New probe tip fabricated by MEMS (LIGA process) for no-cleaning test

Tsuyoshi Haga, K.Okada, J.Yorita, Y.Hirata, S.Shimada*

Harima R&D Department Osaka R&D Laboratories
*Analysis Technology Research Center
Sumitomo Electric Industries, LTD.

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Outline

- MEMS probe background
  Introduction of micro contact-probe fabricated using LIGA process
- Benefits of no-cleaning test
- Analysis of scrubbing motion
- Design of cleaning-free shape
- Sharpening of LIGA probe tip
- Verification of no-cleaning operation
- Conclusions

Background of MEMS probe

<Requirements>

- Fine pitch capability (Down to 50μm or less?)
- Multi test (64DUT → 128DUT → wafer level?)
- High frequency test (at speed testing GHz)
- Low cost testing
- High reliability

→ High accuracy micro spring
Low contact force probe tip

- Limit of conventional machining Accuracy,Shape,etc.
- Increase of conventional machining cost

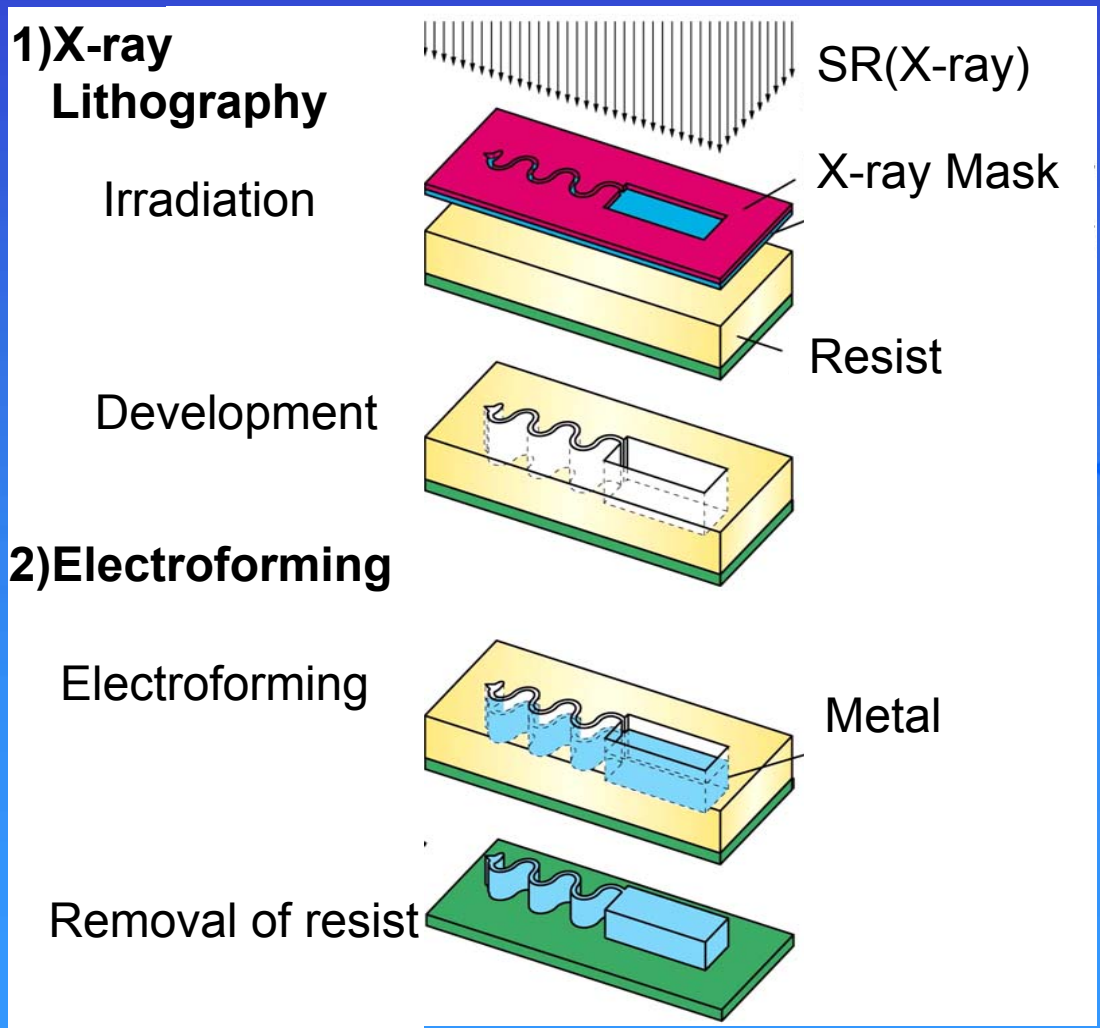
LIGA(MEMS)

- High accuracy,high aspect ratio MEMS technology
- Mass production process based on X-ray lithography

About LIGA process

<Process flow (LIGA)>

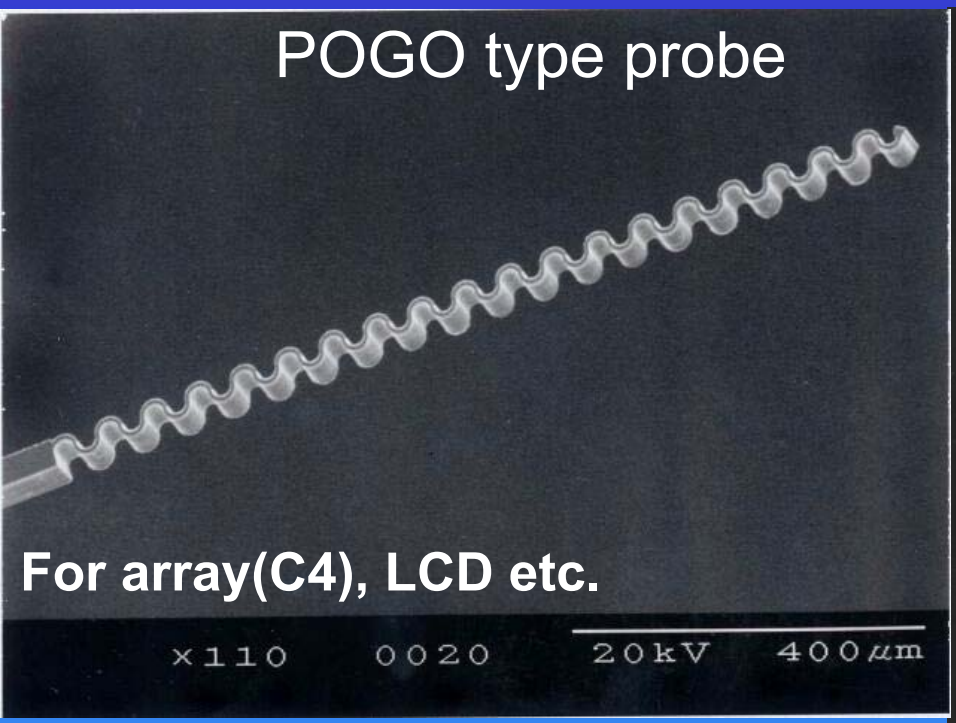
(Lithographie-Galbvanoformung-Abformung)

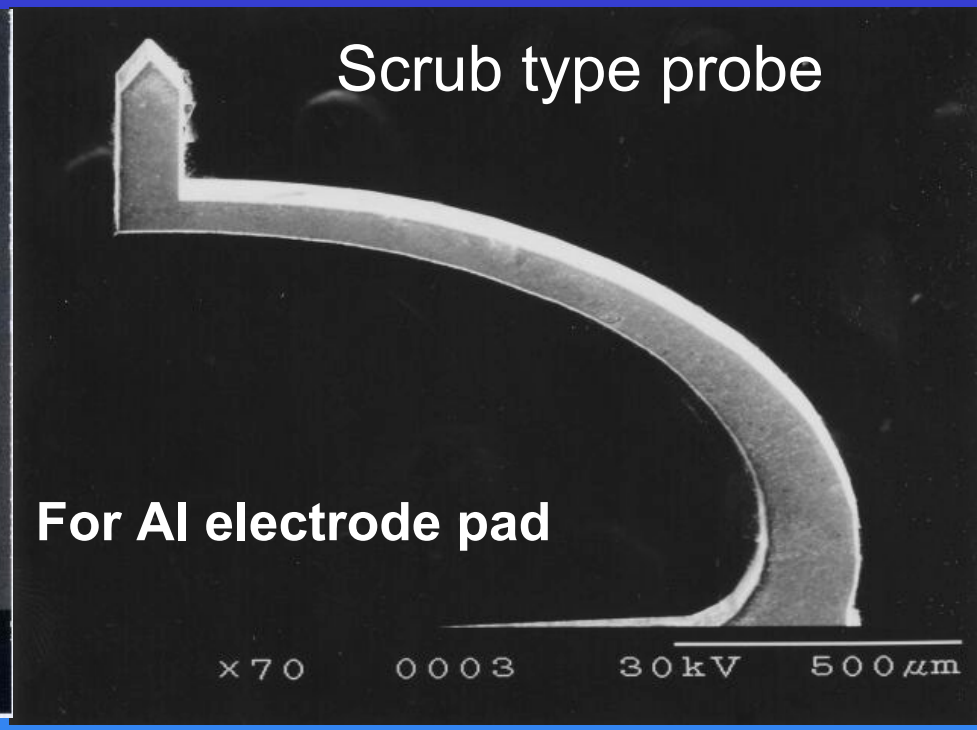


<Advantages>

- High accuracy: ±0.4mm
- Good perpendicularly: 0.1μm/100μm
- High aspect ratio: 10 or more
- High resolution/sharp edge Tip R:< 1μm
- Multi material (metal,plastic,ceramics)
- Mass production process

