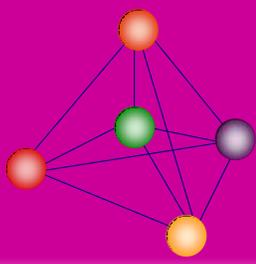




# Effects of the Chemical Components on the Bending Properties of Micro-sized Cantilevers in SU-8

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## INTRODUCTION

### Fabrication of MEMS devices

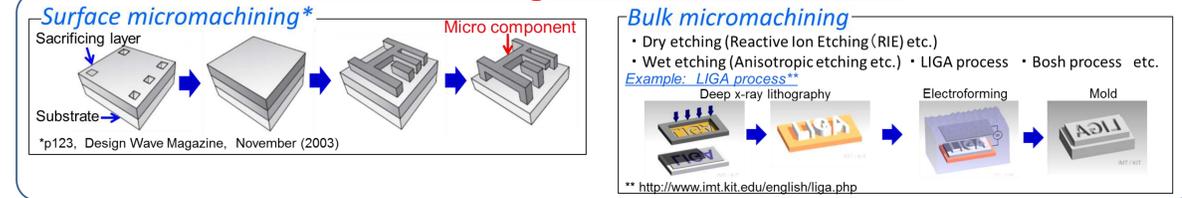
#### Moving parts in MEMS devices

#### Three dimensional (3D) micro-components

Digital micro-mirror device, Micro-accelerometer, Micro-gyro, Micro-fluid, Micro-actuator, Micro-switch, etc.

It is difficult to fabricate using common UV-photolithography for Two dimensional micro-pattern

#### Micromachining for 3D microfabrication



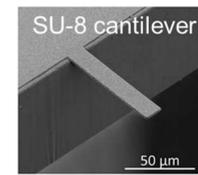
Require additional work and/or extensive equipment compared to UV-lithography

Any photoresists for 3D microfabrication ?

→ Epoxy type photoresist: SU-8  
• easy to fabricate 3D micro-components by UV-lithography

### SU-8 for MEMS fabrication

#### SU-8 as a permanent photoresist



\*J. Micromech. Microeng. 21, 2011 M. Suter et al.

Soft type cantilever (AFM), Waveguide, Microfluidics etc.

Mechanical properties of SU-8 are important

Components in SU-8, should strongly affect the mechanical properties

e.g. solvent, photo-acid generator, additive, etc.

#### Objective

Clarify the mechanical properties between three different types of SU-8 (SU-8, SU-8 2000 & SU-8 3000), especially focused on the bending properties using micro-sized SU-8 cantilevers

## EXPERIMENTAL

### Materials (3 types of SU-8)

	Base resist		PAG	Additive
	Oligomer	Solvent		
SU-8				—
SU-8 2000				—
SU-8 3000				Plasticity epoxy*

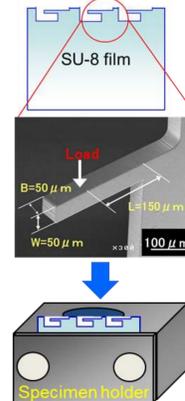
\*The details of additive (plasticity epoxy) in SU-8 3000 is unknown → see the result of NMR analysis

### Micro-sized SU-8 cantilevers

#### Lithography Conditions

Substrate	Glass
Spin coat	600rpm+1800rpm
Pre-bake	65°C/5min
Soft-bake	95°C/50min
Exposure Dose	4mW/cm <sup>2</sup>
PEB	300mJ/cm <sup>2</sup>
Development	65°C for 2min 95°C for 6min
Remove	SU-8Developer 15min
Conditioning	Peel Off 55%RH/ 20°C/ 24hr

