Crystallization Experiments on Amorphous Magnesium Silicates

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Infrared spectroscopic observations (e.g., ISO, Subaru Telescope) have revealed the existence of crystalline silicate dust (e.g., olivine [(Mg, Fe)$_2$SiO$_4$], pyroxene [(Mg, Fe)SiO$_3$]) in comets and circumstellar environments around young and evolved stars (e.g., [1-3]). In contrast to the cometary and circumstellar dust, it is believed that interstellar silicate dust is almost completely amorphous [4]. Therefore, interstellar amorphous silicates are considered to be precursor materials for crystalline silicates in protoplanetary disks. In order to understand the crystallization process and its conditions, a fundamental investigation of crystallization kinetics is required, based on crystallization experiments of amorphous silicates in the laboratory.

In order to make clear crystallization process of silicates in protoplanetary disks, we have performed laboratory simulation of crystallization of silicate materials by use of synthetic samples in the MgO-SiO$_2$ system in the Mg/Si ratio of 1.1 and 2. The starting amorphous material in the Mg/Si ratio of 1.1 was synthesized by the sol-gel method and that in the Mg/Si ratio of 2 was synthesized by the radio frequency thermal plasma processing (Nisshin Engineering). The samples were heated in the electric furnace in the atmosphere. The run products of the heating experiments were analyzed using infrared absorption spectroscopy and X-ray powder diffraction. Enstatite (MgSiO$_3$) and forsterite (Mg$_2$SiO$_4$) were crystallized from the starting amorphous materials in the Mg/Si ratio of 1.1 and 2, respectively. We performed infrared spectral fittings of the heated samples using individual infrared spectra of crystalline and amorphous silicates, and estimated the degrees of crystallization quantitatively [5]. We will have a discussion on the time-dependent crystallization processes by comparison with theoretical crystallization models.

Keywords: dust; infrared spectroscopy; laboratory; crystallization

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