LIGA probe





New material : Ni-Mn alloy

Controlled grain size & crystal orientation

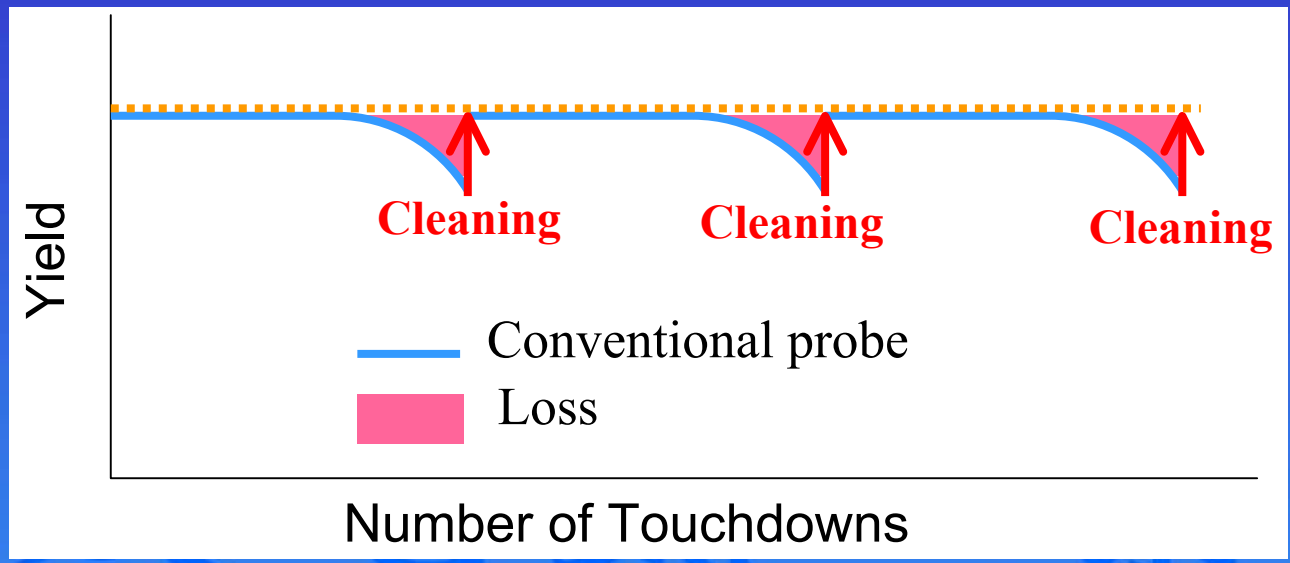
High hardness (HV 600 or more)

High toughness

Good electrical resistivity($1.3 \times 10^{-7} \Omega m$)

Benefits of no-cleaning Test

IC Test Profile



Adhesion and accumulation of debris at the probe tip

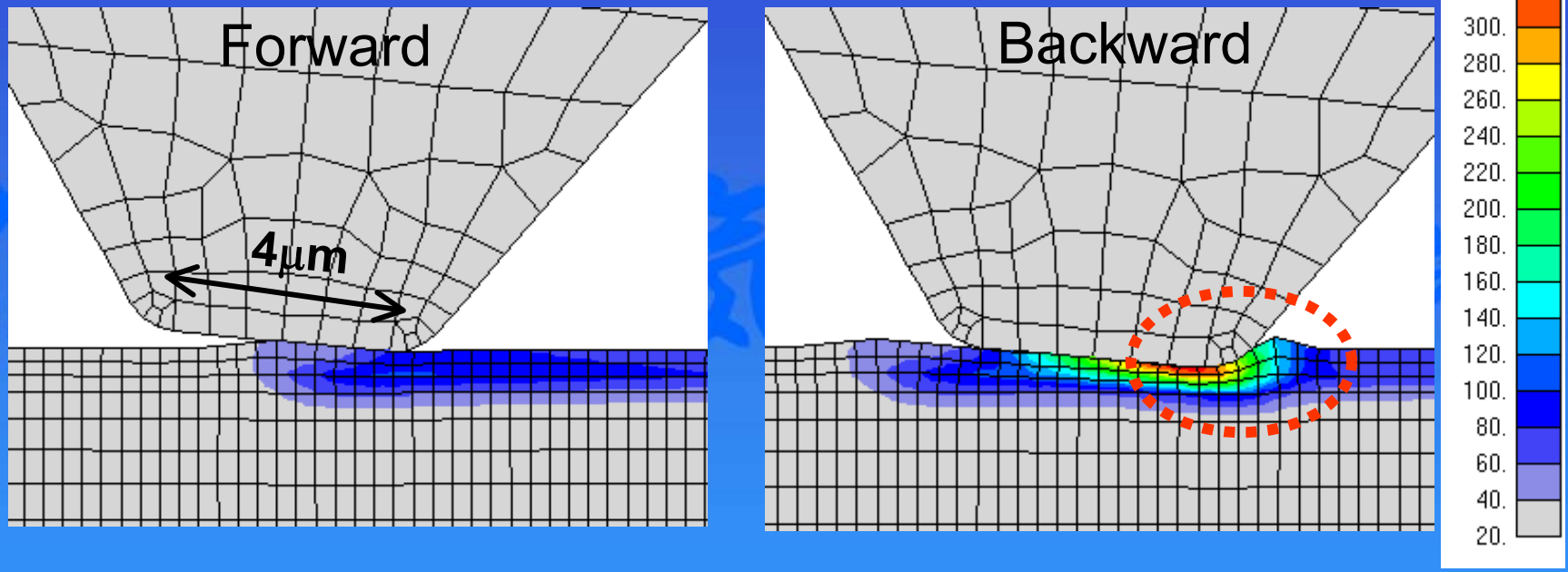
No-cleaning

1) Improve yield & throughput
2) Reduce cost

Simulation of scrub action

Why do adhesion and accumulation of debris occur?

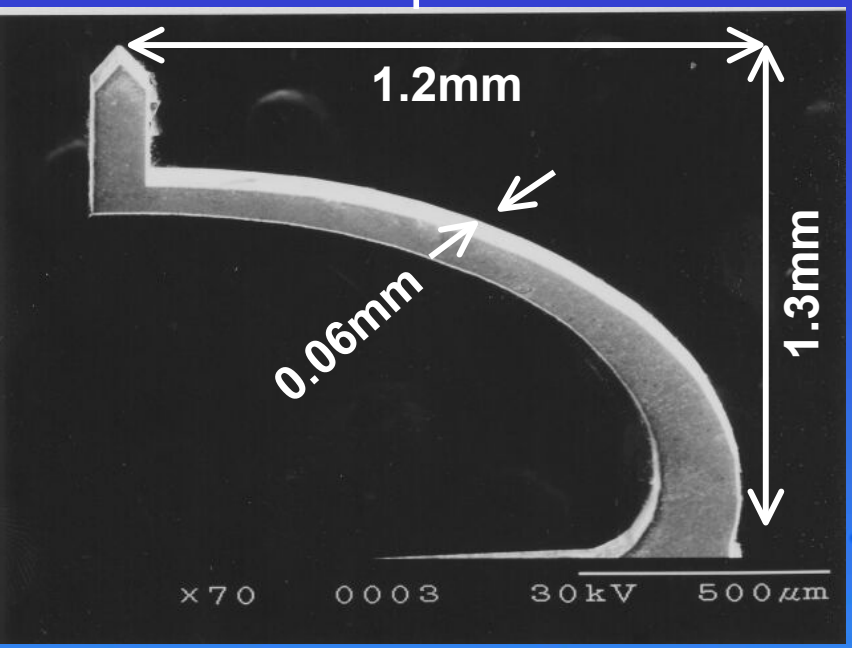
Al contact wiping action of truncated pyramid tip
(Conventional MEMS probe tip fabricated by Si micro machining)



◆Initial adhesion of Al debris occurs at backward scrub action.
→ Al debris increase the debris adhesion at next contact.
Backward scrub action is useless for electrical contact.

