Structure Stability Enhancement of Gold Micro-Cantilever with Top and Bottom Constrains at the Fixed-End for Applications as Movable Structures in MEMS

Minami Teranishi[1,2], Chun-Yi Chen[1,2,*], Tso-Fu Mark Chang[1,2], Hiroshi Toshiyoshi[3], Daisuke Yamane[1,2], Katsuyuki Machida[1,2], Kazuya Masu[1,2], and Masato Sone[1,2]

[1]Institute of Innovative Research Tokyo Institute of Technology, Yokohama 226-8503, Japan
[2]CREST, Japan Science and Technology Agency, Yokohama 226-8503, Japan
[3]The University of Tokyo, Tokyo 153-8904, Japan

Introduction

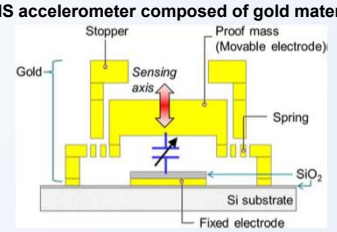
Gold Materials

High electrical conductivity, chemical stability, corrosion resistance.

⇒ **High DENSITY** 19.3 × 10³ [kg/m³]

MEMS Device

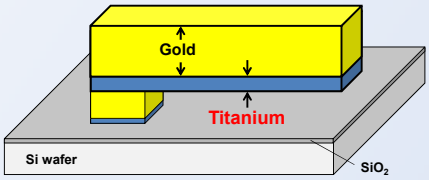
Sub-1G MEMS accelerometer composed of gold materials [1]

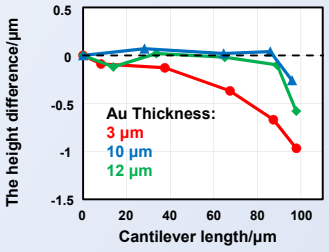


Structure stability of gold-based components?

	Strength	Young's modulus
Si	1-3 GPa (fracture)	130-188 GPa
Au	55~200 MPa (yield)	70 GPa
Ti	480 MPa (yield)	111.5 GPa

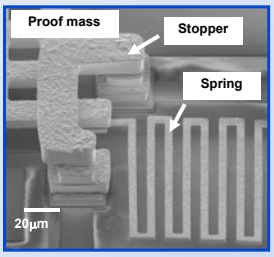
Ti/Au-Layered Structure





The structure stability is improved by the Ti/Au-layered design [2]

Constrained Fixed End



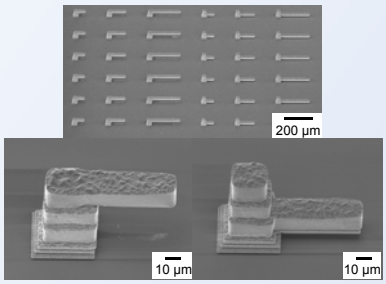
Fixed end of the micro-component is sandwiched between structures, and the effect on structure stability ???

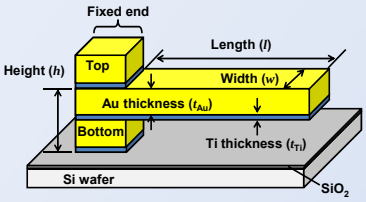
Objective

Evaluate effect of the constraint condition at the fixed end on structure stability of the Ti/Au-layered micro-cantilever.

Experimental

Schematic of the Ti/Au Cantilever





t_{Au}	15 μm
t_{Ti}	0.1 μm
w	15 μm
l	50 ~ 200 μm

Structure Stability Evaluation

- 3D optical microscope (OM)
- FEM simulation (COMSOL Multiphysics software)
- The structure stability was quantified by the following equations

Height difference: $\Delta h_x = h_x - h_0$

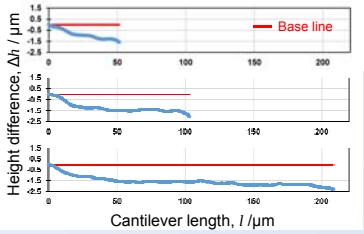
Average deformation: $\Delta h_{\mathrm{ave},l} = \dfrac{\sum_{x=1}^{l/d}(\Delta h_x \times d)}{l}$

where l is total length of the micro-cantilever. d is step size of the measurement

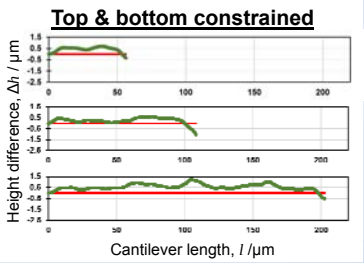
Results and Discussion

OM Observation

Bottom constrained only



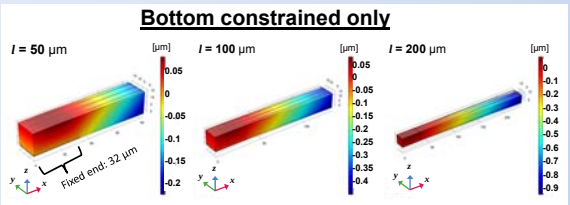
Top & bottom constrained



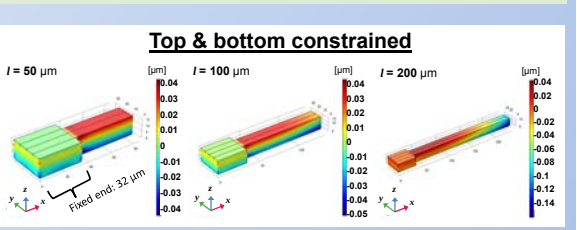
	Length, l [μm]	Tip deflection, Δh_l [μm]	Average deformation, $\Delta h_{ave,l}$ [μm]
Bottom constraint	50	-1.55	0.883
	100	-2.05	1.229
	200	-2.26	1.560
Top & bottom constraint	50	-0.32	0.447
	100	-1.06	0.315
	200	-0.51	0.573

FEM Simulation

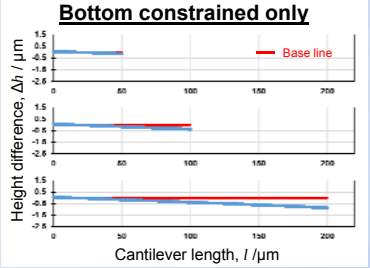
Bottom constrained only



Top & bottom constrained

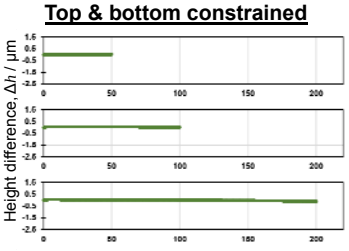


Bottom constrained only



- ✓ Upward deformation on top surface of the fixed end
- ✓ Downward tip deflection in all micro-cantilevers

Top & bottom constrained



- ✓ $\Delta h_{ave,l}$ ranged from 0.032 to 0.044 μm only!
- ✓ Improved structure stability than the bottom constrained micro-cantilevers

	Length, l [μm]	Tip deflection, Δh_l [μm]	Average deformation, $\Delta h_{ave,l}$ [μm]
Bottom constraint	50	-0.153	0.063
	100	-0.378	0.163
	200	-0.867	0.390
Top & bottom constraint	50	0.034	0.034
	100	0.015	0.044
	200	-0.095	0.032

Conclusions

- Results obtained from the OM observation and the FEM simulation showed the same trend.
- The Ti/Au micro-cantilevers having top and bottom constrains at the fixed end showed enhanced structure stability.
- Suppressing deformation at the fixed end is critical in improving the overall structure stability

Acknowledgement

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