Effect of dispersion impurity and grain size on creep deformation of fine-grained polycrystalline ice

*Tomotaka Saruya[1], Koki Nakajima[1], Morimasa Takata[1], Tomoyuki Homma[1], Nobuhiko Azuma[1], Kumiko Goto-Azuma[2,3]

1. Nagaoka University of Technology, 2. National Institute of Polar Research, 3. SOKENDAI (The Graduate University for Advanced Research)

Changes of Greenland ice sheet have an important role in global climate change and sea level rise. Although ice sheet flow is a large-scale phenomenon, the importance of microphysics and microstructures of ice-sheet ice has been indicated from detailed analysis of ice-sheet cores.
Deformation mechanism of large-grained and simple-structured polycrystalline ice is well investigated by laboratory experiments; however, actual ice-sheet ice is complicated by various factors; for example, ice-age ice that has highly-concentrated impurities and small grains deforms rapidly than Holocence ice. (Paterson 1991). Although the roles of solid particles and grain size on mechanical properties of polycrystalline ice have been discussed in previous papers (Hooke et al., 1972, Song et al., 2008), uncertainties are still remained.
We conducted mechanical tests and microstructure observations using artificial ice to investigate the roles of solid particles and grain size (or grain boundaries) on the behavior of polycrystalline ice. We prepared pure-water ice and silica-dispersed ice with particle diameters of 0.3 μm and dispersed concentrations of 0.1 and 0.01 wt. %. To replicate the deformation mechanism of an extremely small strain rate in ice-sheet ice, we used very fine-grained polycrystalline ice. Our experimental results indicate that 1) solid particles restrict the grain growth due to a pinning effect, 2) the strain rate changes by grain size, and 3) the stress exponent becomes 3 in spite of the presence or absence of dispersed solid-particles in fine-grained ice.
These results imply the importance of grain boundaries that is almost ignored in typical dislocation creep used in ice-sheet flow law models. In this presentation, we discuss the deformation mechanism of the fine-grained polycrystalline ice and the roles of solid particles and grain boundaries based on the mechanical experiments and microstructural observations.

Keywords: ice-sheet flow, deformation mechanism, grain size