Introduction of MEMS technology with the ceramic mold for Next-Generation test probes

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Incheon ▪ November 7, 2023

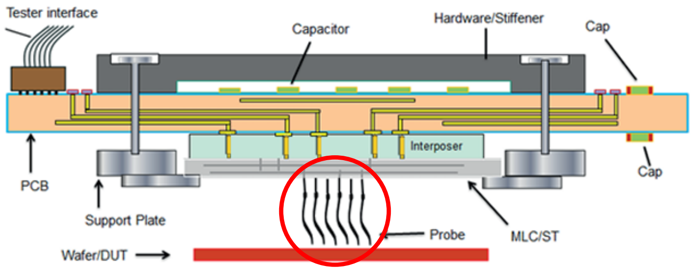
Contents

- Technology Trend
- Bridging the gap
- Suggestion : New tools for MEMS
- Fabrication case / Measurement Results
- Conclusion

Test Pin Application Areas

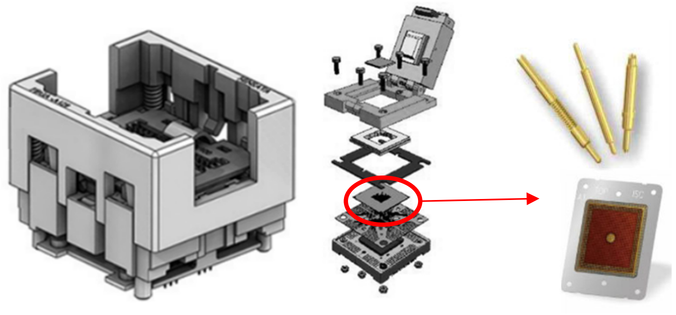
- **MEMS pins with high performance can be built to customer specifications for probe cards and test sockets applications**

1. Probe Card (for Wafer Test) – Probe Pin



[Diagram of probe card]

2. Test Socket (for Package Test) – Socket Pin

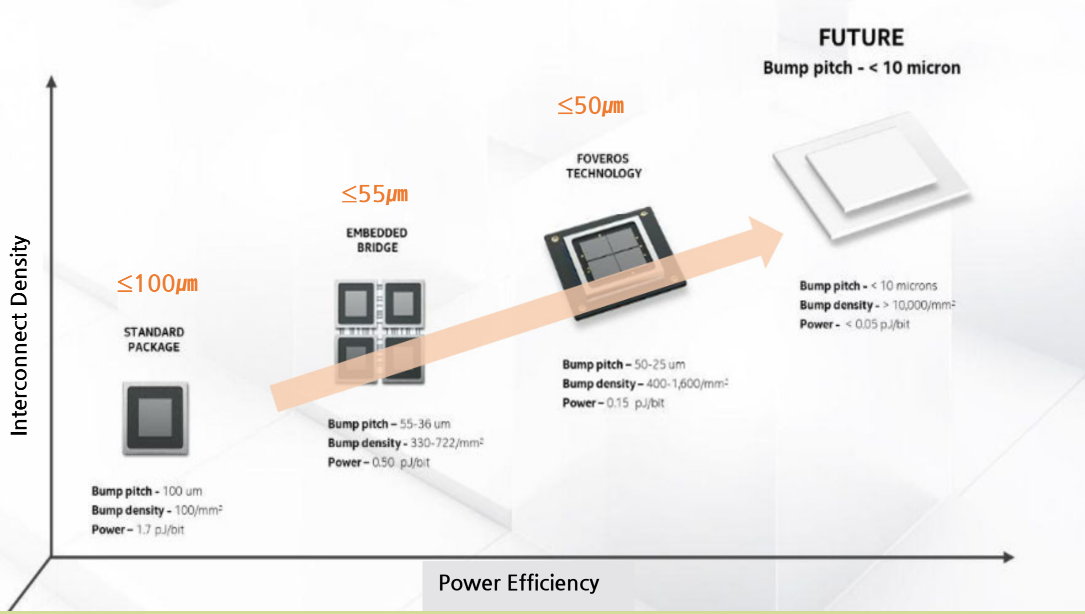


[Diagram of test socket]

Source: Informacije Midem, Vol.46, No.2

Technology Trend

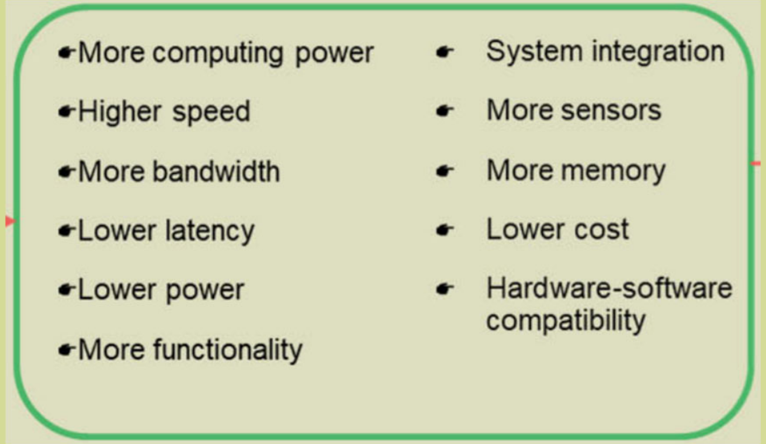
- There is still a need for new solutions that can respond to *Fine-pitch, High-speed, and High-density requirements.*