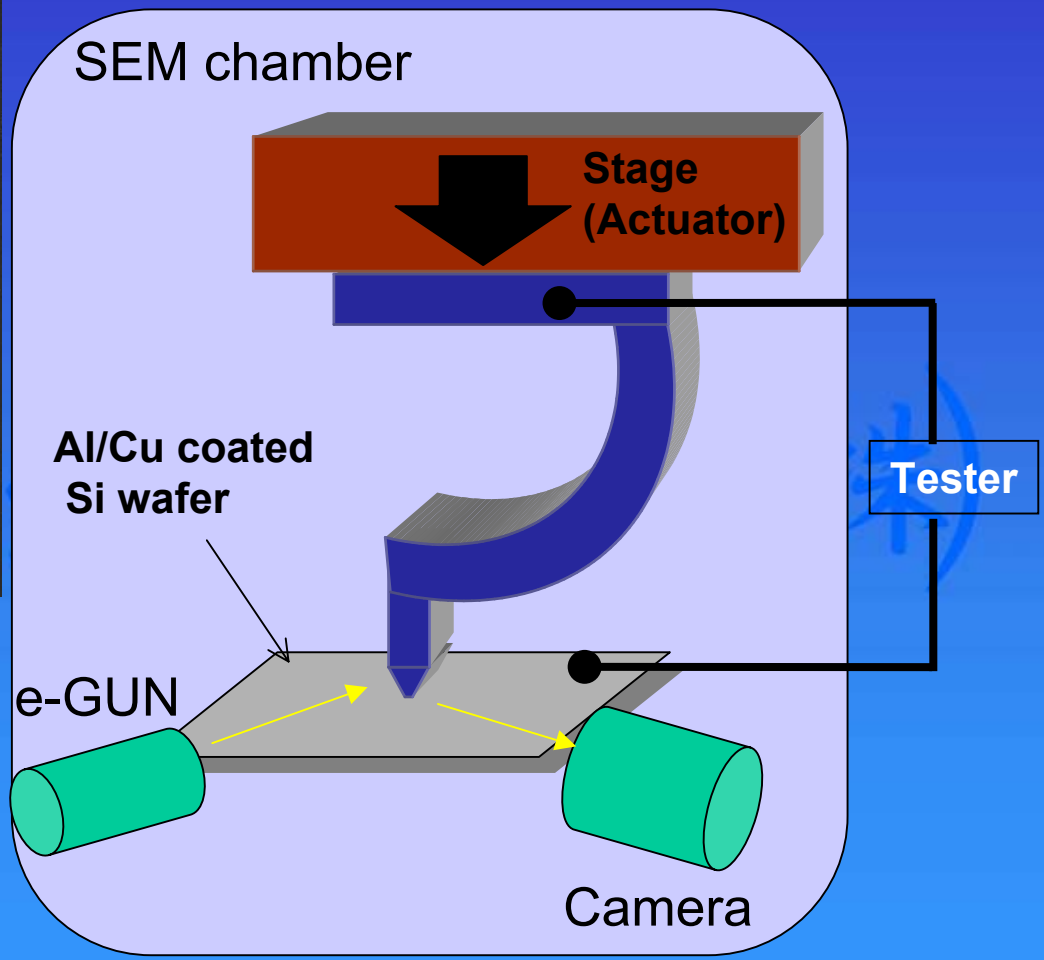
Analysis of scrub motion

LIGA probe

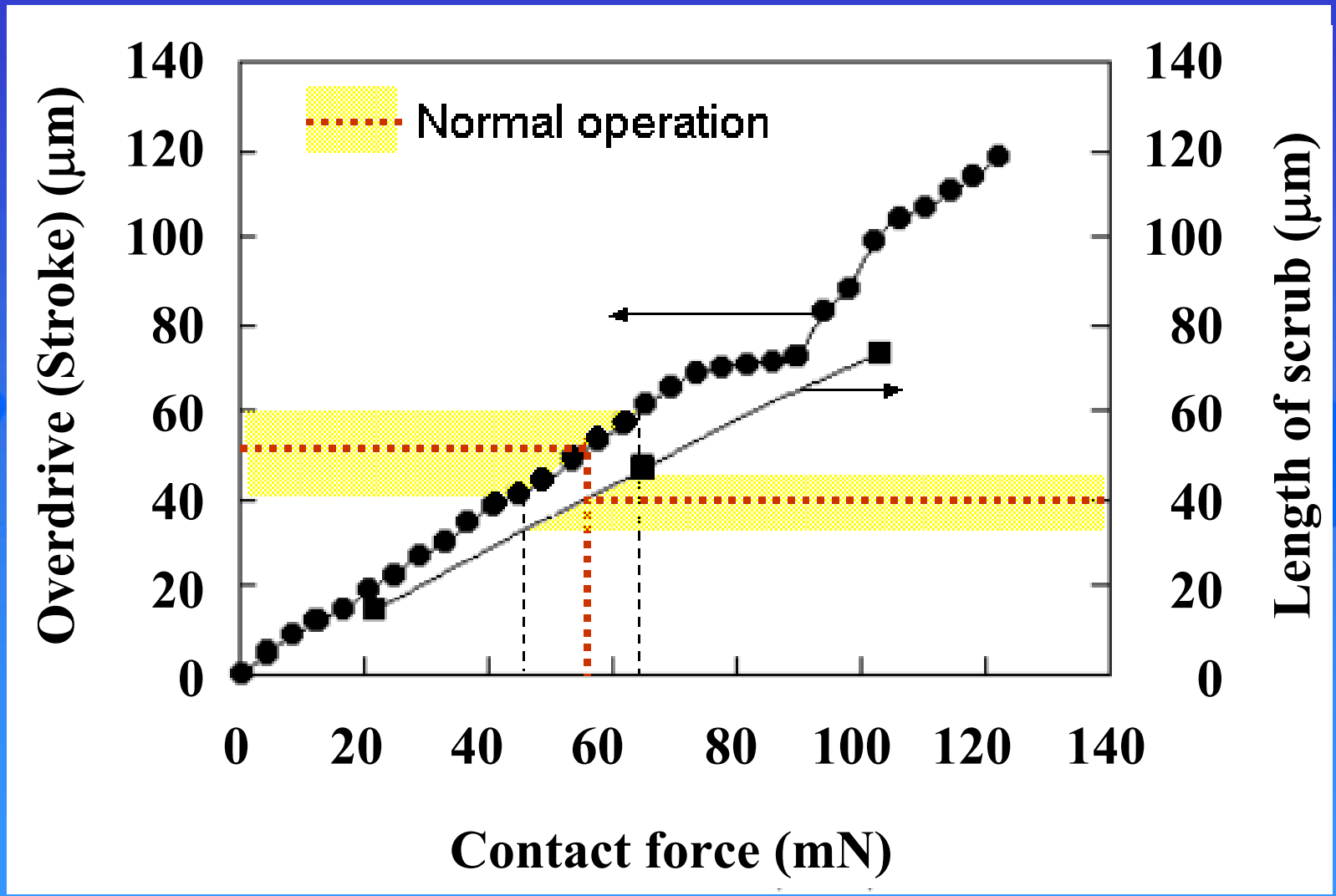


Test condition

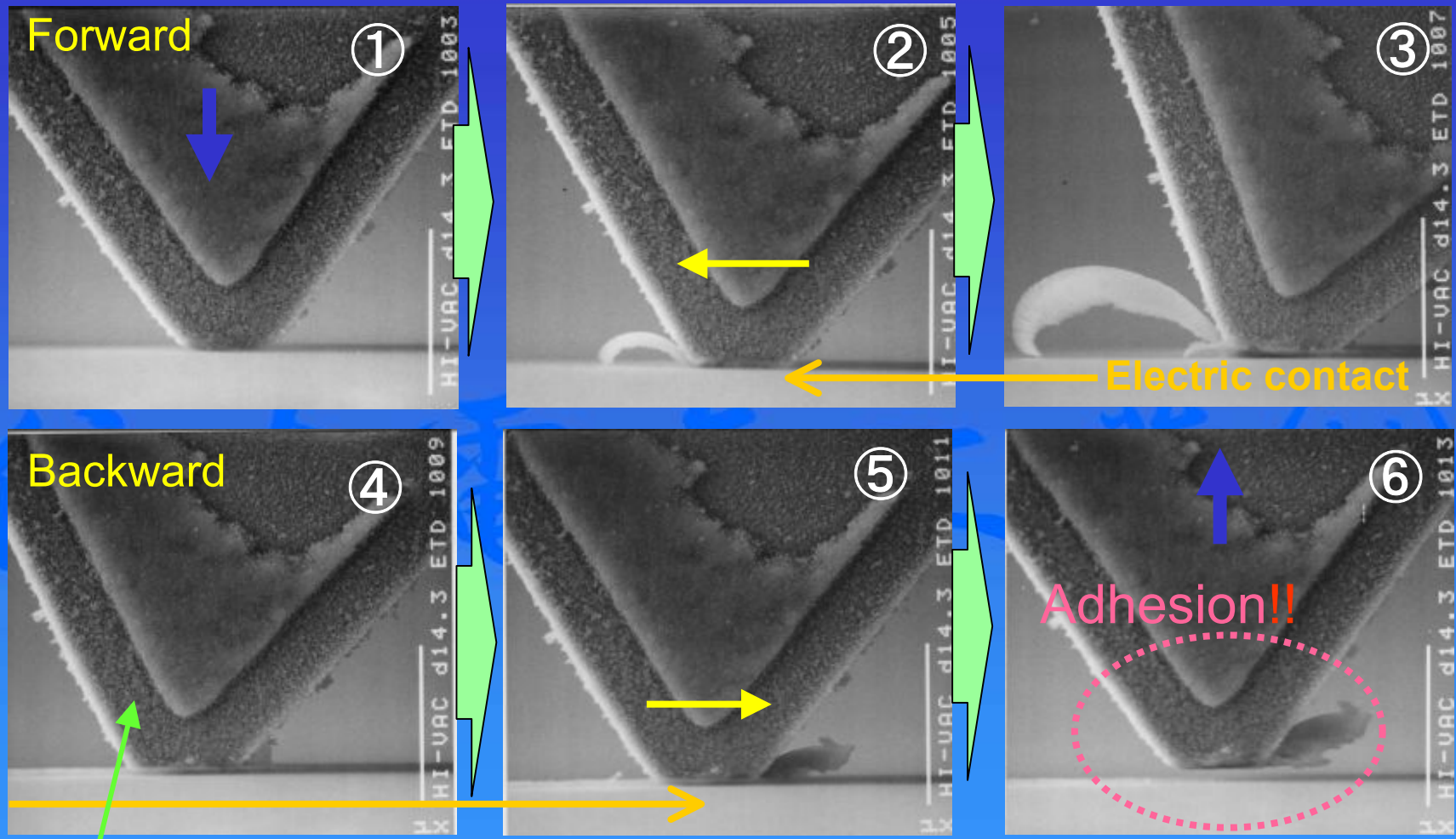
Temp. : R.T.
Pad material : Al-Cu
Substrate : Si



