

# Mechanical Property Anisotropy of Pure Gold Evaluated by Micro-compression Test

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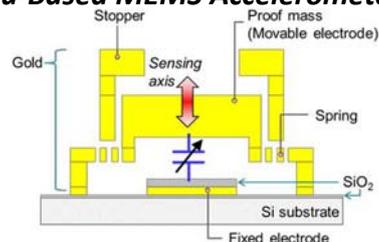
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## Abstract

Micro-mechanical property anisotropy of Au micro-pillars composed of nano-columnar grains embedded in micro-columnar textures was evaluated by micro-compression tests. The micro-pillars having dimensions of  $10 \times 10 \times 20 \mu\text{m}^3$  were fabricated from constant-current electroplated Au film by focus ion beam milling. The long-axis of the nano-columnar grains was parallel to the long-axis of the micro-columnar textures, and the long-axes were parallel to growth direction of the electroplated Au film. The deformation behavior changed from brittle fracture to multiple slip deformation and the yield stress varied from 650 to 300 MPa when the compression direction changed from perpendicular to parallel to the long-axis of the micro-columnar textures.

## Introduction

### Au-Based MEMS Accelerometer



### Merit of Au Material

- High chemical stability • High corrosion resistance
- High electrical conductivity
- Ideal for electronic devices
- High density ( $19.30 \text{ g/cm}^3$ )
- Suppress the Brownian noise
- Achieve higher sensitivity and miniaturization

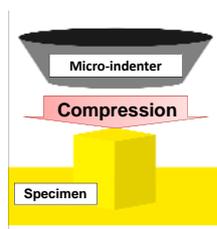
### Electroplating

- Rapid deposition rate
- Room temperature processing
- Feasible to handle to complex geometries

### Micro compression Test

- Mechanical properties of materials having micro dimension is much different from bulk materials

→ Due to **size effect**

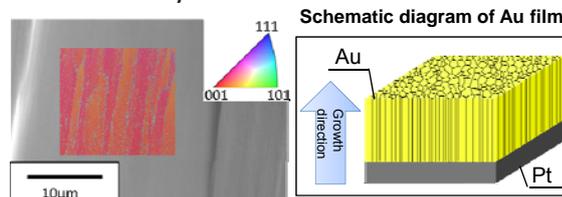


### Micro-mechanical property anisotropy

- **Texture anisotropy** was found in the electroplated Au film

→ Micro-mechanical property may depend on the direction of deformation

→ It is necessary to deform from different directions



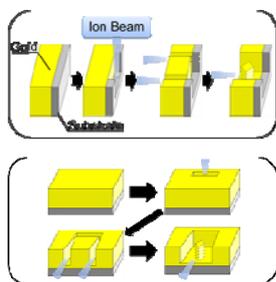
Au film was composed of **columnar grains**, which the long-axis is parallel to growth direction of the Au film, and all grains showed **[001]** direction

## Experimental

### Electroplating Parameter

Au concentration	20 g/L
pH value	5.0
Temperature	60 °C
Current density	0.4 A/dm <sup>2</sup>
Substrate	Pt
Thickness	40 μm

### Micro-pillar Fabrication



#### Pillar 1

Long-side of pillar 1  
⊥  
Growth direction

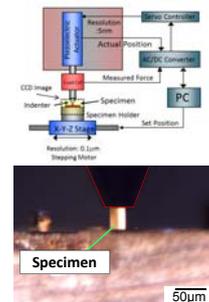
#### Pillar 2

Long-side of pillar 2  
//  
Growth direction

### Micro compression Test

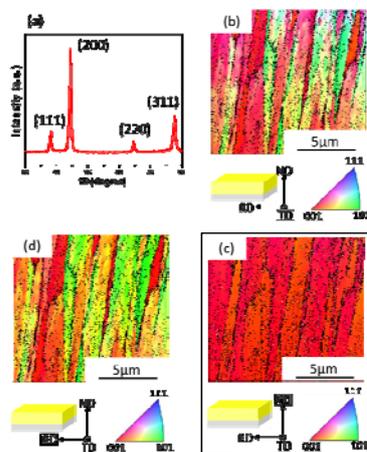


Control	Displacement Rate	Load Resolution
Displacement Control	0.1 μm/s	10 μN

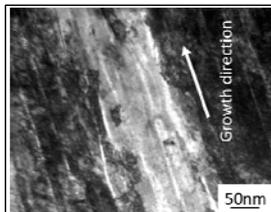


## Results and Discussion

### XRD Pattern and EBSD



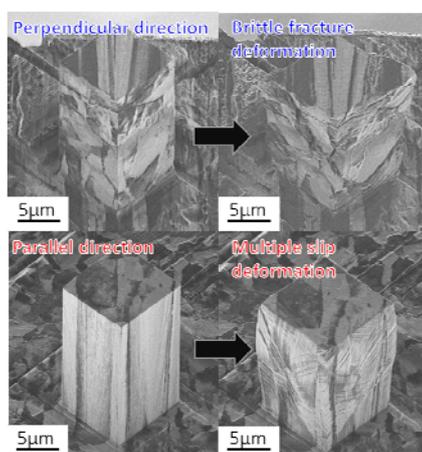
### TEM Image



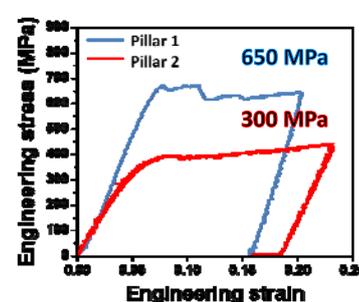
Nano-Columnar Grains embedded in Micro-columnar Textures

High yield stress of Au

### SIM Image of Micro-pillars



### Stress-strain curves



The difference might be attributed to the numbers of texture boundary, which is expected to affect the strength similar to the grain boundary

## Conclusion

- The electroplated Au film was confirmed to be composed of nano-columnar grains embedded in micro-columnar textures. Brittle fracture was observed in the micro-pillar having the long-side perpendicular to the long-axes of the columnar microstructures.
- The yield stress of pillar 1 was ca. two times higher than that of pillar 2. The differences in the deformation behavior and the yield stress are suggested to be caused by the differences in the compression direction and the total texture boundary area in each pillar.

## Acknowledgments

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