Source: https://www.intel.com/content/

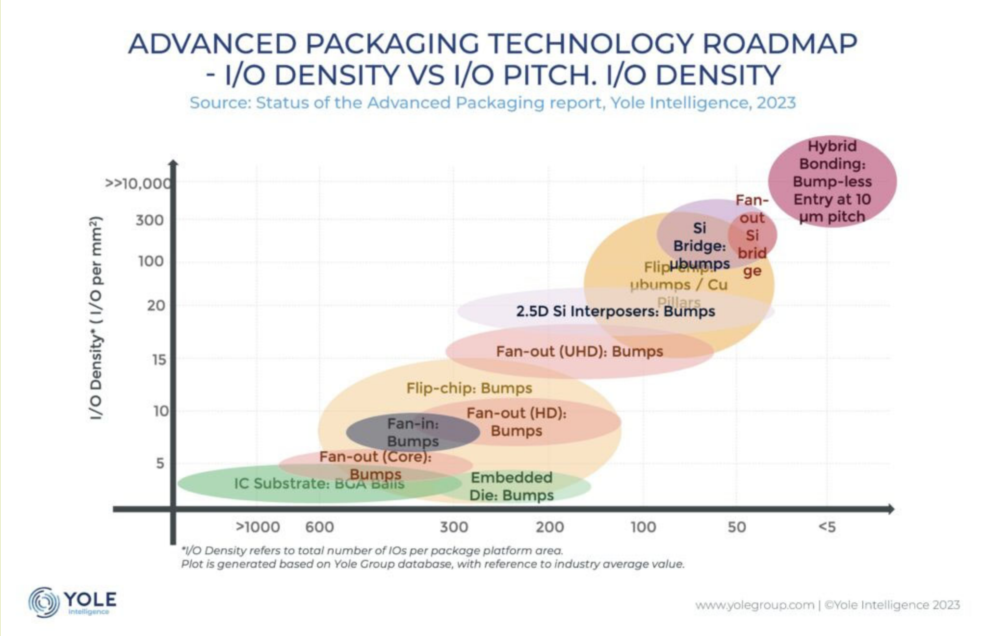
Technology Trend

- As packaging technology is segmented & evolves
- Demands for probes are also being divided based on application
- Requirements



- More computing power
- Higher speed
- More bandwidth
- Lower latency
- Lower power
- More functionality
- System integration
- More sensors
- More memory
- Lower cost
- Hardware-software compatibility

Source: Yole



ADVANCED PACKAGING TECHNOLOGY ROADMAP - I/O DENSITY VS I/O PITCH. I/O DENSITY

Source: Status of the Advanced Packaging report, Yole Intelligence, 2023

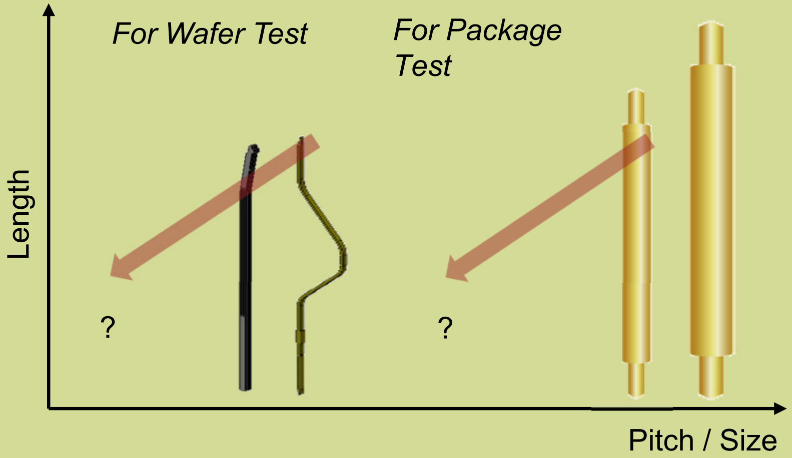
*I/O Density refers to total number of IOs per package platform area.
Plot is generated based on Yole Group database, with reference to industry average value.

www.yolegroup.com | ©Yole Intelligence 2023

Source: Yole

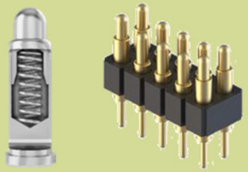
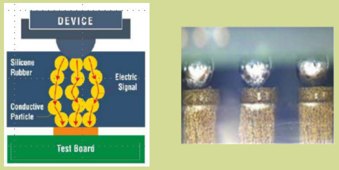
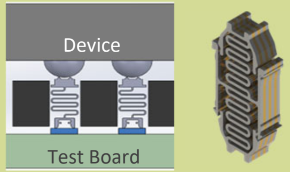
Technology Trend

- Limitation of existing MEMS needle
    1) Long production time
    2) High cost
    3) Limitations in thickness (hard to get >100um thickness)
    4) Still needs for MEMS fabrication technology to make probes finer, shorter



