Mechanical Properties of Gold Electroplating Material for MEMS Device by Micro-Compression Test

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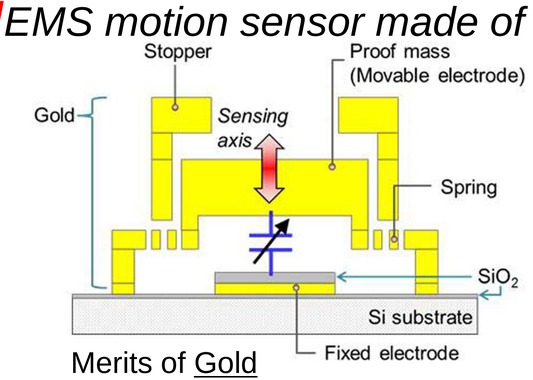
Introduction

MEMS motion sensor made of **gold**



Merits of Gold

・High chemical stability, corrosion resistance and electrical conductivity

→ideal to be used as components of electronic devices

・High density (19.30 g/cm^3)

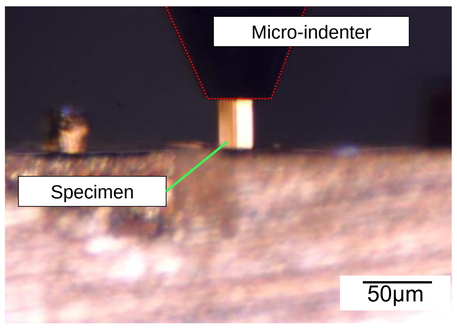
→further miniaturization (suppress the Brownian noise) of the devices with high sensitivity

Manufacturing and evaluation of MEMS

Electrodeposition

- Near-room-temperature operating temperature
- Low cost
- Rapid deposition rates
- Capability to handle complex geometries

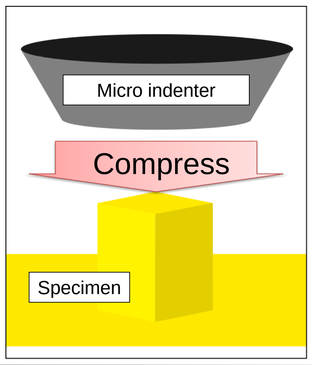
→Highly applicable to MEMS !



Micro-compression tests

- Reliability of the micro-components
- Mechanical properties in micro-scale are different from these of bulk materials due to size effect

→Important for MEMS !

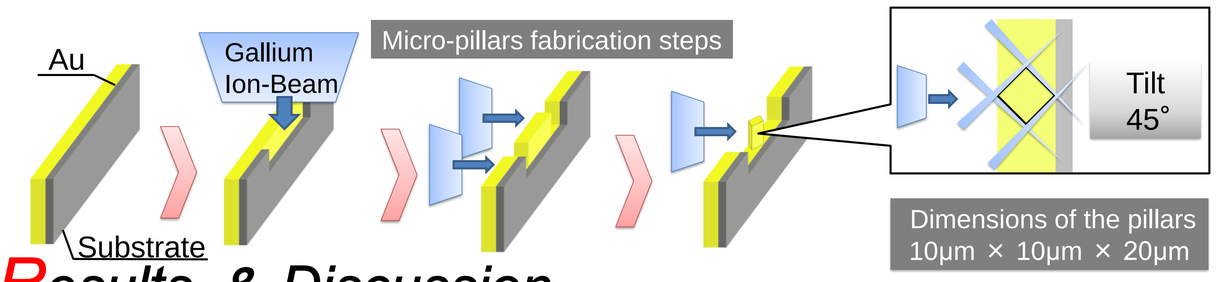


Experimental Procedures

Fabrication methods

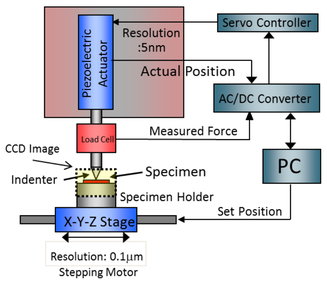
Electrodeposition conditions

Name	Current Pattern	Pulse Peak Current I_p/mAcm^{-2}	Pulse Peak Current I_0/mAcm^{-2}	Average Current I_A/mAcm^{-2}	Pulse ON-Time /ms	Pulse OFF-Time /ms	Reaction Time /min	Base of Electrolyte
CE-Cy	Constant	—	—	4	—	—	—	Cyanide
CE-S	Constant	—	—	5	—	—	100	Sulfite
PE	Pulse	10	0	5	10	10	100	Sulfite



