Dielectric anisotropy measurement of Dome Fuji ice core and implications for crystal orientation fabric development

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Crystal orientation fabric (COF) is one of important factors in the physical properties of ice cores. Deformation and flow of ice-sheet ice are highly controlled by COF development. Generally, orientation of c-axes is measured using ice thin sections and crystal fabric analyzers. For the last decades, several systems of automatic fabric analyzers were invented. However, automatic methods still require making many thin sections of ice, which means that we need much effort and a long time. In addition, numbers of crystal grains within a thin section are of the order of several hundreds. To make bulk ice-core based measurements of the COF possible, we developed a new measurement method for COF of ice cores by measuring tensorial components of the dielectric permittivity of ice core using an open resonator.
Hexagonal ice crystal has physical properties with uniaxial symmetry around the c-axis. The dielectric property also has such a symmetry. High-frequency- limit permittivity in ice is approximately 3.15 under the temperature of Cryosphere of the earth. The difference in permittivity between parallel and perpendicular to the c-axis is approximately 0.037 (Fujita et al., 1993). Based on this anisotropic property of each crystal grain, polycrystalline ice has macroscopic anisotropy of permittivity caused by COF. By measuring the macroscopic dielectric property parallel and perpendicular to the ice core axis, we can estimate the degree of the c-axis cluster around the vertical.
We investigated Dome Fuji Station ice cores drilled at Dome Fuji, the second highest dome summit in East Antarctica. To better understand meaning of the COF with respect to glacial processes, successive measurement was performed with an interval of every 5 m. At each step, 1 m-long ice core was measured continuously with a resolution of about 30 mm. Measurements were done to a depth of 1800 m. We used an open resonator of microwave using frequencies between 15 and 20 GHz. All measurements were conducted under -30C in a cold temperature room. We used thick sections of slab-shaped ice core samples with thickness between 35 and 75 mm, which contains 1000 times volume of ice compared with thin section measurements.
As a result of the successive measurement down to 1800 m, we observed that the dielectric anisotropy increased with increasing depth. This trend is consistent with the c-axis clustering toward the core axis due to the uniaxial compression. In addition to the large-scale trend of increase, we found the small fluctuations of the degree of the c-axis cluster with scales of 10 –100 m. In this presentation, we discuss variations of the dielectric anisotropy along core depths in terms of (i) insolation at the timing of snow deposition and (ii) the other physical and chemical properties.

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