# Experimental condensation of forsterite

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Vaporization and condensation are the most important processes responsible for formation and evolution of solid materials in the space. Especially silicates are the abundant dust components, which directly condense from gas at high temperature and low pressure around evolved and young stars including the early solar nebula. Recently the Infrared Space Observatory (ISO) discovered the abundant crystalline silicates around evolved stars, which are very Fe-poor silicates such as forsterite or enstatite (Molster, 2002). In order to understand the kinetics of silicate condensation, particularly conditions for condensation of crystalline forsterite and amorphous silicates, we have conducted condensation experiments of forsterite at low pressure. Because nucleation is difficult to control in laboratory experiments, the experiments are focused mainly on growth kinetics.

Fragments of single crystal of forsterite were heated and vaporized for 20min to 8hours at 1700C at low pressure (10^(-8)bar-10^(-9)bar). Condensation of evaporated forsterite occurred on a molybdenum wire, suspended on the evaporation source, along the temperature gradient (from about 1200C to 500C). The condensates on the wire were examined with a scanning electron microscope (SEM) equipped with an energy dispersive spectrometer (EDS) for composition and by electron back scattered diffraction patterns (EBSD) for crystallinity. The size, phase assemblage and composition of condensed grains varied depending on condensation temperature, heating time and gas flux density in the furnace. Crystalline forsterite starts to condense at about 650C, and is an aggregate of flakes with the size about ten microns. With lowering condensation temperature, the condensates become smaller, which changed into bunches of petals at about 200C, condensates become much smaller and spherical (about a few microns in size). Although the condensates are larger in the experiment of longer duration, the change of texture as a function of condensation temperature is similar. The gas flux becomes smaller with lowering condensation temperature in the present experimental configuration, and therefore, the change of crystal shape depends on either temperature, flux, or both. A significant change of gas flux density is expected between inside and outside of the alumina tube that was used for the W-wound wire furnace though, we observed no significant shape change at the gas flux boundary.  Thus, the change of forsterite crystal shape is considered to be dependent mainly on temperature. This is consistent with the shape change of snow crystals as a function of condensation temperature and degree of supersaturation.

The experimental results may suggest that forsterite condenses around evolved stars, where gas cools rapidly in a low flux tends to be smaller and spherical. In contrast, that in the early solar nebula, where the condensation must have taken place more slowly in a relatively higher flux density, may have been larger and flake-like.