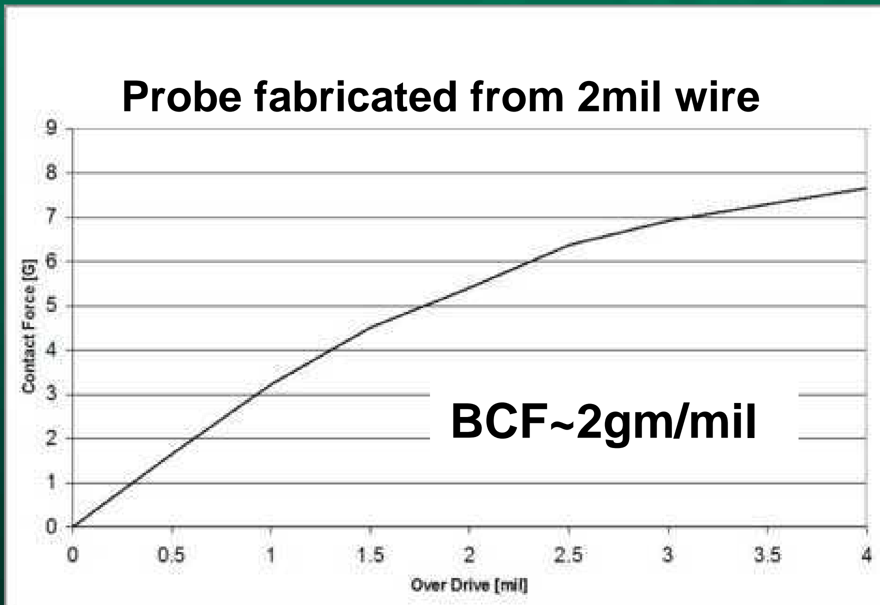
# Lower Die Measurements

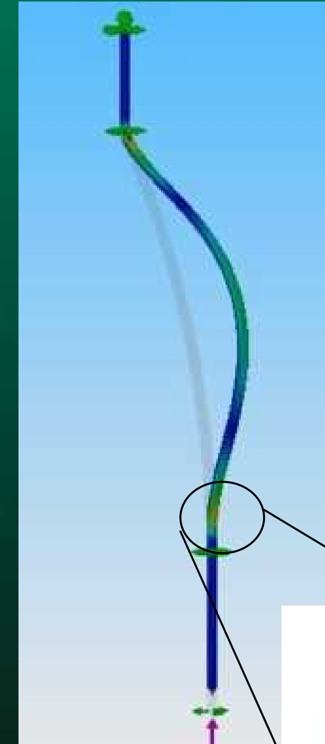



**Mechanical drilling of machinable ceramic**

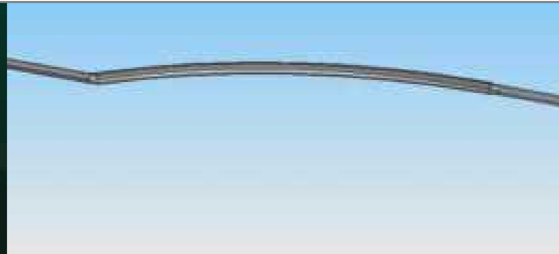
# Buckling Beam Review

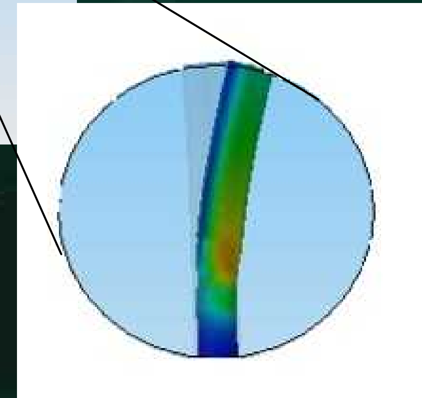


**High Stress Concentrations Limit Force and Overdrive**

Coined from wire





**Coined from a slender wire.**

**Bending in curved section**

# Observations Regarding Standard Buckling Beam Probes

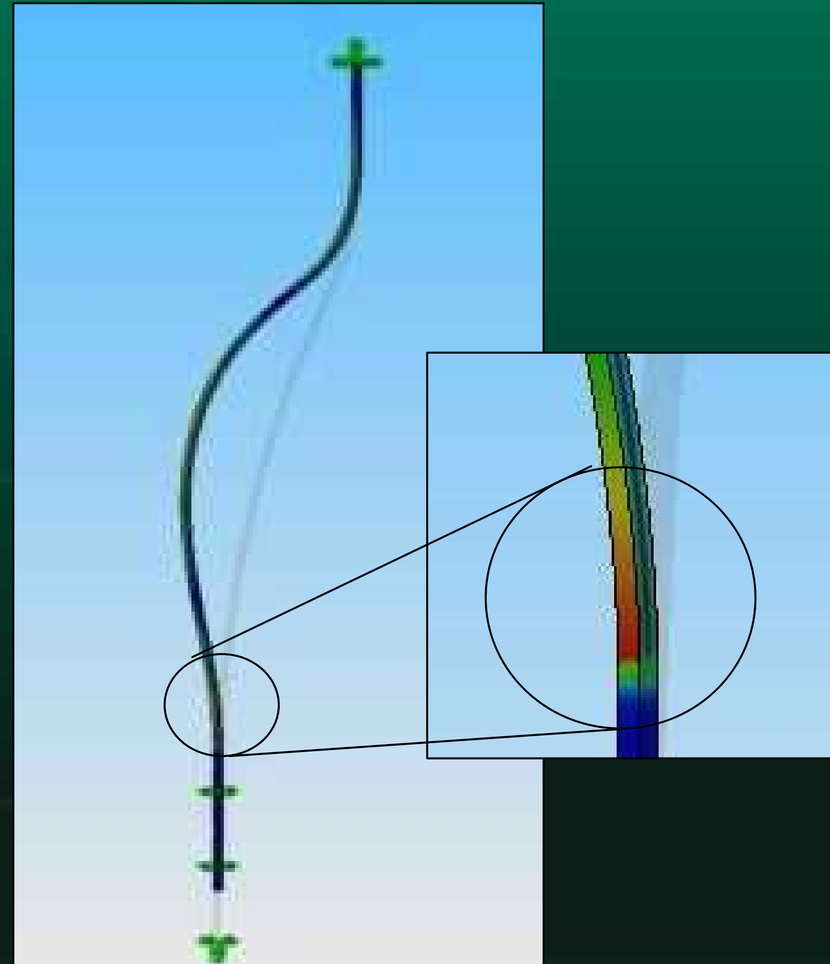
- **Spring rate of probe is driven by**
