In-situ observation of natural snow crystals by optical techniques

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Natural snow crystals excite our interest because of several reasons such as its beautiful geometry, its symmetricity and variety. Relationship between geometry of snow crystal and its formation environment (temperature and humidity) was investigated by Ukichiro Nakaya and has been well known as Nakaya diagram. After that, the reason of why snow crystal changes their geometry, such as platy, needle and column, with slight difference of temperature and humidity, and the growth mechanisms have been studied [e.g., Sanchez et al. *PNAS* 114 (2017) 227; Brumberg et al., *PNAS* 114 (2017) 5349]. Nevertheless, there are several questions have been remained. For instance; origin of twelve-fold snow can be explained not only by a twin but by contribution of secondary prism plane; and origin of characteristic pattern can be appeared not only by intrinsic defects but also by a result of growth.

To understand snow crystals more, we have performed in-situ observation of natural snow crystals and its sublimation/regrowth experiments in an environment controllable cell under originally designed optical systems at the base of Asahi-dake in the Taisetsu area, Hokkaido, Japan for 15 nights in total for five winter seasons from 2015 to 2019. The environment controllable cell has a Peltier cooling unit, which has a water vapor source with a heater and a chromel-alumel thermocouple on top, windows for optical observation, capillary to handle a snow crystal and a platinum resistance temperature detector for temperature measurement of the cell. The optical systems consist of the modified Mach–Zehnder-type interferometer (Maki-type laser interferometer), the Michelson-type white-light interferometer microscope with a long working distance, the optimized color-filtered optical microscopes, a polarized optical microscope and so on.

We set the optical systems in a snow-lab, which is a handmade igloo-like snow room, also works as a good sound and vibration absorber. Temperature in the Taisetsu area and inside the snow-lab are around -10 to -20°C and -5 to -13°C, respectively. Higher temperature in the snow-lab than outside is due to observers and experimental systems. One advantage of the snow-lab is maintaining the humidity close to 100% because all the walls of the snow-lab have been made of snow.

We collected snow crystals directly on a black felt just outside the snow-lab and selected a snow crystal, which was put onto a glass plate for general observations of the shape and surface textures. A snow crystal is also put onto a tip of a glass rod of 1.4 mm in diameter for the Maki-type laser interferometer. Rates for sublimation and regrowth of a snow crystal were successfully measured in thickness and lateral direction simultaneously at a certain environment, where supersaturation was controlled using the environment controllable cell. In addition, surface topography of both surfaces of a snow crystal, which was put onto a Y-shaped metallic holder, could be observed using the Michelson-type white-light interferometric microscope. Here, we will summarize our attempts of these in-situ observations and the results.

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