Cu-Alloying Effect on Structure Stability of Au Micro-Cantilever Evaluated by Long-Term Vibration Test

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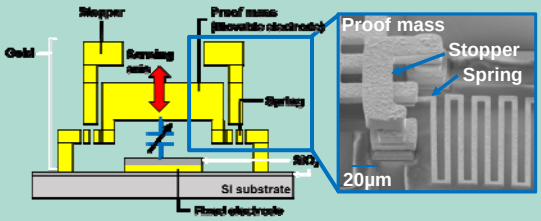
Introduction

Au materials

- High density
- High electrical conductivity
- High corrosion resistance

Applications in MEMS Devices

- Au-based MEMS acceleration sensor[1] can detect Sub-1μG
- Concerns about reliability and lifetime due to gold's week mechanical property



Solutions by Au-Cu alloy plating

- Solid solution strengthening
- Grain boundary strengthening

The yield strength was improved from 0.22 GPa to 1.1 GPa [2]

Long-Term Structure Stability

- Long-term fatigue resistance is required for applications to movable parts in an acceleration sensor
- No report on the structural stability of the Au-Cu alloy micro-components

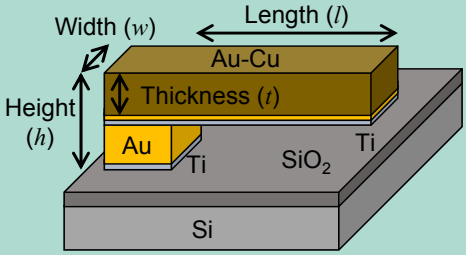
Objective

Evaluate long-term structure stability of the electrodeposited Au-Cu alloy

[1] D. Yamane *et al*, *Applied Physics Letters*, **104** 074102 (2014)
[2] H. Tang et al., *J Electrochem Soc*, **164** 04D244 (2017)

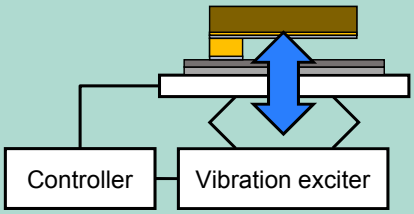
Experimental

Au-Cu Alloy Micro-Cantilever

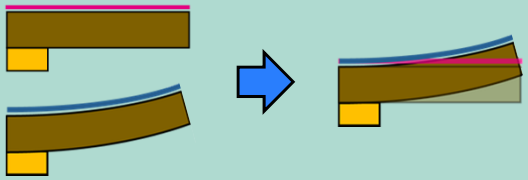


Length (l): 500, 1000 μm Width (w): 10 ~ 20 μm
Ti thickness: 0.1 μm

Long-Term Vibration Test



Acceleration: 1.0 G
Frequency: 10.0 Hz
Cycle: up to 10^7



- Measure height profile by 3D optical microscope
- The structure stability was quantified as Δh_{tip}

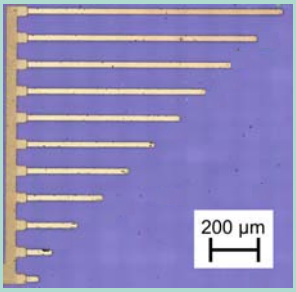
$$\Delta h_{\mathrm{tip}} = h_{\mathrm{tip}} - h_{\mathrm{tip},0}$$

h_{tip}: height of the surface at the tip
$h_{tip,0}$: height of the tip before the vibration test

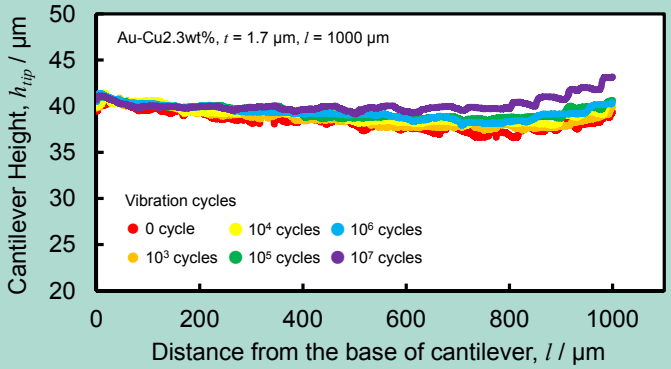
- Compared to micro-cantilever of pure Au plating

Results & Discussion

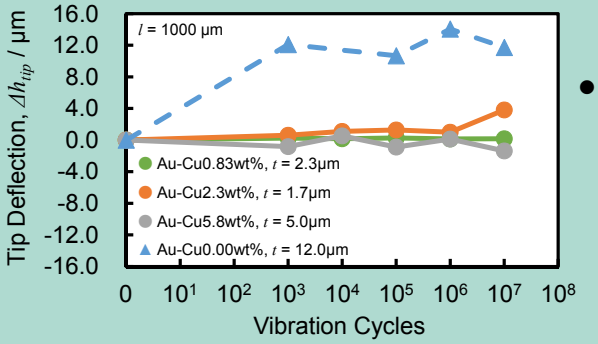
OM Image and height profile after vibration fatigue test



- No cracks and defects
- Remains straight
- Hardly changed



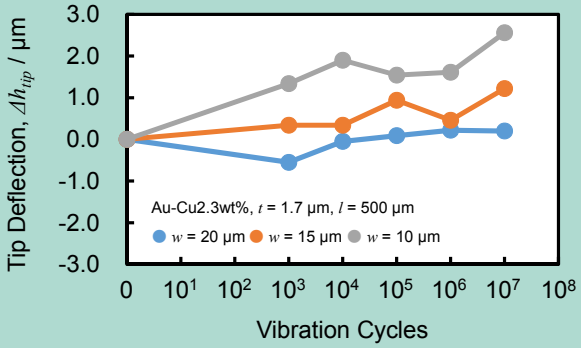
Structure stability after vibration fatigue test



- Alloying with Cu

↓

Small Δh_{tip}



- Wide width

↓

Small Δh_{tip}

Conclusions

- There were no cracks and defects in the cantilever beam after 10^3 ~ 10^7 cycles of vibration
- Structural stability was enhanced by alloying with Cu against vibration fatigue

Acknowledgement

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