  - Length and offset of coined section
  - Width of coined section
- **Stress concentrations**
  - Transitions
  - Micro-hole constraints
- **Pitch Limitation**
  - Wire size
  - Cross-sectional length of coined section

# MEMs Probe Design

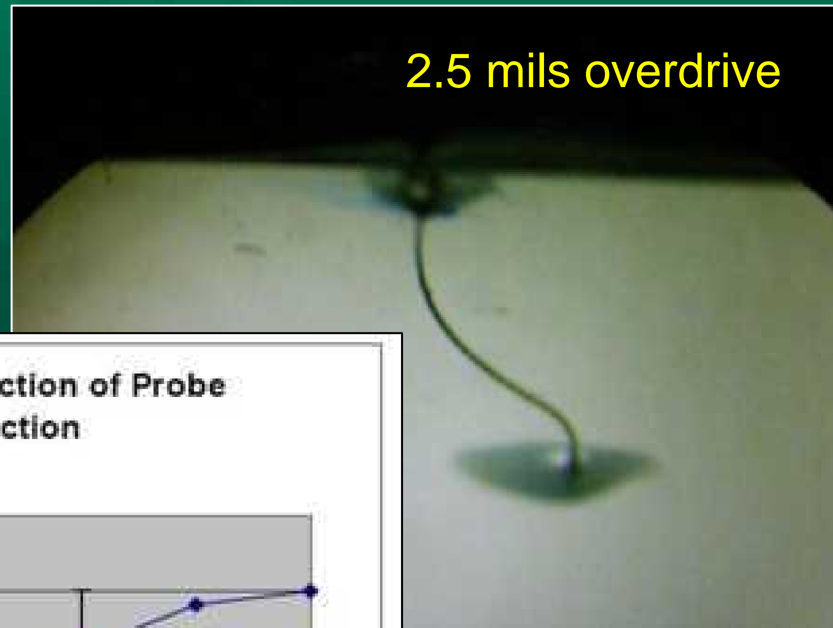
- **Design Constraints**
  - Multiple layer photolithographic & plating process
  - Minimize layer count
  - Maximum stress less than ½ ultimate strength at greater than 5mil OD
  - Minimize cross-section for fine pitch applications