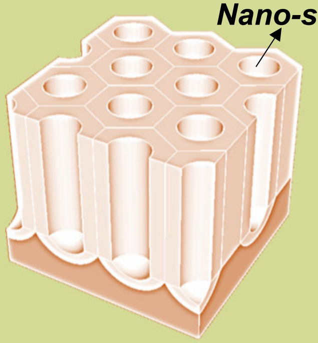
Bridging the gap

- **MEMS probes satisfying high frequency, short length with fine patterning could be formed**

	Pogo Type	Rubber Type	PEC MEMS socket
			
Size / Pitch	Wide range of pitches Long Length (high inductance)	Short Length (low inductance)	**Fine Pitch with Short Length** **(≤ 0.3mm Pitch, ≥ 0.65mm Length)**
Precision / Manufacturing	High precision (contact tip) Price & manufacturing time ↑	Price & manufacturing time ↓ Manufacturing price & time ↓	**Fine Patterning, High Precision** **Fabrication difficulty & Manufacturing time ↑** **No Assembly**
High frequency / Signal loss	High speed & frequency Durability, Longevity ↑	Thermal durability, Longevity ↓	**High speed & frequency** **Durability, Longevity ↑**

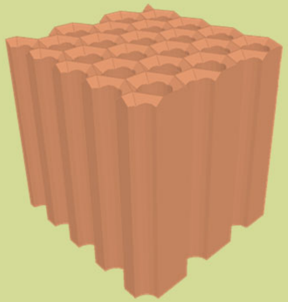
Suggestion : New tools for MEMS

- **PEC's distinguished "Ceramic mold applied MEMS technology"**
  - Replacement of pre-existing PR mold with the Ceramic mold

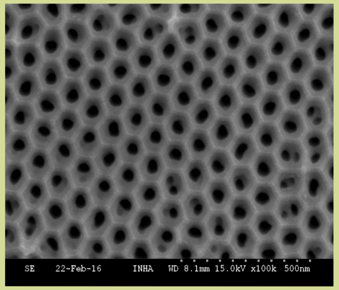


[The mold formation / electrochemical reaction]

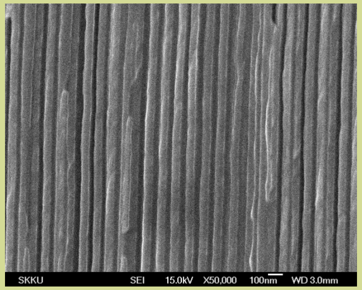
Separation



[Ceramic mold]



[Top view]



[Cross section view]

Suggestion : New tools for MEMS

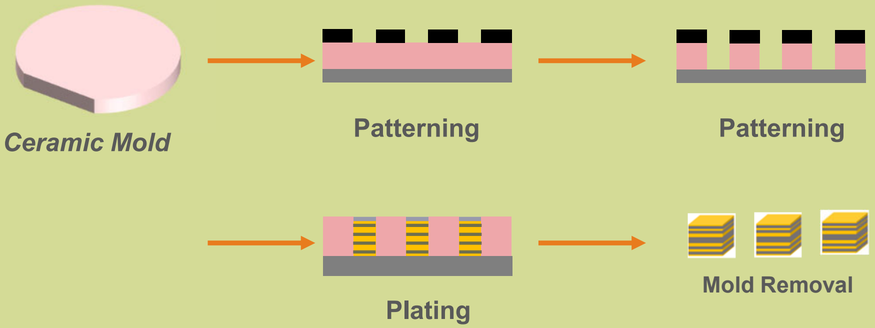
- **Properties of PEC's Ceramic mold**

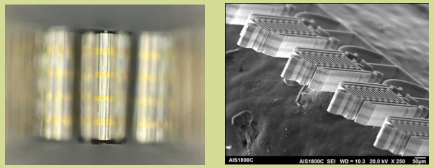
1. **Mechanical**
   - Highly Flexible and Bendable
2. **Thermal**
   - Low thermal conductivity
   - Low thermal expansion
3. **Electrical**
   - Dielectric Strength
   - Low Permittivity

Bending Strength(Mpa)	810
Young's Modulars(Gpa)	110
Thermal Conductivity(W/mk)	2.197
Thermal Expansion(x10^{-6})	1.5~3.78
Dielectric Strength	>50x10^{6}
Permittivity	3.7~4.5

Suggestion : New tools for MEMS

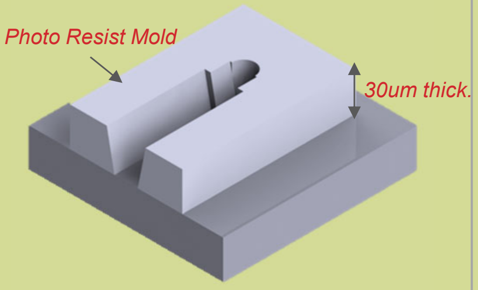
- **MEMS Process using PEC Ceramic mold**

