

# Elasticity of the electrode of CNT actuator and its effect on the deformation

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カーボンナノチューブアクチュエータの変形機構の解明のため、内部に含まれるイオン性液体量による電極弾性率の変化、およびそのアクチュエータ変形に及ぼす影響を調べた。イオン性液体の量により弾性率は変化するものの、アクチュエータの変形量は弾性率には依存せず、充電量と厚さに依存した。これによりアクチュエータの変形は、両極の応力差により生じているものではなく、両極に集まるイオンの体積差によるものだと考えられる。

## 1 Introduction

The carbon nanotube actuator is a soft actuator which has bimorph configuration [1]; the electrolyte layer is sandwiched by the electrode layers. The electrolyte layer consists of polymer and the electrode layer consists of carbon nanotube and polymer, and the whole contains ionic liquid. When a voltage is applied across the actuator, it bends toward the anode side. The cause of the deformation is not clear; the size difference between cation and anion, the electrical stress working on the interface of electrolyte and electrode, or others.

To make the cause of the deformation clear, the elasticity of the electrode of CNT actuator is measured by changing the ionic liquid fraction and its effect on the deformation is investigated.

## 2 Experiment

The CNT actuator and the electrode are made according to Ref. [1]. The ionic liquid fraction is varied according to samples. Young's modulus of the electrode and the actuator is measured by the tensile test in the air. The deformation of the actuator is measured by the laser displacement meter under 4V rectangular wave. The charge in the electrode layer is obtained by integrating the electric current.

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### 3 Result and Discussion

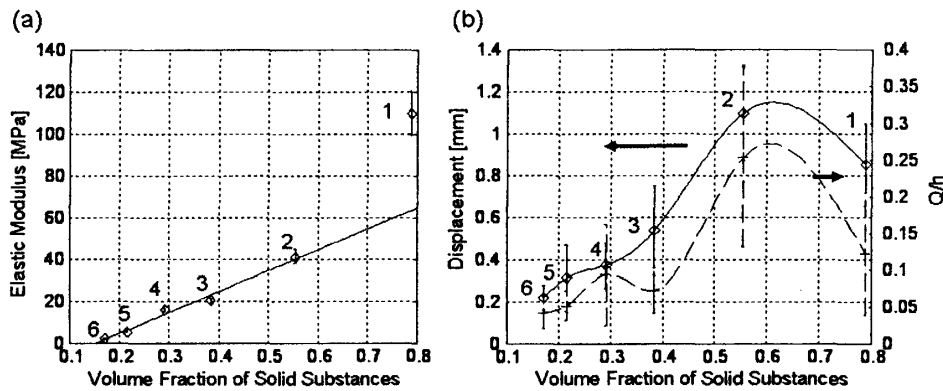


Figure 1: (a) Young's modulus of the electrode. (b) Displacement and charge divided by thickness

Fig.1 (a) shows the experimental result of Young's modulus of the CNT electrode. Young's modulus is proportional to the volume fraction of the solid substances (CNT and polymer). In the case of sample 1, Young's modulus is higher than others. This is thought to be caused by the capillary force [2].

Fig.1 (b) shows the measured displacement and the charge divided by the thickness of the CNT actuator. The deformation is large when the volume fraction of the solid substances is large although Young's modulus is large. The dependency of the deformation on the electrode elasticity is not clear. Two curves have same trend. This means the deformation is caused by the strain difference between cathode side and anode side. The deformation is thought to be caused by the volume of ions.

### 4 Conclusion

The ionic liquid fraction effects on the elasticity. And the deformation is influenced by the ionic liquid fraction. This is not because of the elasticity but because of the charge and the thickness.

### Acknowledgment

The authors thank Kinji Asaka (AIST) for his advices and helpful discussions.

### References

- [1] T. Fukushima et al. :Angew. Chem. Int. Ed. **44** (2005), 2410.
- [2] P. G. Whitten et al. :Carbon **43** (2005) 1891