Basic characteristics of LIGA probe



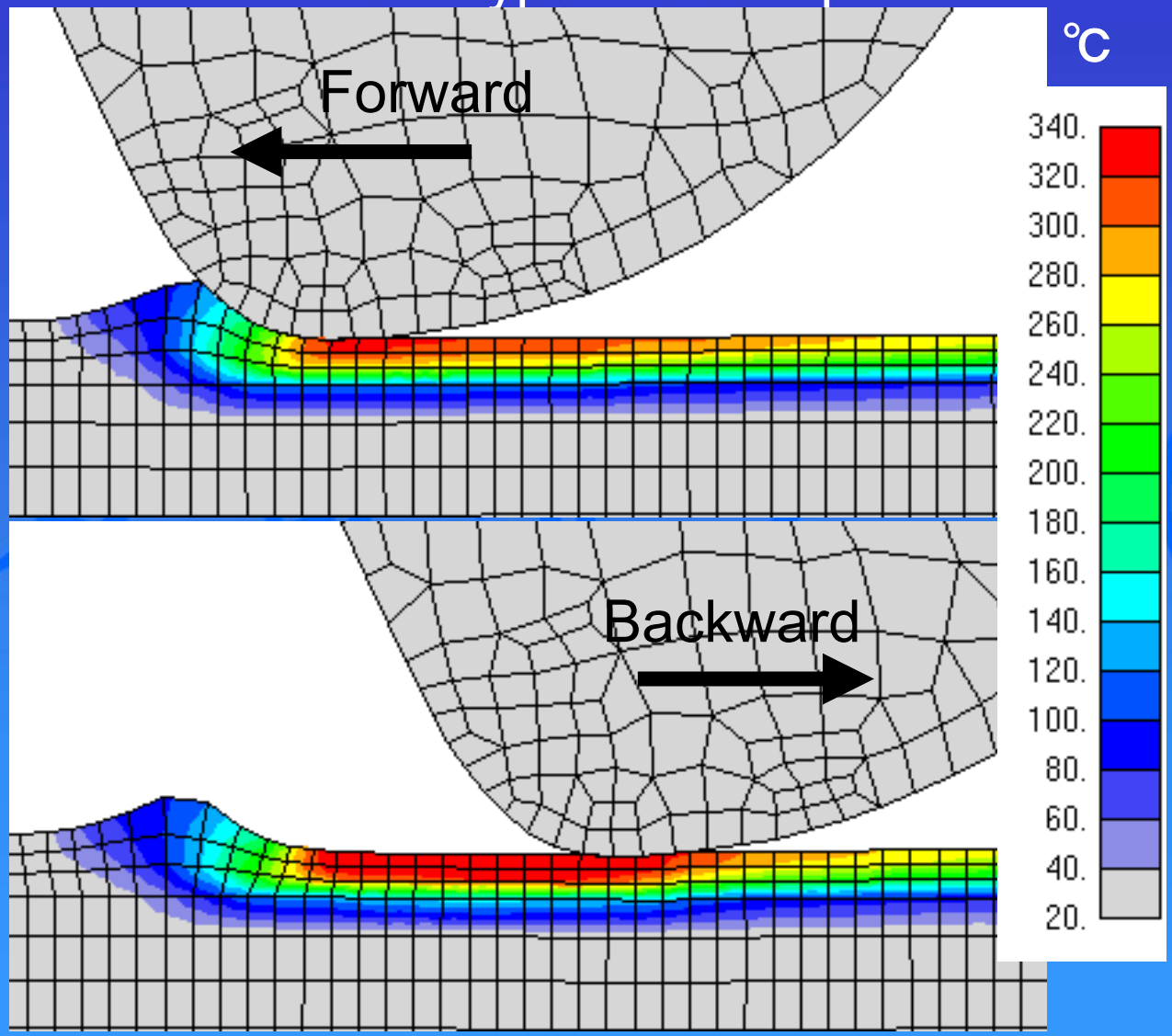
Analysis of scrub action



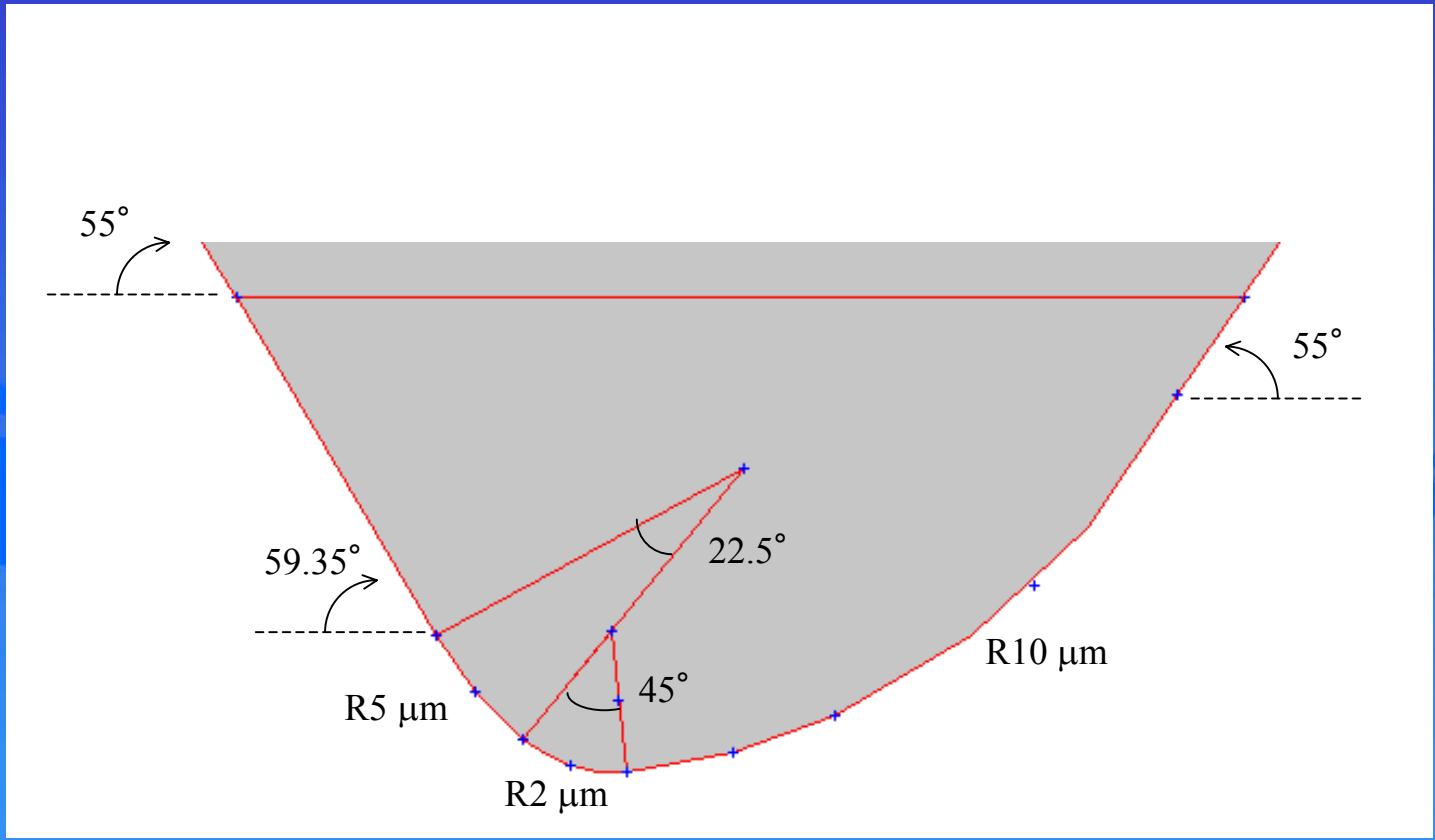
Probe Tip : Pillar-shaped structure imitated truncated pyramid tip