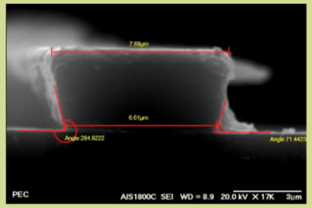




Suggestion : New tools for MEMS

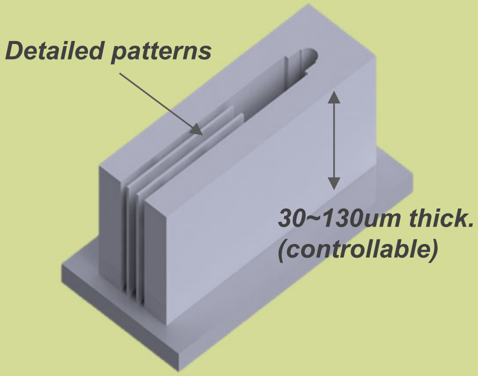
PR Mold





Ceramic mold

MEMS Process with PEC Ceramic mold



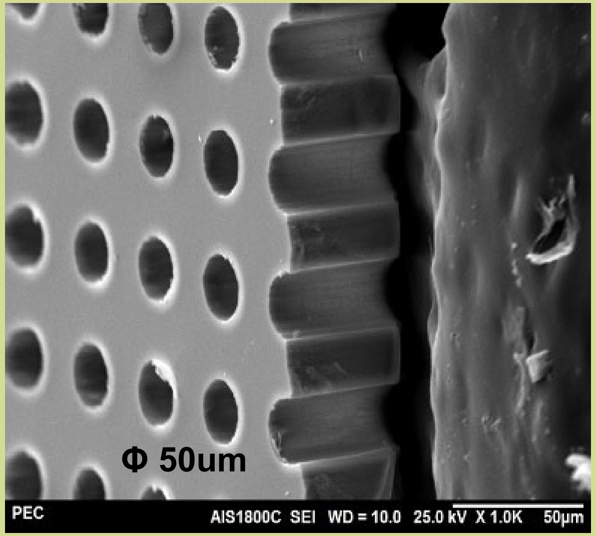
- Complex patterns with minimum 5um gaps can be stably implemented
- Top-Bottom dimension tolerance
  : max 1.5um (@ >100um thickness)

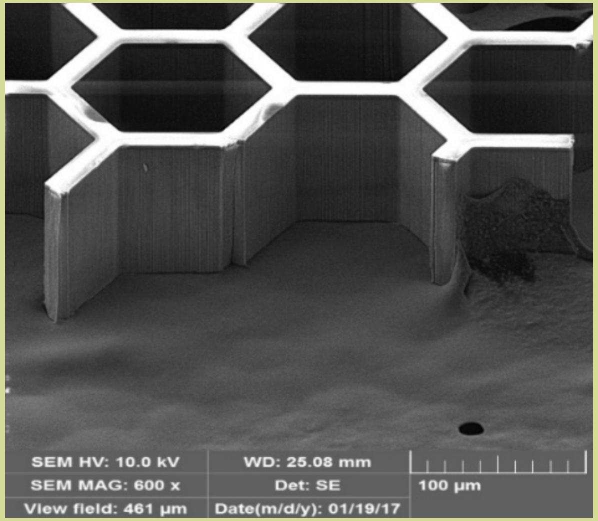
[Image of PEC's Ceramic wafer]

Enable MEMS
Corrosion Resistance
Thermal Resistance
Stable Dimension

Suggestion : New tools for MEMS

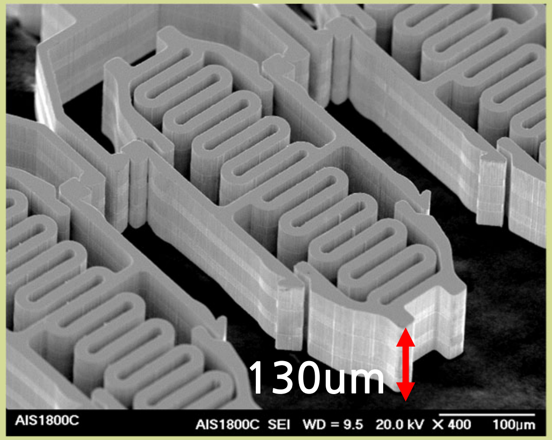
- **Image of patterned ceramic mold**



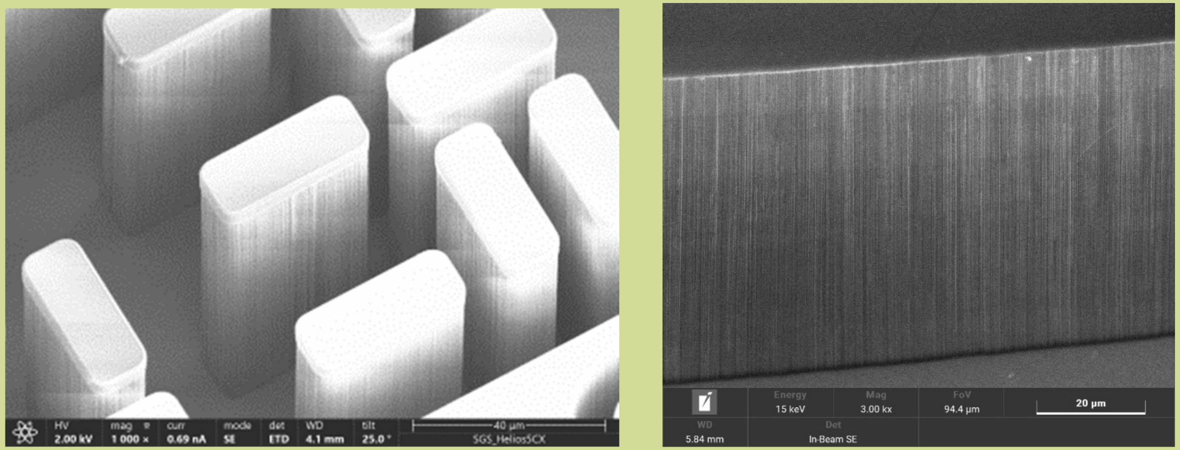


Suggestion : New tools for MEMS

- **The ceramic mold enables to straightened probe manufacturing with desirable thickness (up to 130um)**



