Measurements of surface profile of amorphous solid water by a non-contact atomic force microscope

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Amorphous solid water (ASW) is abundant material of interstellar ice and is mainly present so as to cover the interstellar dust grains which are mineral particles with sub-micron size. The physical and chemical phenomena occurring on ASW surface are affected by the surface profile, because the adsorption, the desorption and the diffusion processes of atoms and molecules depend on the that profile. Therefore, the surface profile of ASW is one of the important information for understanding of the surface reactions on icy dust grains. However, the profile of ASW in nano-scale range depending on the growth conditions is still unknown.

Recently, we performed the real-space observations of surface profile of ASW formed by a vapor deposition method by using non-contact atomic force microscope (NC-AFM) at 45 and 103 K. The low-temperature ultrahigh-vacuum NC-AFM which was built by incorporating a self-designed cooling system into JSPM-4500A (JEOL) was used in this study. Measured ASW films were prepared on a cold Si(111)7×7 surface by a oblique deposition using a effusive H_2O beam collimated by a micro capitally plate. An injection angle of H_2O beam to the substrate was selected to be 60°.

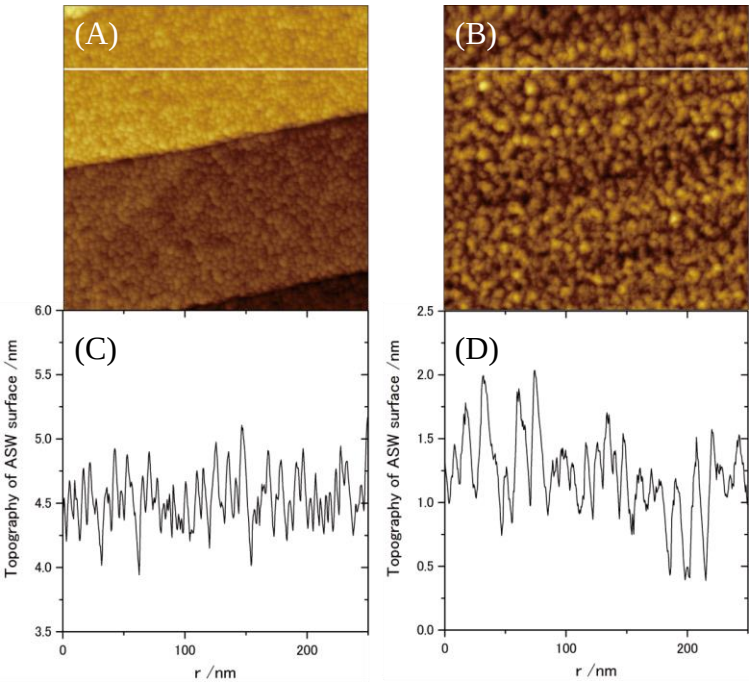

Figure 1: Comparison of surface profile of ASW formed by the oblique deposition method at (A) 45 and (B) 103K. The image size is 250 × 250 nm^2. Thickness and deposition rates of both samples are 2 nm and 1 pm/s, respectively. (C) and (D) Height profiles at solid lines in Fig.1 (A) and 1(B), respectively.

Figure 1(A) and 1(B) show surface profiles of ASW formed at 45 and 103K, respectively. The ice thickness and growth rate of those samples are about 2 nm (54 BL) and 1 pm/s, respectively. The surface structure at 45K shows the relatively flat and uniform size structure than that at 103K. From the height profiles of Fig. 1(C) and 1(D) on the lines of Fig. 1(A) and 1(B), respectively, it is found that the surface roughness at 103K sometimes exceeds 1 nm within the ice thickness of 2 nm, whereas the roughness almost falls within ±0.5 nm at 45K.

In this presentation, the formation mechanisms of observed surface profiles depending on growth temperatures will be discussed.