Simulation of no-cleaning shape

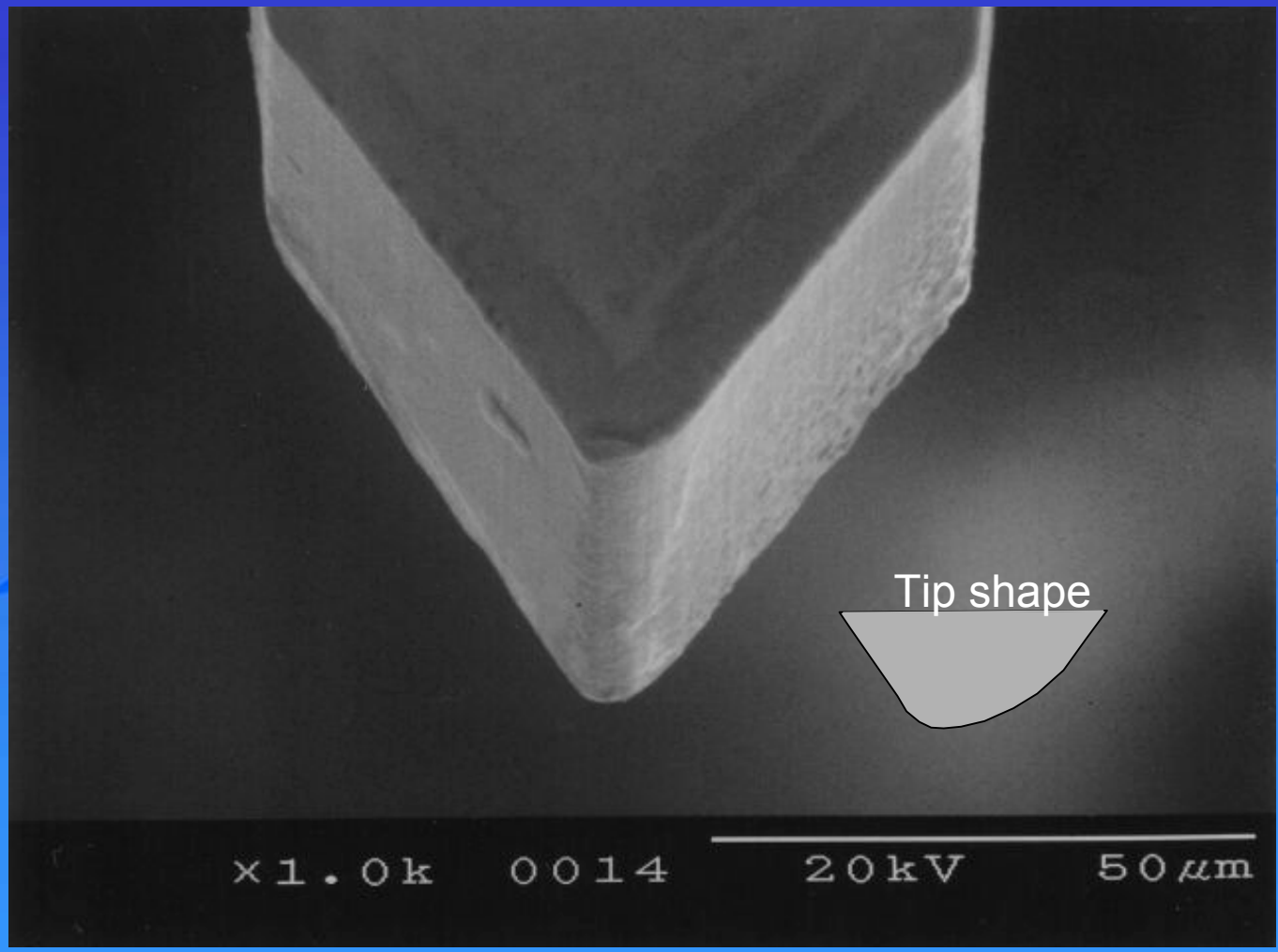
New Type Probe Tip



Design of no-cleaning shape

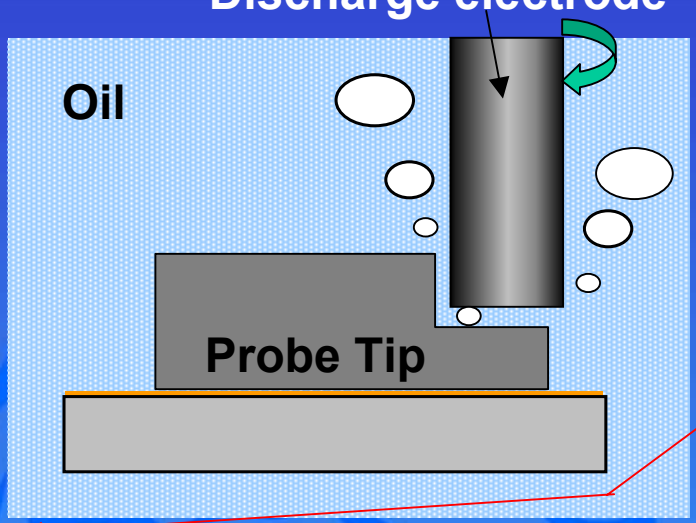


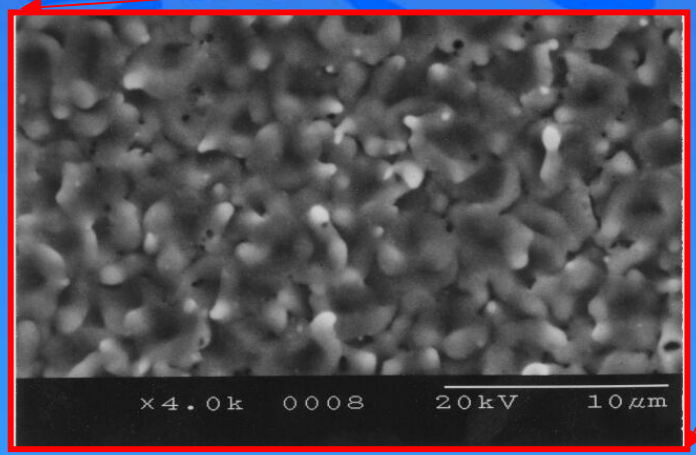
No-cleaning shape Fabricated by LIGA



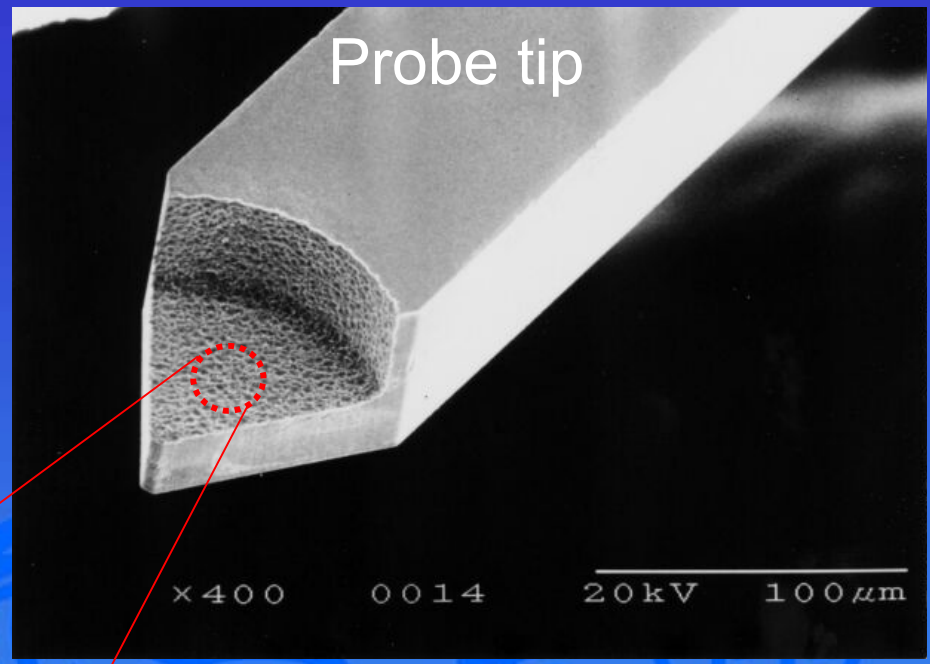
Sharpening of LIGA probe tip

Combination of LIGA and
Micro Electro Discharge Machining

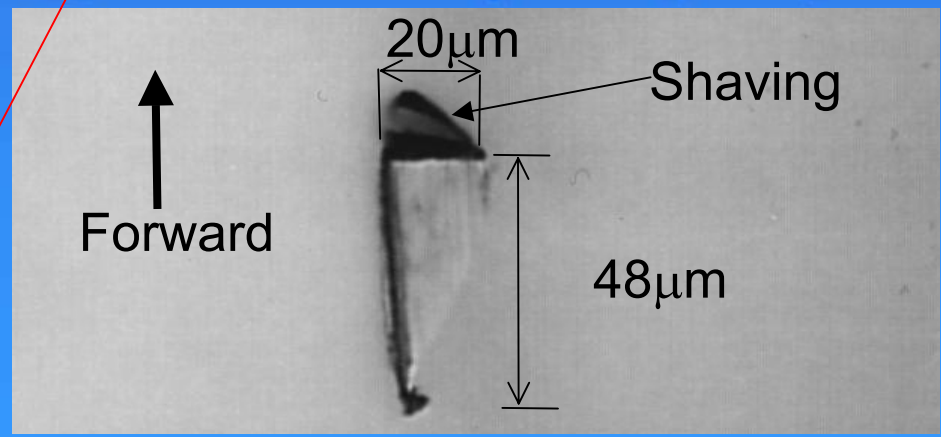




SEM micrograph of discharge scar



Scrub Mark



EDMed surface profile

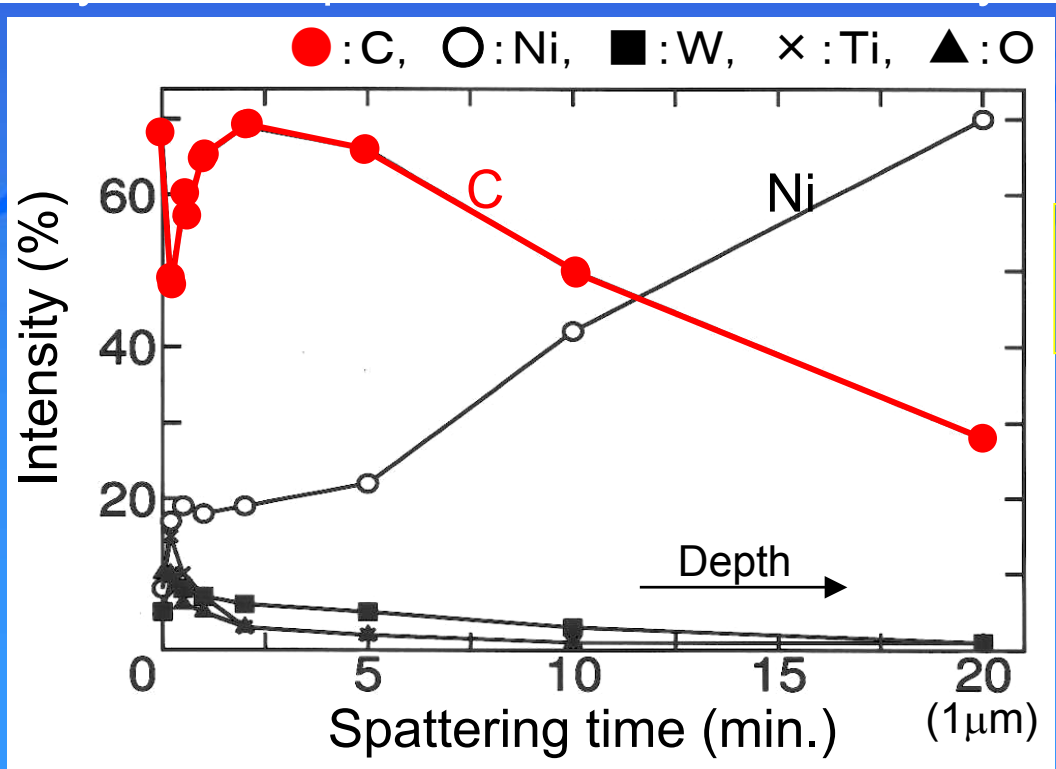
Hardness variation of the EDMed surfaces

(Discharge Voltage)	Before machining	After machining (110V)	After machining (60V)
Hardness(HV)	616±20	540±68	672±96

