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Development of an automated measurement system for the complex dielectric permittivity tensor of ice cores at millimeter wave and its application to Dome Fuji deep ice core

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Dielectric permittivity of polycrystalline ice at microwave and millimeter wave varies depending on density and crystal orientation fabrics (COF). Therefore, continuous measurement on it along ice cores, can obtain depth profile of density and COF simultaneously. We report development of an automated measurement system.

The author has studied dielectric properties of ice and the measurement system. First, in 1995-1998, an open resonator system to measure permittivity of ice at 30-40 GHz range was built. This system yielded precise values of dielectric permittivity tensor for ice single crystal [Matsuoka et al., 1997]). And then, it gave direct measurement on that deep ice core is birefringent medium [Matsuoka et al., 1998]. The system was extended to an automated one for measurement of slab-shaped long samples with motor drive system. This system can give precise permittivity components both with electrical field vector along depth and with that along horizon, simultaneously, with resolution less than 0.001. These values cam be converted to precise values of ice density and cluster strength of COF.

Normally, we use optical birefringence of ice to measure orientation of each crystal grain. The new millimeter-wave based system cannot resolve orientation of each crystal grain because beam width of millimeter wave is several centimeter. However, the system can detect strength of c-axes cluster within the beam and its depth profile along ice core. It still requires slab-shaped sample but it does not require thin sections.

Both density profile and COF profile is useful to better understand mainly physical properties of ice core and ice sheet. In particular, it will provide information of permittivity variation and the causes which is important for remote sensing of strata in the ice sheet by radar sounding.

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