Testing conditions

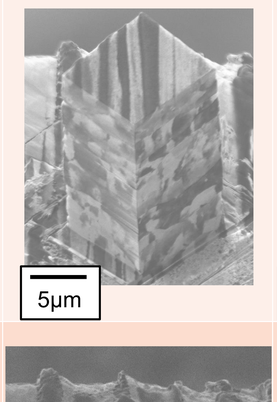
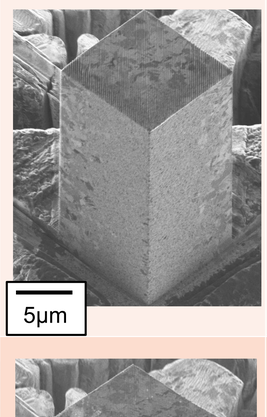
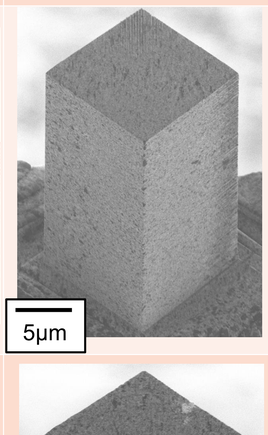
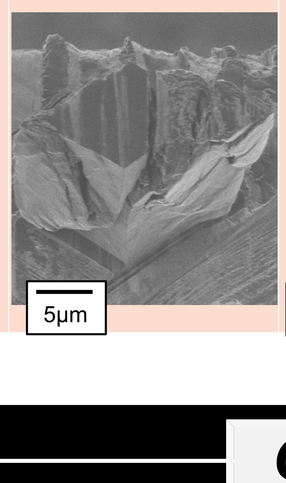
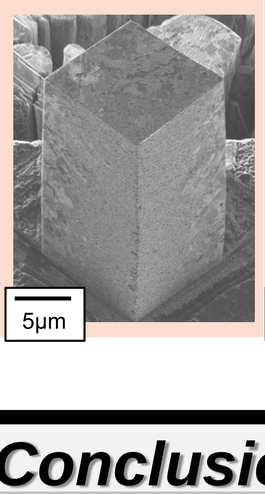
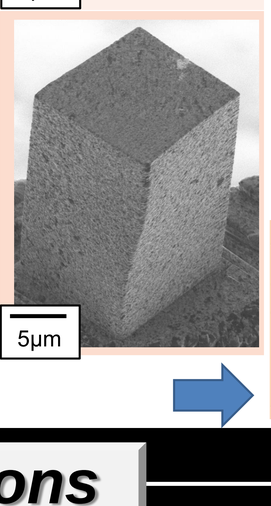
Test machine



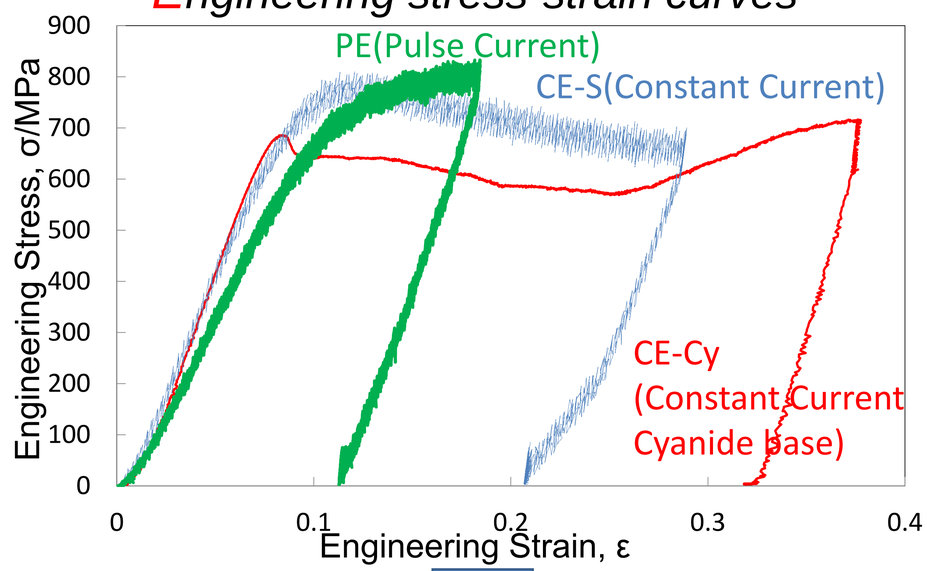
Control	Displacement rate	Load resolution
Displacement control	0.1 [μm/s]	10 [μN]

Results & Discussion

Grain sizes & SIM images of the micro-pillars

	CE-Cy	CE-S	PE
Grain size/nm	22.8	17.5	10.4
SIM images before compression			
SIM images after compression			

Engineering stress-strain curves



All Au micro-pillars showed higher yield strength, more than 600MPa, than bulk Au (100～150MPa)

→Grain refinement strengthening

All grain sizes (measured by XRD pattern and Scherrer equation) of the specimens were nm order(PE>CE-S>CE-Cy), while large grains were observed

→Texture?

Also, brittle fracture was observed in the pillar of CE-Cy

Conclusions

- All Au films in this study have nm order of grain sizes.
- Brittle fracture was observed in the Au micro-pillar of CE-Cy.
- All Au micro-pillars showed higher yield strength, more than 600MPa, than bulk Au (100～150MPa) due to Grain refinement strengthening .

Acknowledgement

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