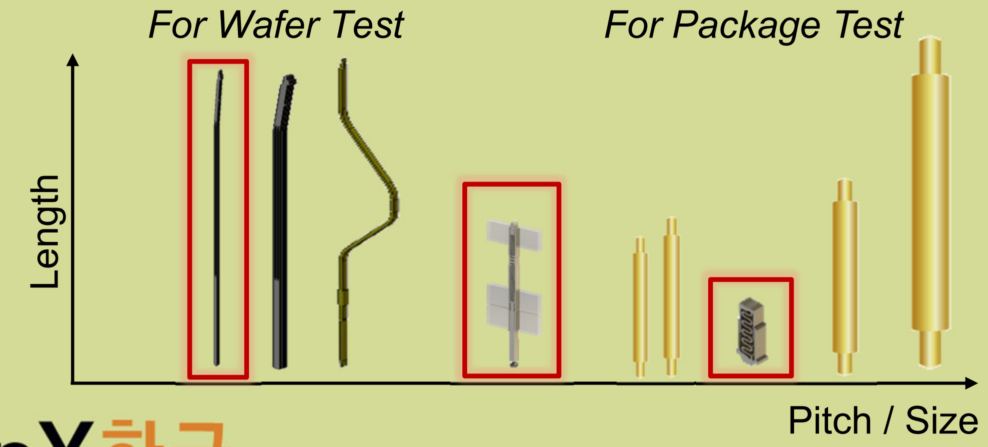
Fabricated socket probes using the mold



Fabricated ceramic mold with thickness

Suggestion : New tools for MEMS

- **Shorter probe length while maintaining pattern & shape**
- **This advantage point can be applied to**
  1) Fine pitch MEMS buckling with high C.C.C
  2) Short length MEMS vertical spring pin with relatively high current
  3) Short & thick MEMS Pogo probe for RF test solution

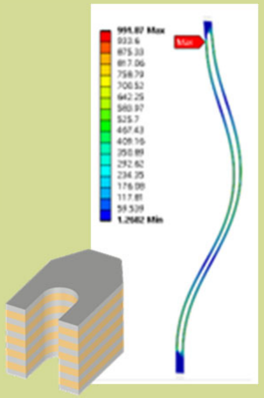


Development & Fabrication case

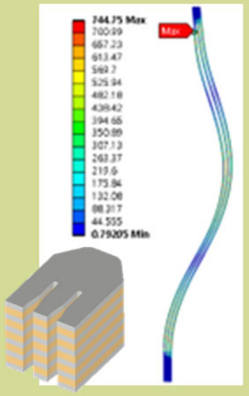
- **Probes fabricated with ceramic molds have relatively more volumes which enables probes to carry more C.C.C in same dimension**

Comparison between

Conventional MEMS needle **vs** **Ceramic Mold MEMS needle**



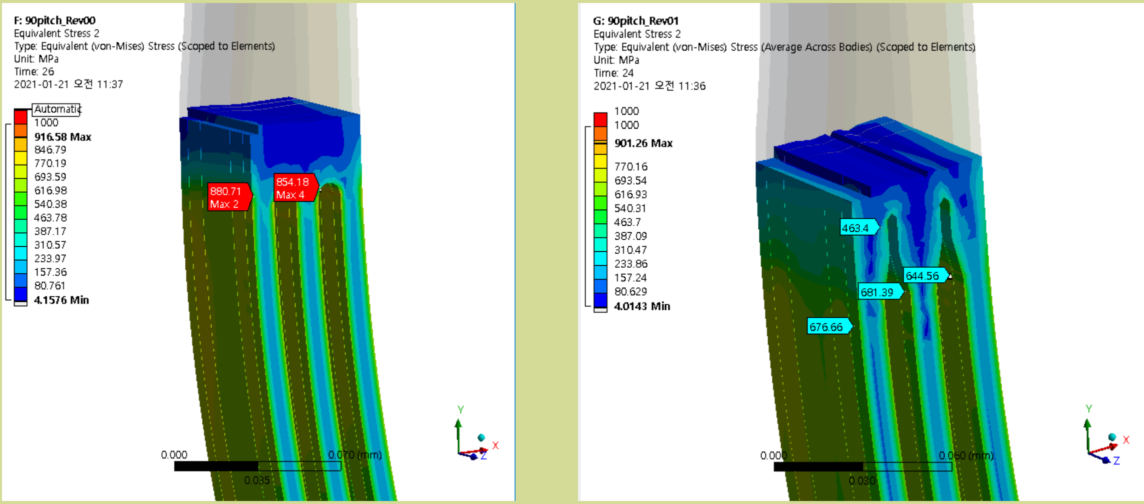
- Needle dimension
  : 55 X 55 X 4,400 ㎛
- Volume: 4.67 X 10^6 ㎛^{3}
- Predicted C.C.C: 1.18A
- Max Stress: 991MPa