Annealing

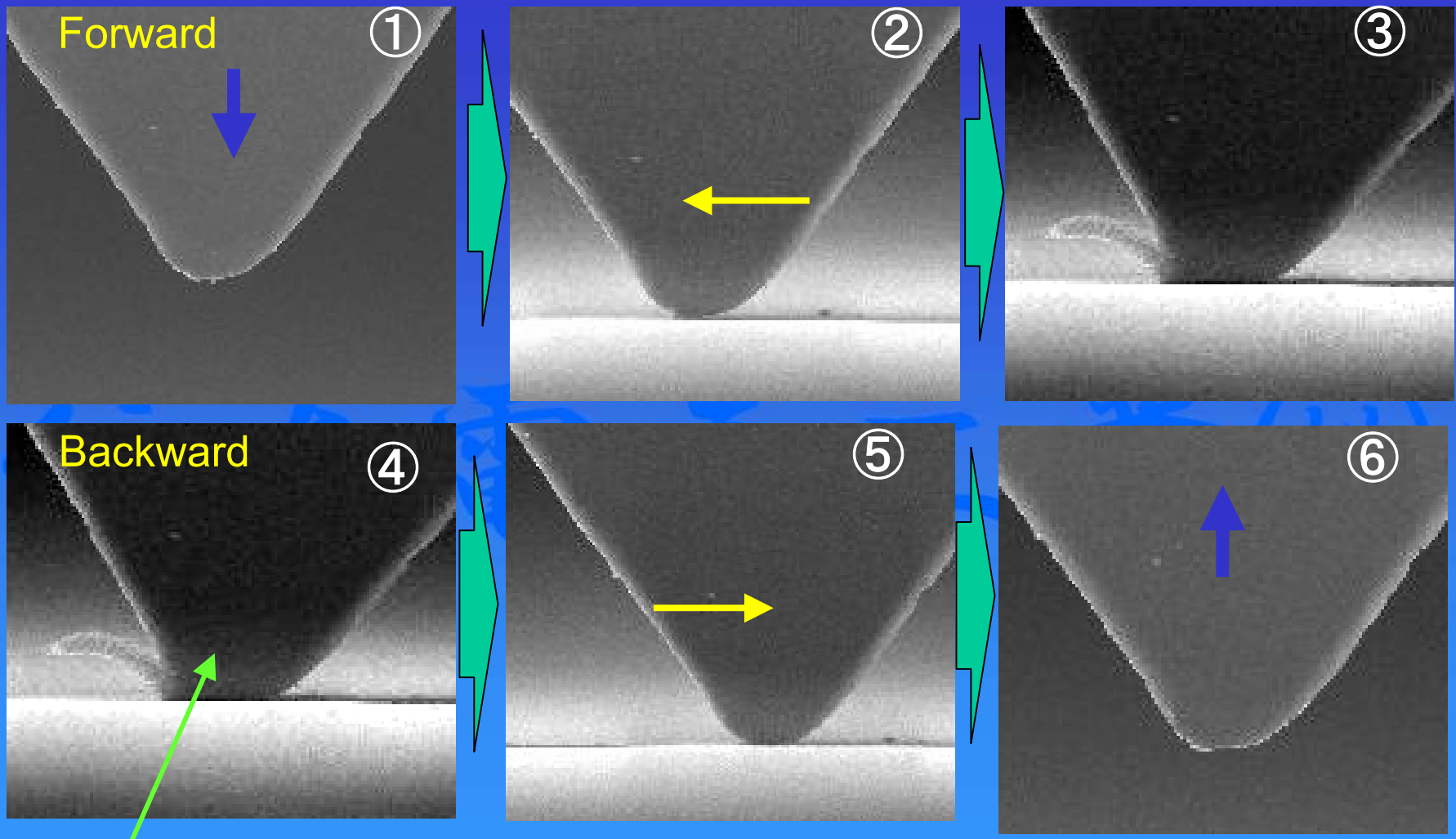
Carburizing

Element density in the depth direction of the recast layer (the recast layer)



Discharge voltage
60V

Verification of no-cleaning operation



Verification of no-cleaning operation

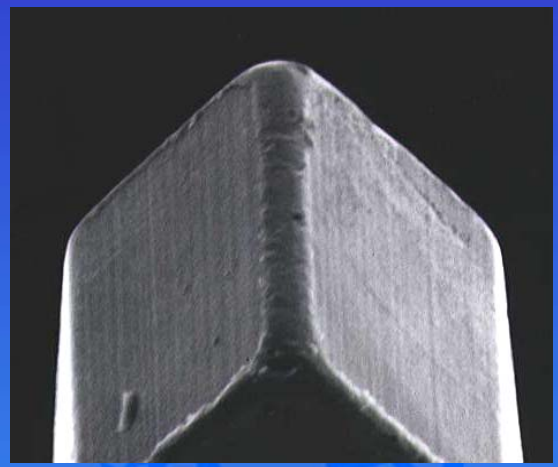
Before touchdown

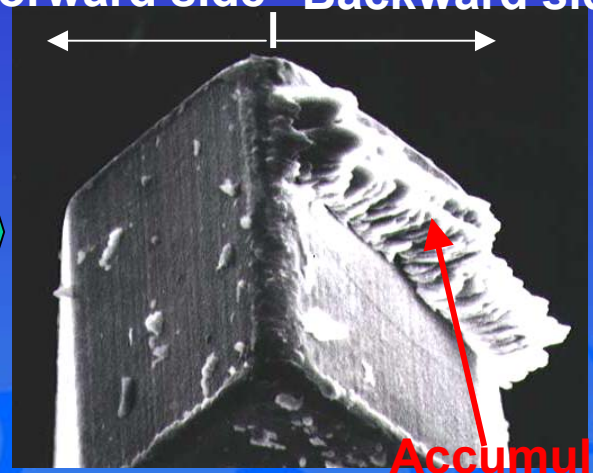
After 10,000 touchdowns

Forward side

Backward side

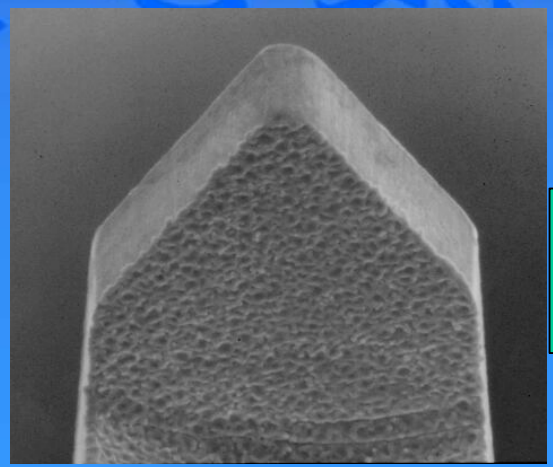
Conventional (trapezoidal) tip

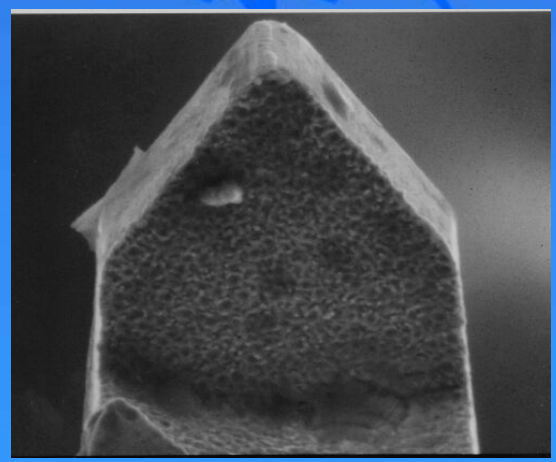




Accumulated aluminum

Newly designed (no-cleaning) tip sharpened by μ-EDM





Conclusions

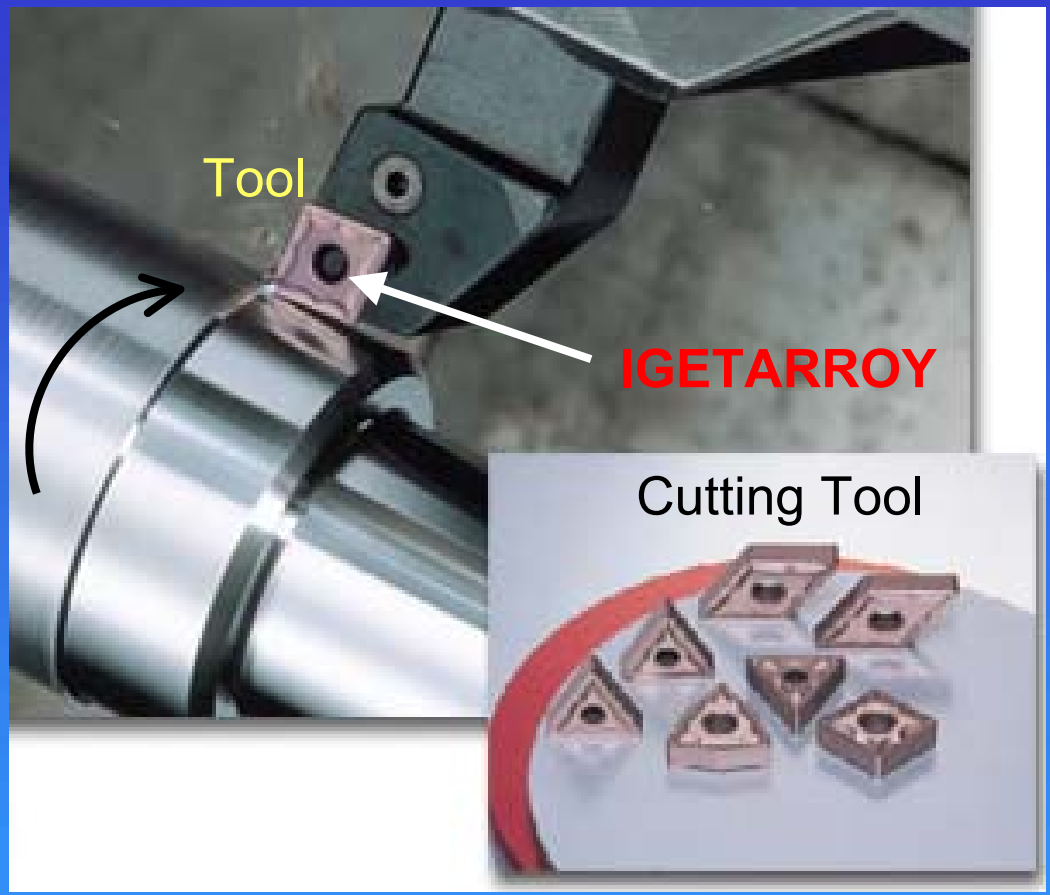
- Micro contact probe fabricated by LIGA process (MEMS).
- Probe tip sharpening using the LIGA and μ-EDM combination.
- New probe tip shape for cleaning free test.
- To realize cleaning-free test:

  Aluminum debris generation phenomena were analyzed by dynamic SEM.

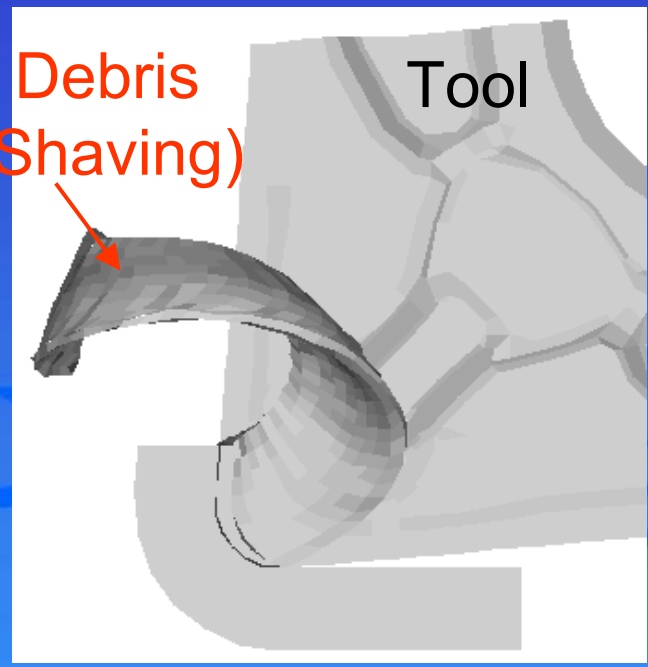
  The scrub simulation technology by applying cutting simulation technology was developed.

