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MS-2-P-2888 Wetting behavior of ionic liquid on a carbon nanotube

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It is interesting question how a single nanomaterial such as carbon nanotube gets wetting by liquid. Wettability of materials is generally determined by the balance of interface tensions acting at air-liquid, liquid-solid, solid-air boundaries, but nanometer-scale morphologies of solid surfaces often cause anomalous wetting behavior. Regarding carbon nanotubes, they have extremely high curvature surfaces due to their cylindrical shapes with nanometer scale diameters. In this study, we investigated wetting behavior on a single CNT by in-situ electron microscopy. Prior to the experiment, CNT probe was prepared by using TEM-STM holder for nanomanipulation in a transmission electron microscope (TEM, JEM-2500SE) at 90kV acceleration voltage. A multi walled CNT was attached to the tip of cantilever probe used for scanning probe microscopy. On the other hand, ionic liquid was used as a liquid specimen, since it is rather stable in vacuo due to extremely low evaporation pressure. It was supported as the liquid level was parallel to the incident beam direction on a specimen stage of nanomanipulator. Tip of the CNT was then approached to the ionic liquid from the normal direction to the liquid level, and the series of images were recorded as movies at the moment when the tip touched to the ionic liquid. As the result, meniscus formed at the contact region, and a thin film with 3nm thickness simultaneously formed to cover entire the CNT. The contact angle measured at the meniscus was almost zero. These results indicate that CNT shows autophobic wetting, although macroscale droplet on a plane graphite surface shows about 25˚ contact angle. In addition, similar experiments were performed in a scanning electron microscope, and attractive wetting forces were measured on the basis of Wilhelmy method for CNTs with 5~15 nm diameters. Measured values indicated a tendency to be greater than the expected values from Wilhelmy equation representing the correlation of the force, tube diameter and surface tension. Instead, fitted curve to the experimental data showed the increment of effective diameter of cylindrical sample. The corrected value was 2.84nm, which is consistent to the thickness of liquid film formed on CNT. Accordingly, the wetting behavior observed in the present study can be explained by considering that the liquid film acts as a part of a solid cylinder, which suggests a possibility that liquid molecules are rather strongly constrained on the CNT surface.

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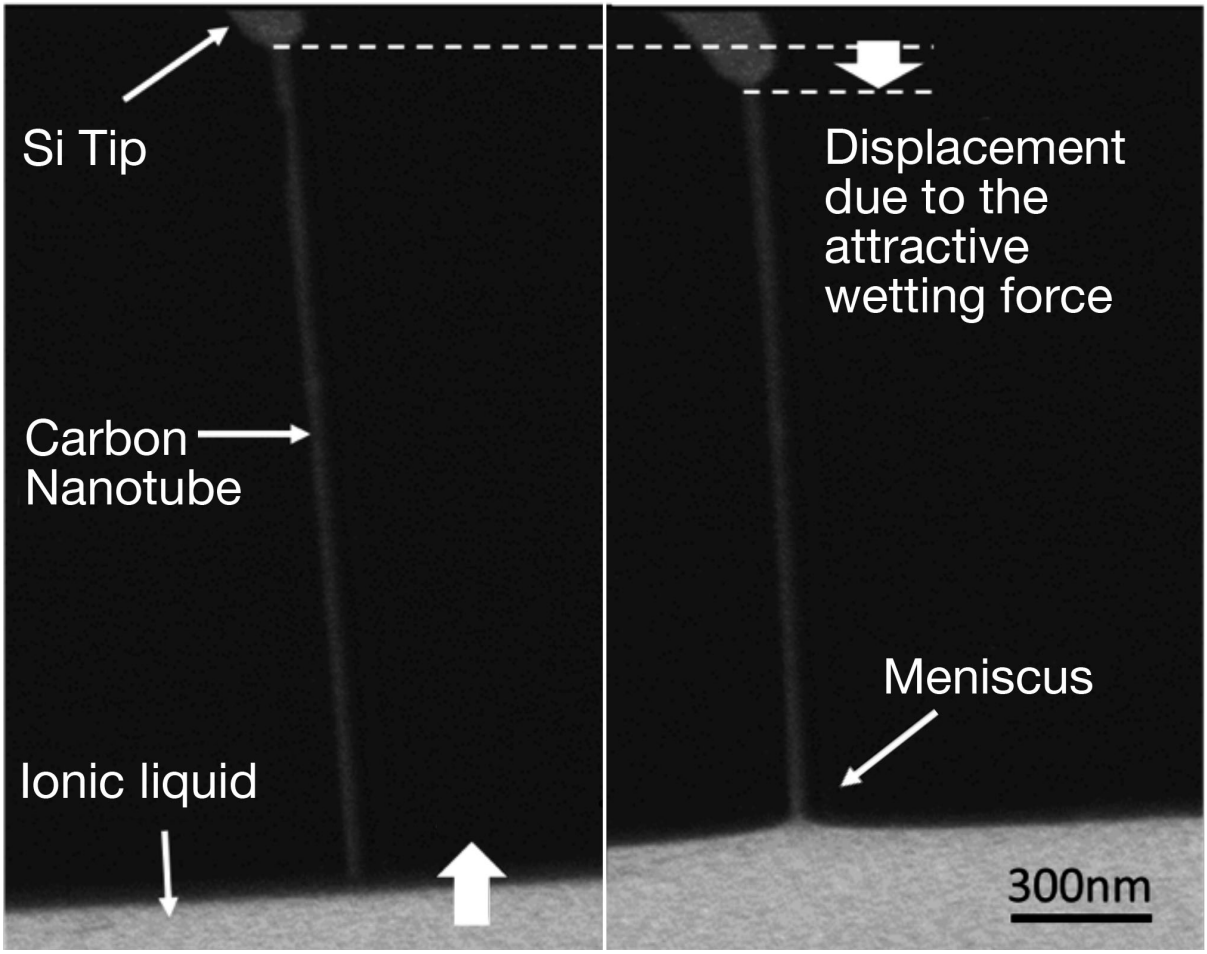

Fig. 1: SEM images of a CNT probe before and after contacting to the ionic liquid. We can see that the CNT is pulled into the ionic liquid due to the attractive wetting force. For this case, the force was measured by 1.2nN.