- Needle dimension
  : 55 X 55 X 4,400 ㎛
- Volume: 4.96 X 10^6 ㎛^{3} (6% higher)
- Predicted C.C.C: 1.40A (19% higher)
- Max Stress: 744MPa (25% less)

Development & Fabrication case

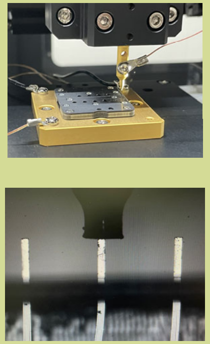
- **Fine slit structure for stress relief**
  - With accurate & precise fabrication, fine slit structure can be implemented on probe needle to reduce probe stress and increase life span

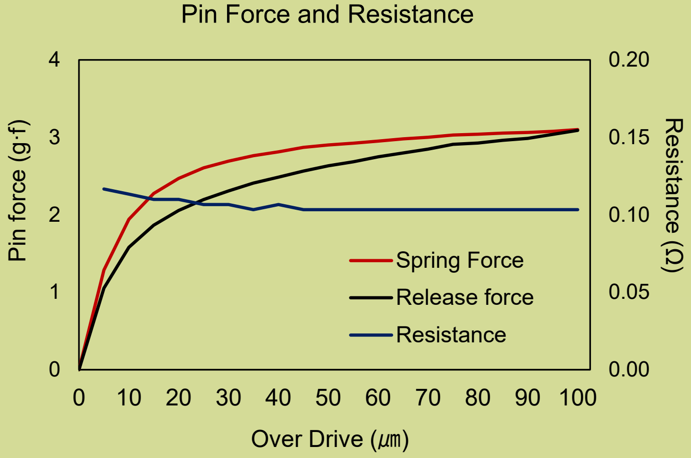


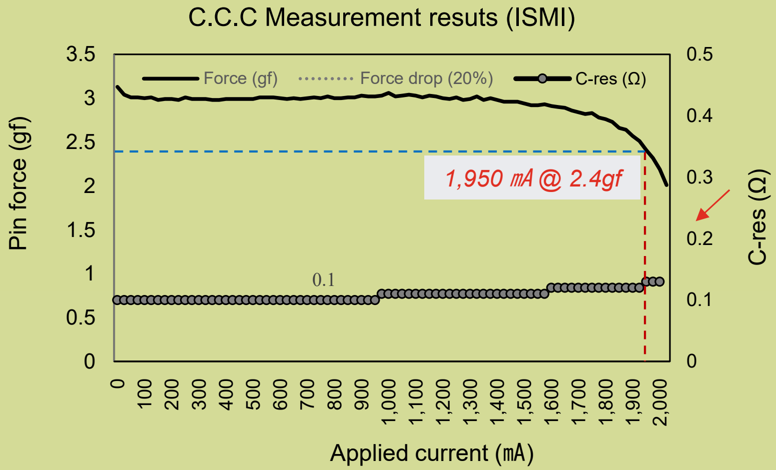
Comparison of stress between the conventional & fine slit structure manufactured with ceramic mold

Development & Fabrication case

- **Mechanical & Electrical performances of 110um pitch model**
  - Low resistance was maintained within O.D 100um range
  - High C.C.C through designs of Low resistance (material, structural)

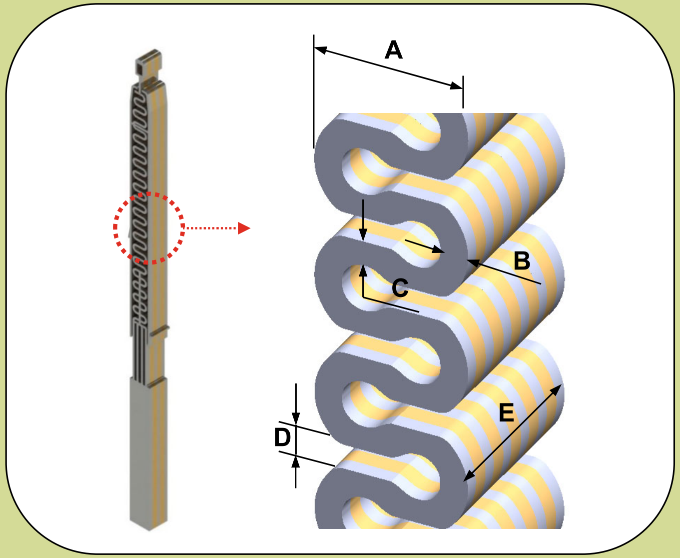




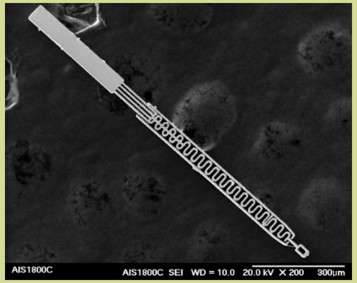


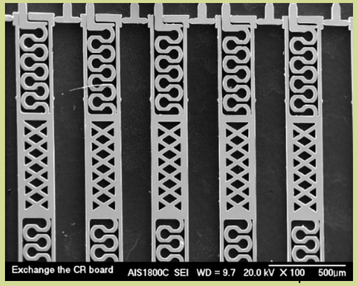
Development & Fabrication case

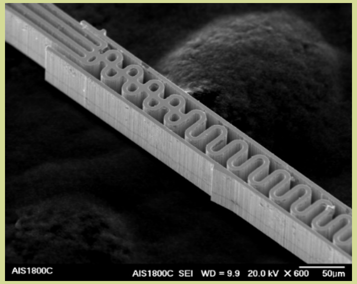
- **Design Rule of Point spring structure**