Spare

Cutting tool simulation technology



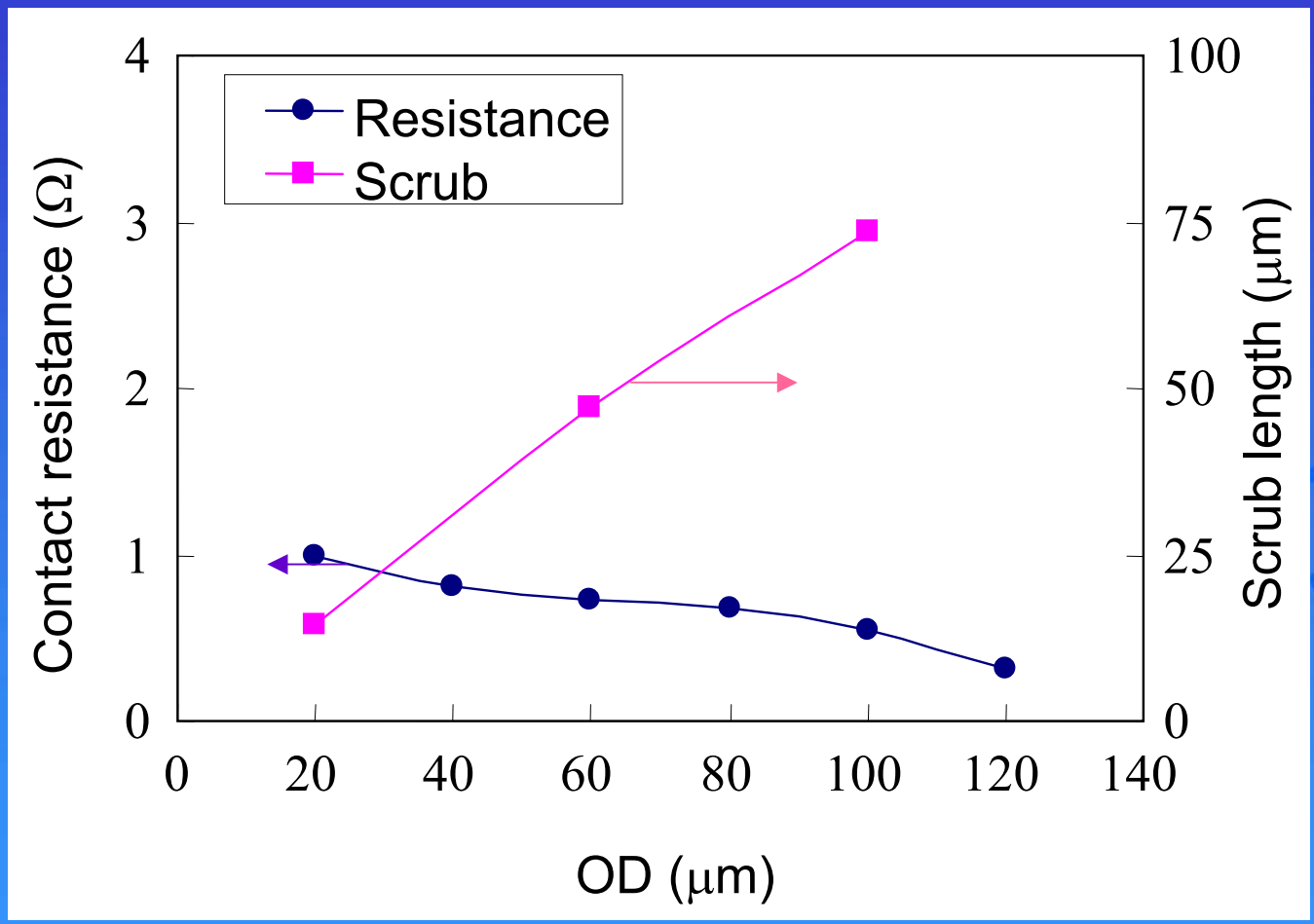
3D Machining simulation



For cutting tool shape design & cutting condition analysis

Scrub simulation

Basic characteristics of LIGA probe



Test Condition

Temp. : R.T.

Pad : Al-Cu

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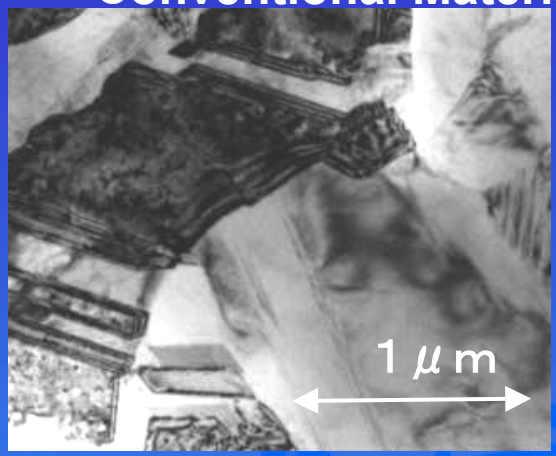
Ni Grain Size Control