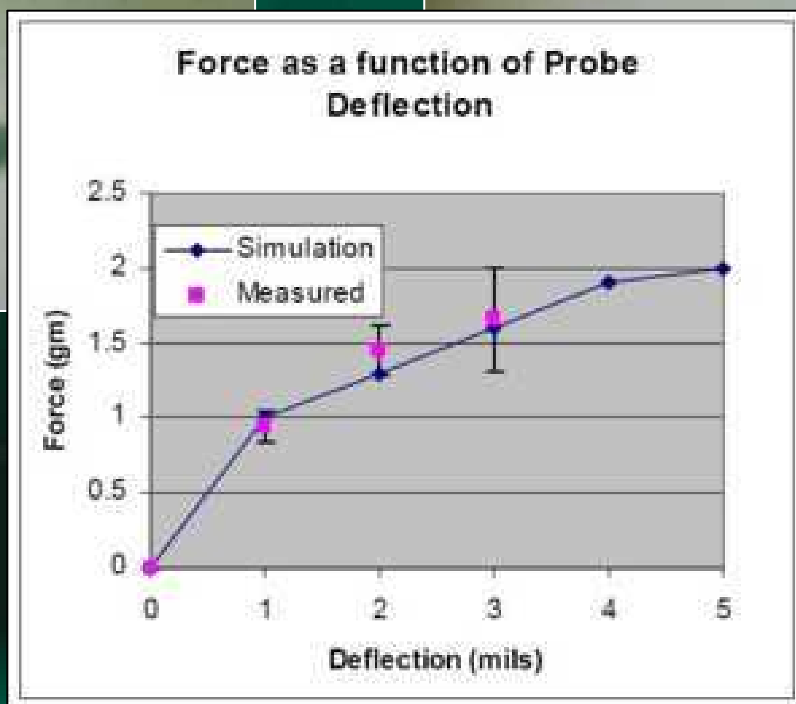
# Final Design

- **Long slender probe**
  - Three layers
    - Fine pitch (less than 60um)
    - Lower production costs
  - Stress concentration
    - Limits spring rate
  - Low BCF
    - 1.0 to 1.5 gm from 50um to 75um OD
    - Maximum 2.0 gm



# Probe Tip Contact Force

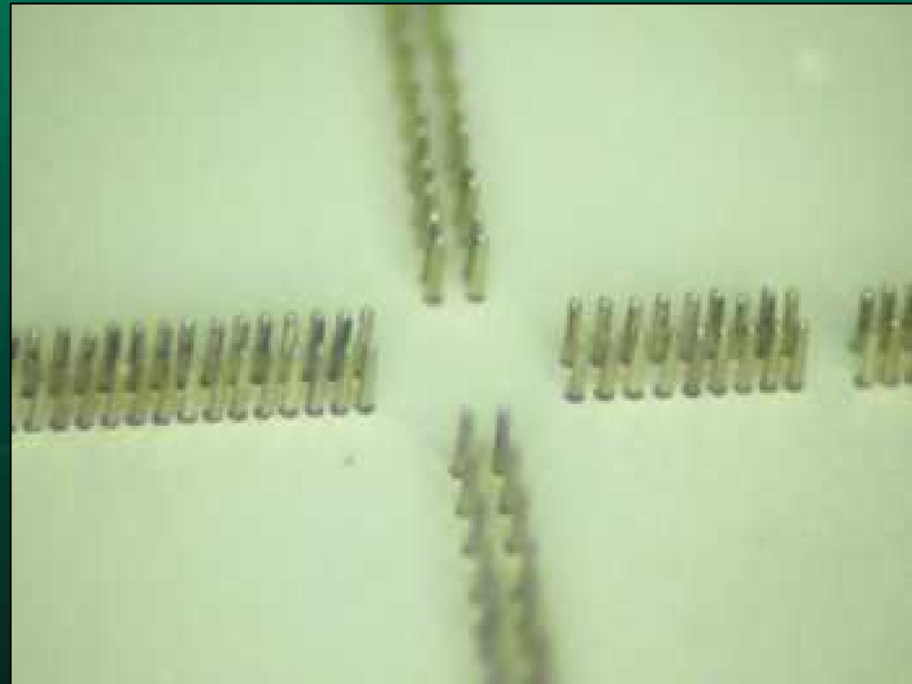


# Will Low Force Work?

- **Build test vehicle**
  - Fully functional
  - 60um pitch
- **Evaluate**
  - Life time contact resistance
  - Scrub
    - Depth
    - Alignment

# MEMs Probes



- **Unique probe tip geometry**
- **Superior material properties**
- **Prime manufacturing tolerances**

# Test Procedure

- **Wafer scrub analysis**
  - Scrub wafer at 50um and 75um overdrive
  - Measure scrub position and depth with WaferWoRx 300
- **CRES as a function of touch downs**
  - Measure test vehicle path resistance with PRVxII
  - Scrub on wafer multiple times at 50um overdrive
  - Periodically remeasure path resistance with PRVxII