A	B	C	D	E
≥ 50	≥ 5	≥ 5	≥ 5	< 150





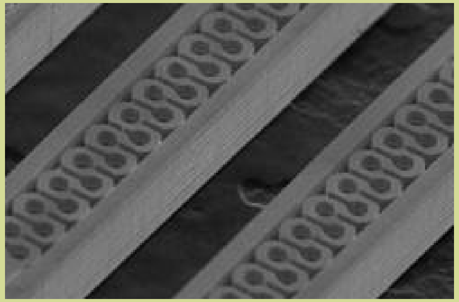


Development & Fabrication case

- **Unique MEMS vertical probes with spring structure**

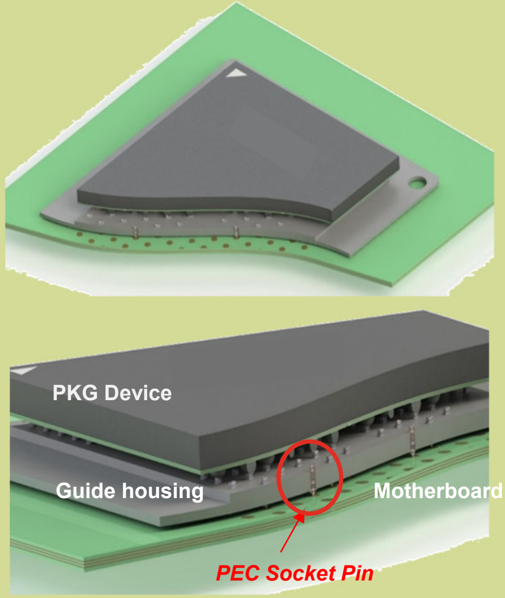
Parameters	Specification
Pitch	150㎛
Probe Dimension	Thickness 80㎛
Probe Length	1.6mm
Recommended stoke (Full Stroke)	150㎛ (200㎛)
Contact force	3.0gf
Max. Current (ISMI)	~2,000mA
Contact Resistance	0.1Ω

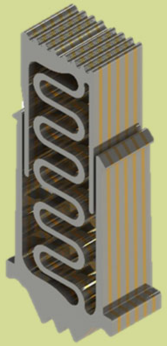
- **Straightened probe structure**
- **Solution for 110~150um pitch**
- **Carry relatively high current**



Development & Fabrication case

- **Extremely short and thick MEMS sockets**

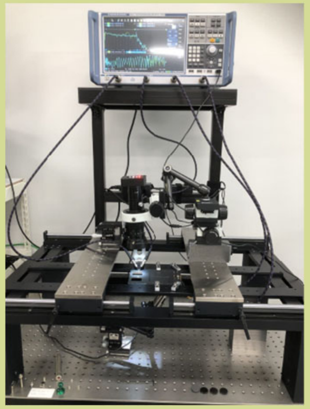




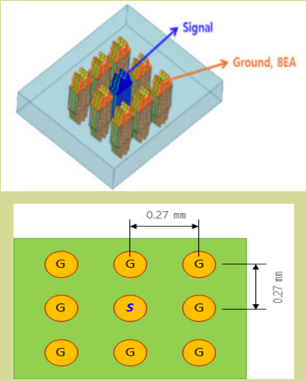
Parameters	Specification
Pitch	>270㎛
Probe Dimension	Thickness 130㎛
Probe Length	< 650um
Contact Force	5~15gf
Max. Current (ISMI)	1,000㎃
Contact Stroke	50~150um
Frequency	100GHz@-1dB

Development & Fabrication case

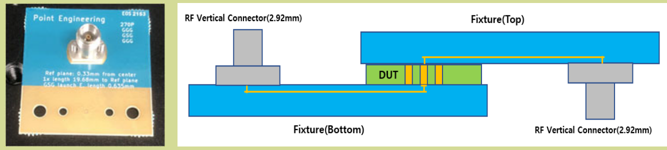
- **Frequency test result of PEC MEMS socket pin**



[Measurement Device - ZNB40]

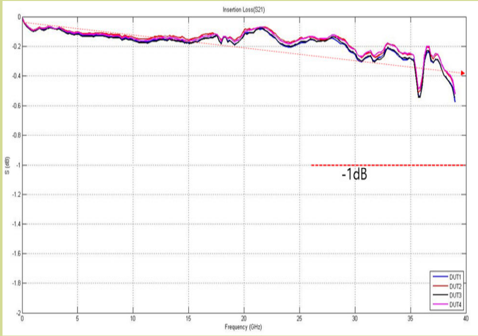
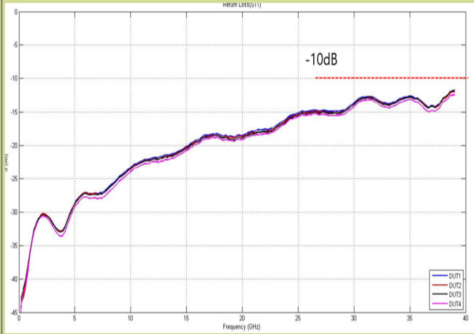


