Sample Geometry Effect on Mechanical Property of Electrodeposited Gold Evaluated by Micro-Bending Test

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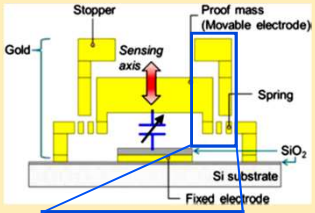
Background

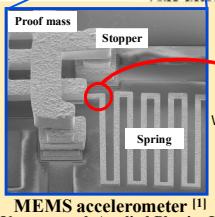
Gold-based MEMS accelerometers



Merits

High mass density of gold reduce Brownian noise

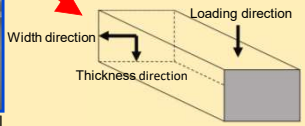
➡ Higher sensitivity
Further size reduction



MEMS accelerometer [1]

Bending deformation

There is dimensional anisotropy

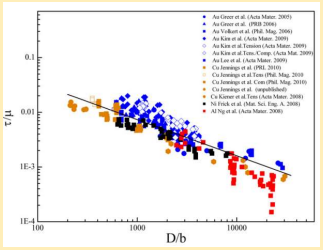


[1] D. Yamane et al. Applied Physics Letters, 104, 074102 (2014)

Sample size effect

Micrometers order metallic materials have different mechanical properties from that of bulk materials

e.g. Yield stress increases with size reduction[2]



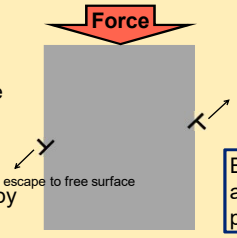
[2] J.R. Greer et al., *Prog. Mater. Sci.*, 56 (2011) 654

Dislocation starvation model

sample size is small

Dislocations escape to free surface before being pinned by other dislocations and multiplaying

Plasticity become accommodated by the nucleation of new dislocations



Micro bending test

Deformation behavior of the movable components of MEMS can be closely simulated

Size effect when there is dimensional anisotropy?

Purpose

Examine influences of the thickness and width on the mechanical property by micro-bending tests.

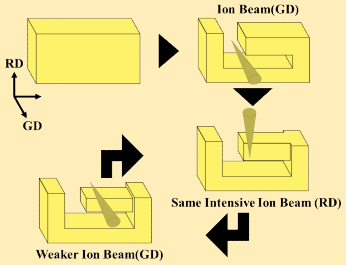
Experimental

Electroplating of gold

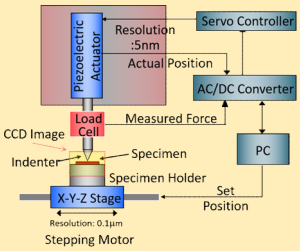
Electrolyte	Sulfite-based (10 g/L of gold)
Cathode	9M HCl treated titanium plate
Anode	Platinum plate
Current density	5 mA/cm^2
Time	80 min

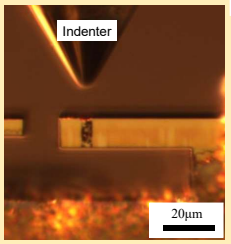
Average grain size measured by EBSD : 1.1~1.3μm

FIB (Focus Ion Beam)



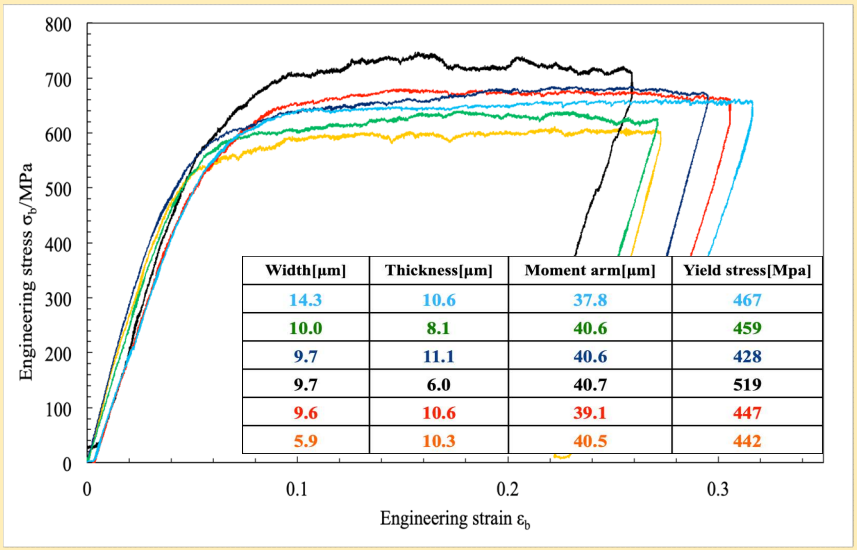
Micro-mechanical test



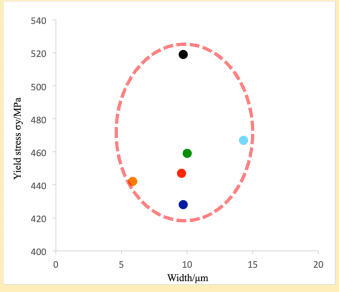


Results and Discussion

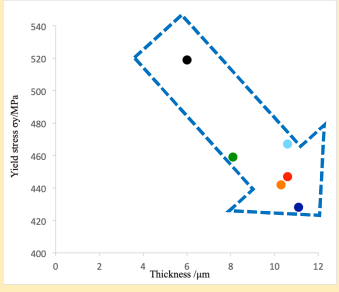
Stress-strain curve for the bending test



Width[μm]	Thickness[μm]	Moment arm[μm]	Yield stress[Mpa]
14.3	10.6	37.8	467
10.0	8.1	40.6	459
9.7	11.1	40.6	428
9.7	6.0	40.7	519
9.6	10.6	39.1	447
5.9	10.3	40.5	442



sample width vs. yield stress



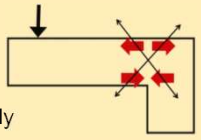
sample thickness vs. yield stress

・Yield stresses of the micro-cantilevers increased with the decrease in thickness (parallel to loading direction)

・There was no relationship between width (perpendicular to loading direction) and yield stress

Dislocations move in the thickness direction

thickness ↓ ➡ dislocation escape easily



Conclusion

・Micro bending test was conducted on electroplated gold cantilever with different width and thickness.

・The size effect appeared in the thickness direction, which is parallel to the loading direction, and did not appear in the width direction, which is perpendicular to loading direction.

Acknowledgement

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