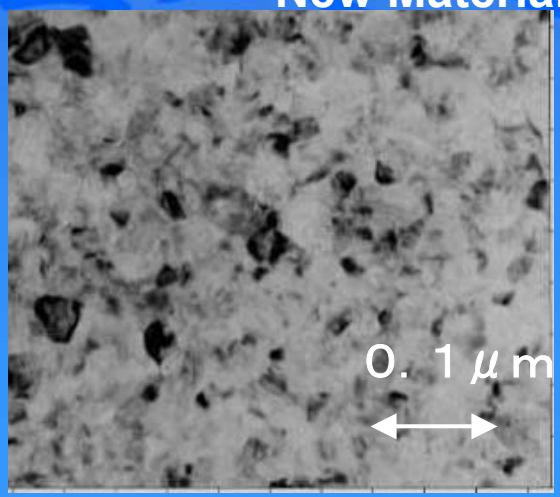
Grain TEM photograph

Conventional Material



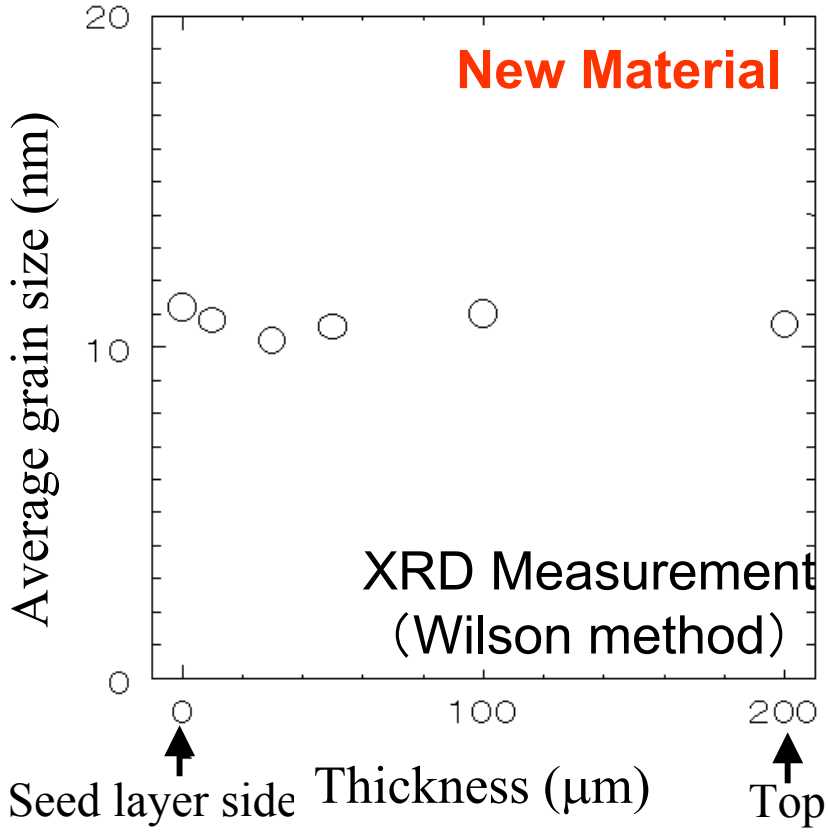
Hardness:Hv400-500

New Material



Hardness:Hv620

Grain size uniformity along thickness



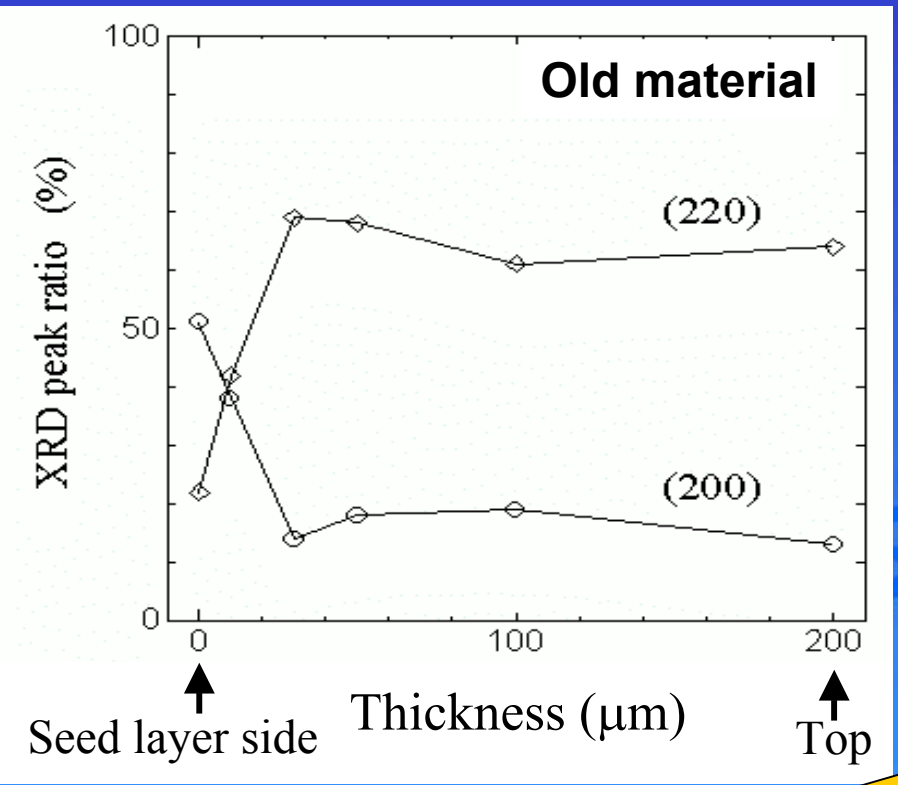
Miniaturization of grain size

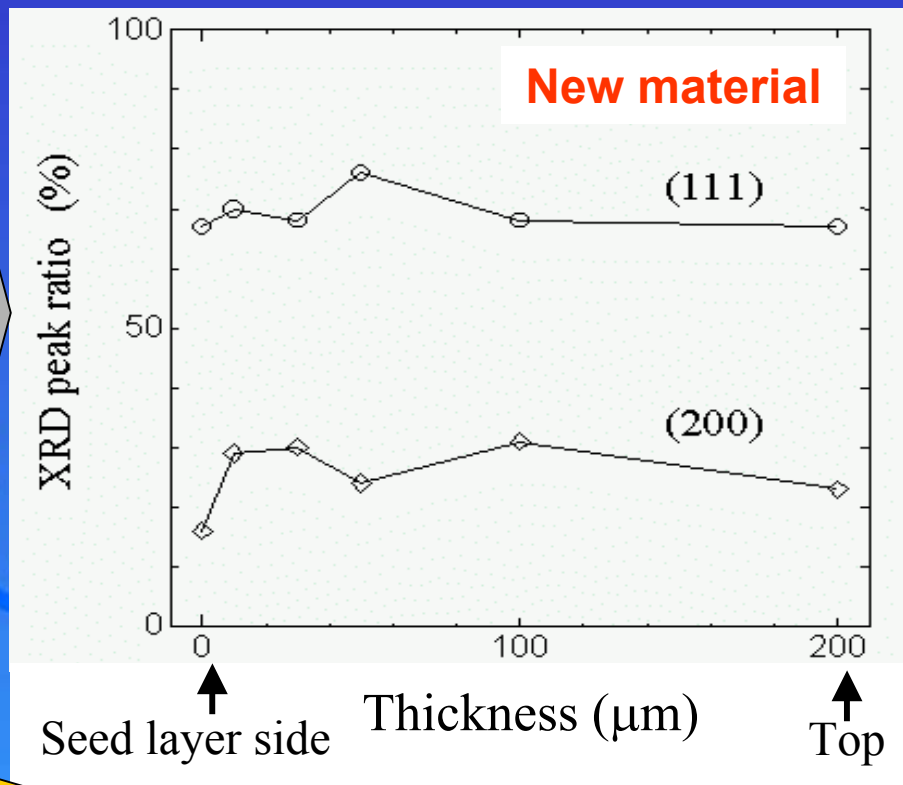
→ High hardness: up to Hv600

Good uniformity

Crystal orientation control

Crystal orientation distribution





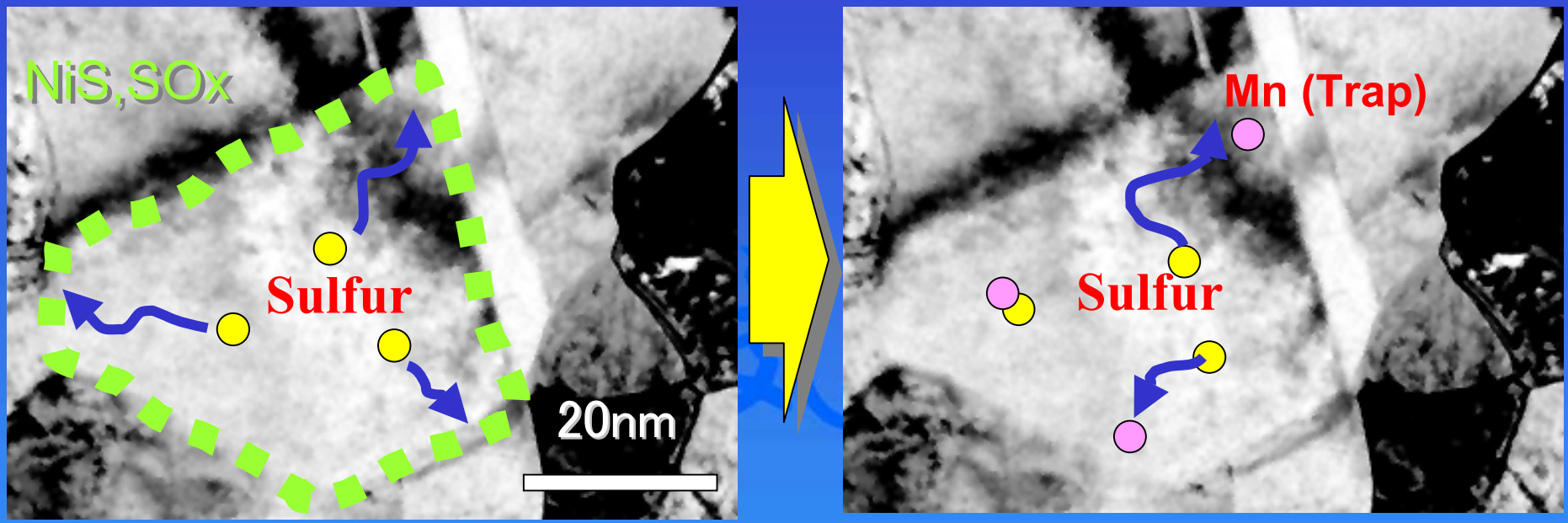
Control of the seed layer
Fitting current condition and additive agent

Good uniformity of grain size and crystal orientation along thickness

Alloy design

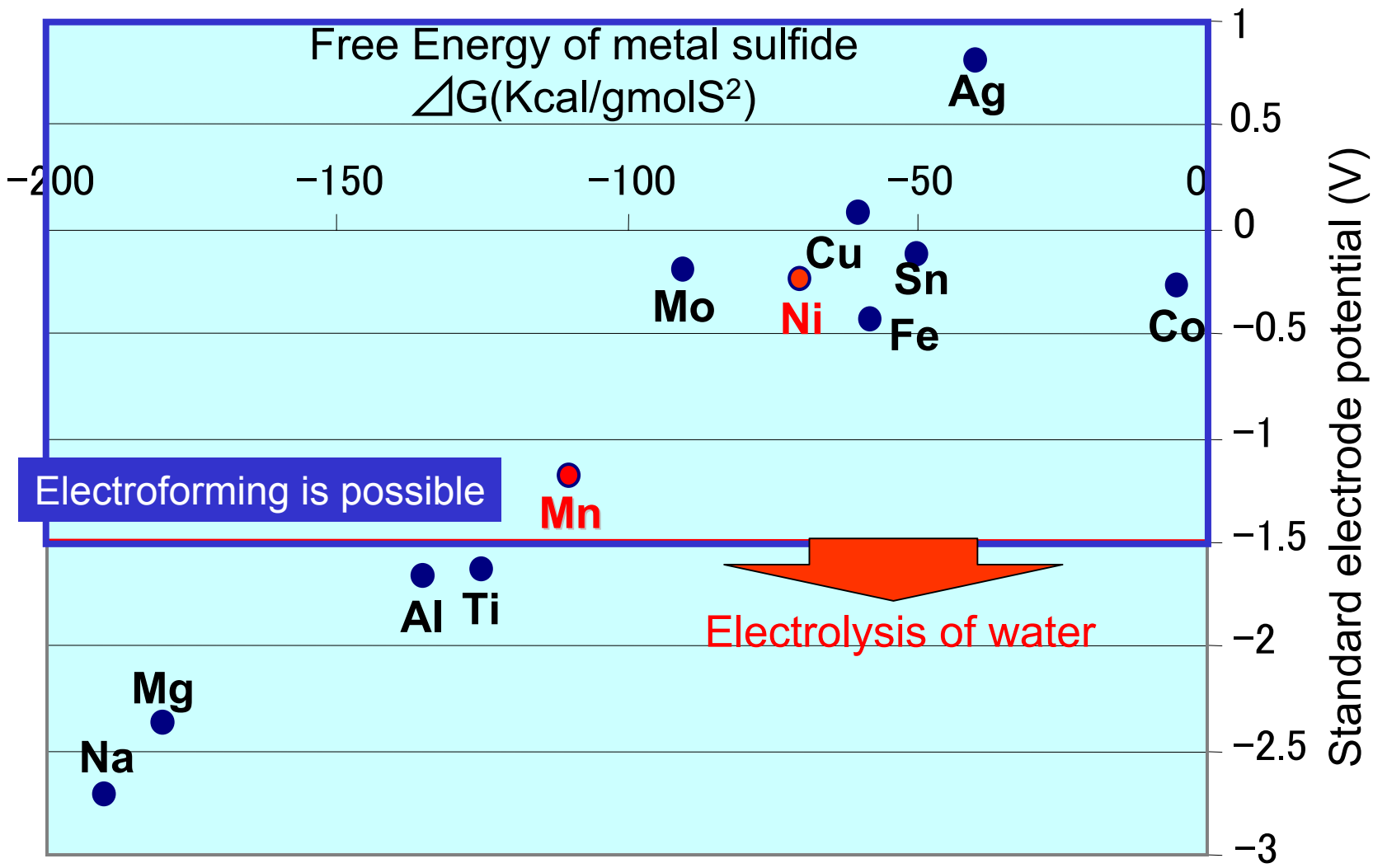
High heat resistance Ni alloy

Suppress NiS,SOx generation



Ni + S → NiS (Very brittle)
S + O2 → SOx (brittle)

Mn + S → MnS


Free Energy of metal sulfide
⊿G(Kcal/gmolS²)
−200
−150
−100
−50
0
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
Standard electrode potential (V)
Ag
Cu
Sn
Mo
Ni
Fe
Co
Electroforming is possible
Mn
Al
Ti
Electrolysis of water
Mg
Na