Structure Stability of High Aspect Ratio Ti/Au Two-Layered Cantilevers for Applications in MEMS Accelerometers

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Introduction

Gold materials

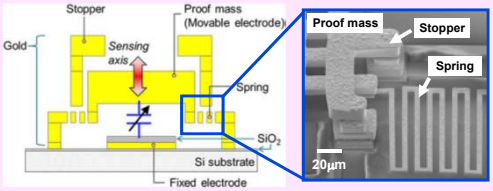
High chemical stability, corrosion resistance, electrical conductivity and density.

19.3×10^3 [kg/m^3]

Previous study

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

Need to investigate structure stability of the gold materials



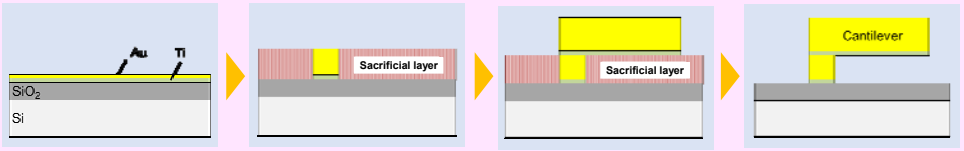
Objective

Evaluate the movable structure stability of Ti/Au two-layered cantilevers with high aspect ratio (length/thickness) in microscale by a 3D optical microscope and COMSOL Multiphysics simulation.

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

Experimental

Process flow of micro cantilevers



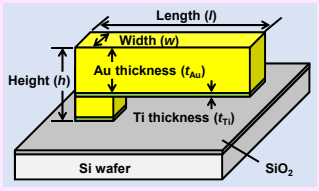
Ti/Au layers were sputtered on Si/SiO_2 substrate.

Patterns was formed by photolithography. Au was deposited by electroplating.

Ti/Au cantilever was formed and annealed at 310℃.

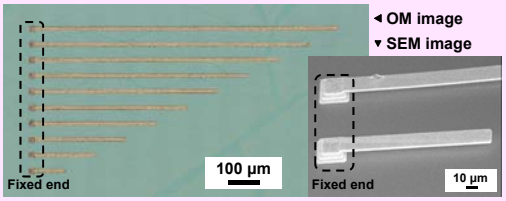
Sacrificial layer was released by dry-etching.

Schematic of the Ti/Au cantilever



		l	w	t_{Au}	t_{Ti}
Cantilever	A	100 μm ~ 1000 μm	10 μm	3 μm	0.1 μm
	B			10 μm	
	C			12 μm	

Images of the Ti/Au cantilevers

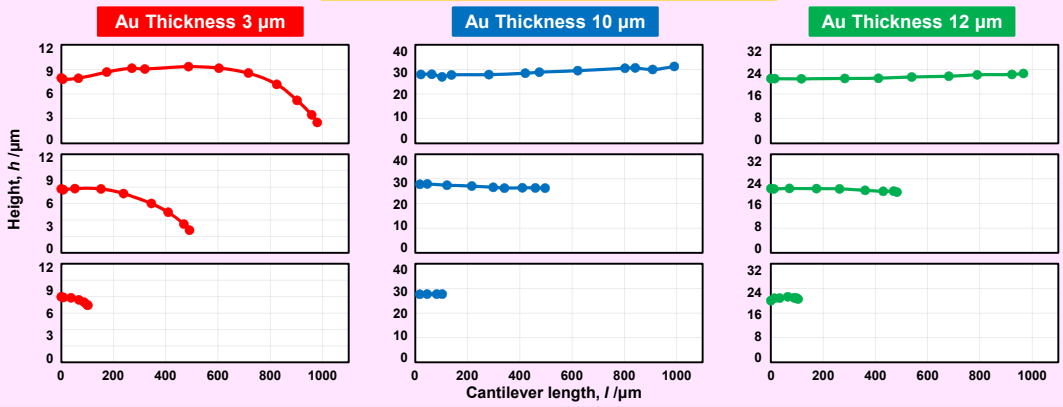


Evaluation of the Ti/Au cantilevers

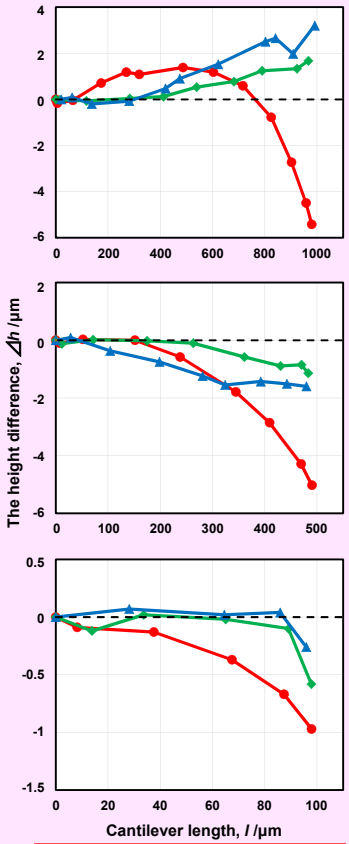
- Scanning electron microscope (SEM)
- 3D optical microscope (OM)
- COMSOL Multiphysics simulation

Results and Discussion

Height profile of the Ti/Au micro-cantilevers

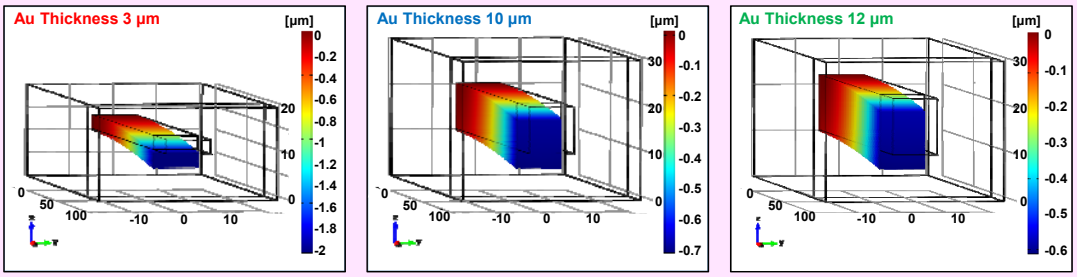


Deflection curve of micro-cantilevers with length varied from 100 to 1000 μm



Au thickness 12 μm is the most stable cantilever.

COMSOL Multiphysics simulation for Ti/Au micro-cantilevers



Cantilever length = 100 μm

Au thickness	Deformation	
	OM	COMSOL
3 μm	-1.05 μm	-2.1 μm
10 μm	-0.26 μm	-0.7 μm
12 μm	-0.27 μm	-0.6 μm

- Tip deflection downward

⇒ The difference in thermal expansion between Ti and Au.

- The results obtained from COMSOL were different from those observed by the OM.

⇒ Titanium could be oxidized when it is heat-treated in air.

⇒ High temperature can accelerate formation of an intermetallic layer at Ti/Au interface.

	Thermal expansion
Au	14×10^{-6} [K^{-1}]
Ti	8.6×10^{-6} [K^{-1}]

Conclusions

- Ti/Au cantilevers with different aspect ratio were fabricated using lithography method and electroplating in microscale.
- COMSOL Multiphysics simulation showed downward deflection for all of the cantilievers.
- We revealed that the Ti/Au two-layered structure can enhance stability of the movable structure and reliability of materials.

Acknowledgement

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