[Diagram of DUT Array Data]



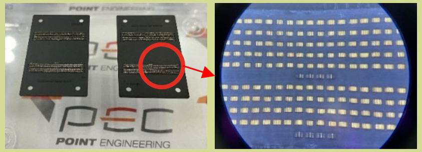
[Diagram of DUT Fixture]

[Insertion / Return loss Measurement Results]

Insertion loss (S21)			Return loss (S11)		
					
Insertion loss	-0.2dB	15 ㎓	Return loss	-15dB	25 ㎓
	-0.4 dB	38 ㎓		-20dB	151㎓

Development & Fabrication case

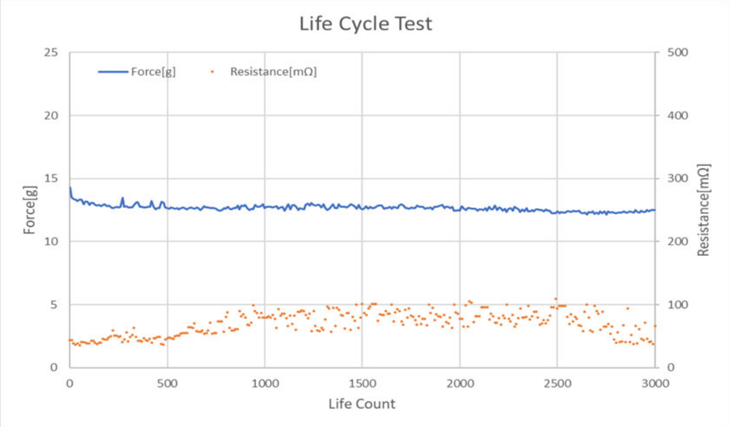
- **Reliability test result of PEC MEMS socket pin**



[MEMS Socket Pin Module for the Test]

[Test Device – SDS2000]

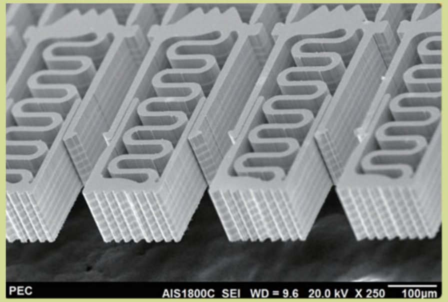
[Diagram of repeatedly contact test]

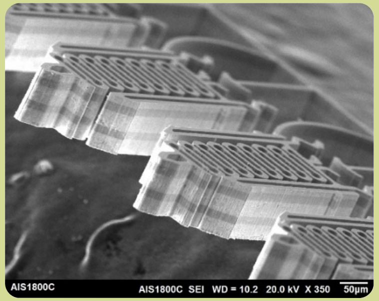


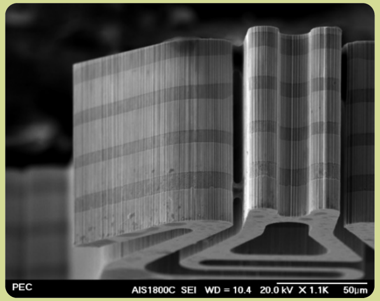
During 3K repeated contact test…

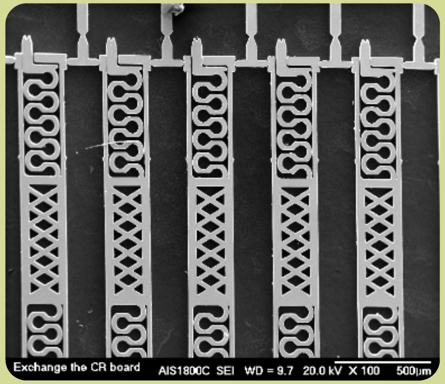
- ≤1% Force drop during 3K touch down test
- ≤100mΩ Contact resistance changes

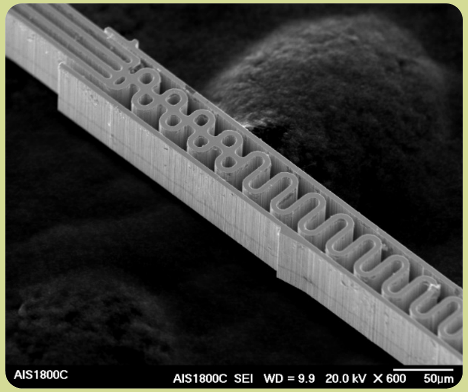
Design flexibility of AAO MEMS Solution











Conclusion

- Customized test pins upon requests as well as churning out MEMS pins for wafer-level testing and socket pins for packaging testing.
- Using distinguished PEC ceramic mold, probes with thickness, short length and fine patterned could be stably fabricated.
- Satisfying emerging packaging technologies' requirements of high density, high frequency, high speed, and stability through our MEMS element technology.

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