# Wafer Scrub Analysis

- **Scrub wafer at 50um and 75um OD**
- **Use WaferWoRx 300 system**
  - Measure scrub depth profiles
  - Measure scrub position

# Wafer Scrub Analysis

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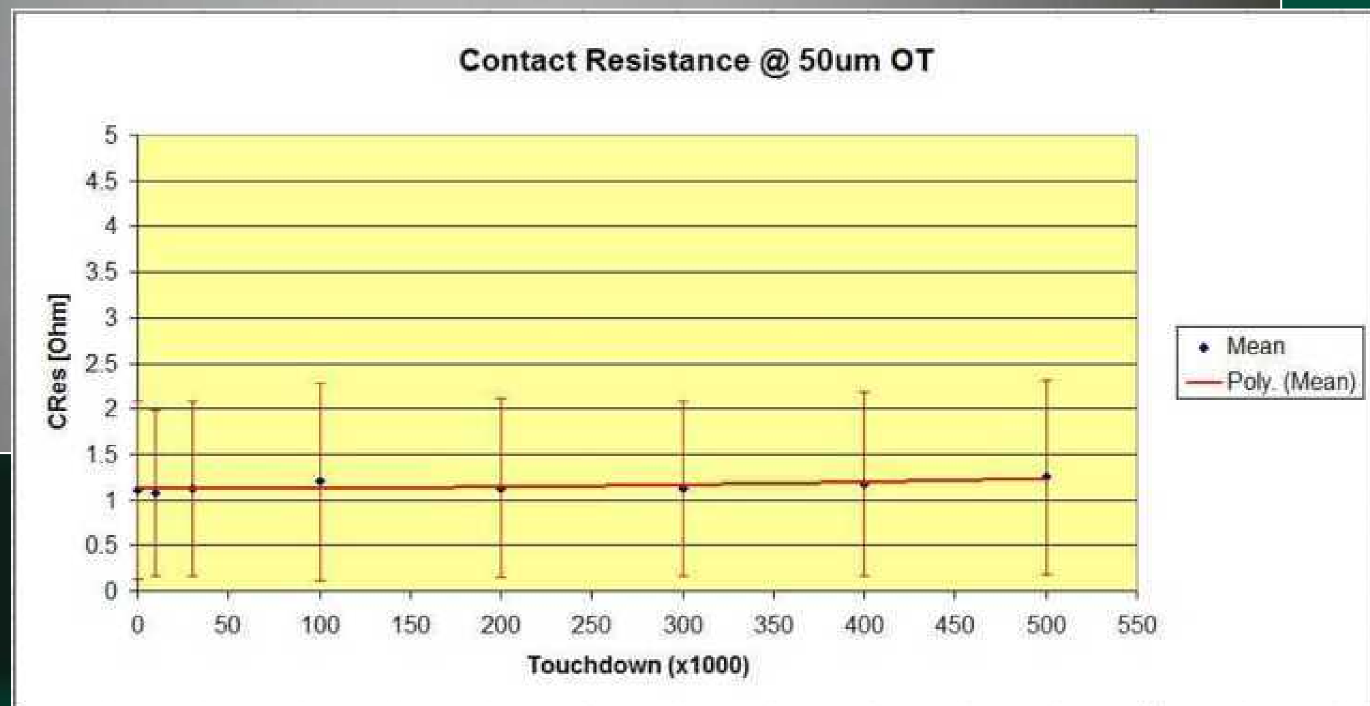
# Summary of Readings

- **Scrub depth – 0.18um ± 0.03um (one sigma)**
- **Scrub length – 15um ± 7um (one sigma)**
- **Scrub width – 12um ± 4um (one sigma)**
- **Scrub alignment – 7um ± 4um (one sigma)**

Comments:

All measurements at 75um OD
Probe tip width 8um
Rejected alignment outliers

# Life Testing: CRES



# Conclusion

- Design constraints led to low force probe design with maximum force of ~2gm
- Probe penetrates wafer .18um for 75um OD yielding good wafer contact
- Small probe tip contact with hard plated metal yields low, consistent, and stable CRES
- Path resistance drops to less than 2 Ohms when probing aluminum wafer
- New drill technology and machinable ceramic material aids in improved alignment accuracy

# Acknowledgements


- **Rod Doe**
  - Senior Engineer
  - Rudolph Technologies
- **Shoichi Asanuma**
  - **- TOTO Advanced Ceramics**
- **Additional data regarding hard ceramics will be presented during Wednesday morning session**