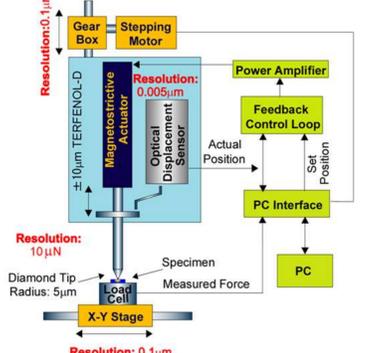
#### Specimen Dimensions



\*set into a specimen holder

### Experimental apparatus

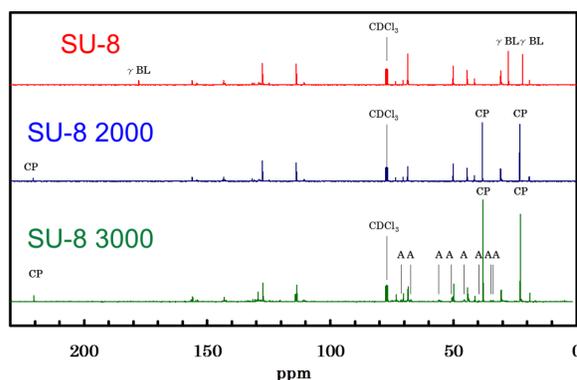
#### Material testing machine for micromaterials



Load cell: 50 gf  
Crosshead speed: 71 μm/min

## RESULTS & DISCUSSION

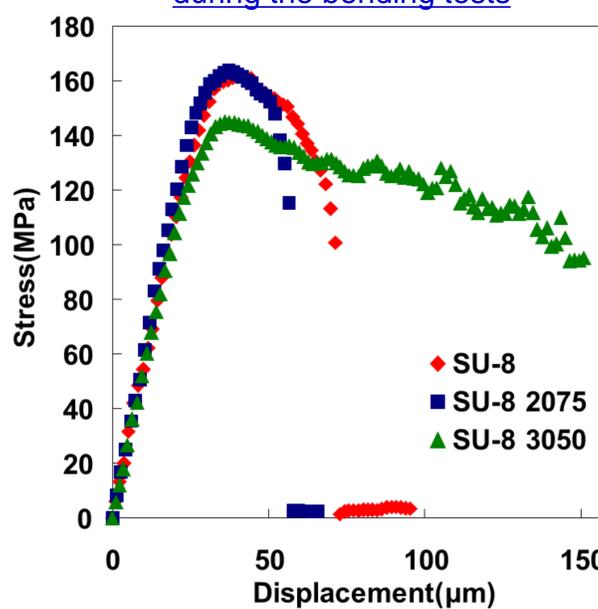
### C<sub>13</sub>-NMR analysis



The peak "A" in SU-8 3000  
A kind of aliphatic compounds  
↓  
Additive (Plasticity epoxy)

### Adhesive bend strength

#### Load-displacement curves during the bending tests



#### Young's modulus

Almost the same in all SU-8s

#### Bending strength

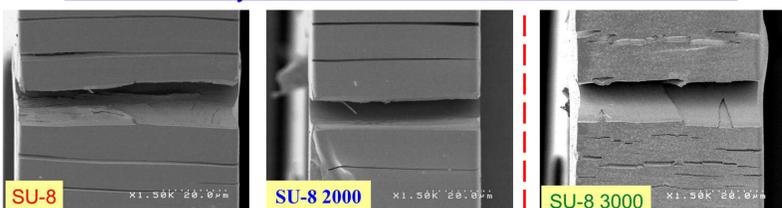
in SU-8 and SU-8 2000  
- not so much different  
in SU-8 3000  
- lower than the other SU-8

#### Deformation behavior

in SU-8 and SU-8 2000  
- brittle  
in SU-8 3000  
- much ductile

### Cracking behavior

#### At the vicinity of the main cracks after the failure



- Several long cracks are observed near the vicinity of the main crack

- Many short cracks are observed near the vicinity of the main crack  
- Short cracks seems to coalesce into the main crack

The additive should be responsible in generation of small cracks, which seems to suppress the crack growing

SU-8 should become softer by the additive

## CONCLUSIONS

1. Bending properties of micro-sized cantilevers are similar between SU-8 and SU-8 2000. It is suggested that difference of the solvent has little effect on the bending properties in SU-8.
2. The bend strength of micro-sized cantilevers in SU-8 3000 is much smaller than that in the other types of SU-8. In addition, SU-8 3000 shows ductile behavior, although the others show brittle behavior. It is suggested that the additive makes SU-8 softer, because aliphatic compounds can easily deform in the SU-8.