Experimental studies on the formation and dynamics of silicate crystal dusts

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Crystal silicate grains in space have attracted recently a wide interest of astrophysicists by the Infrared Space Observatory (ISO). The knowledge of silicate properties related to the conditions where they are found in space is strictly related to the study in the laboratory on the formation condition and their observations on dynamics. In the present paper, the dynamics of SiO, SiO_2 and Mg silicate amorphous grains by heating in vacuum was captured by the direct observation of the structure alteration in electron microscope. The crystal and amorphous Mg silicate grain formation condition have been elucidated by the coalescence between MgO and SiO_2 smoke grains.

In the observation of the dynamics of SiO grains by heat treatment, Si crystallites were predominantly grown at 500 to 700°C in SiO grain. The diffuse of silicon atoms selectively took place in the SiO grain which was composed of Si and SiO_2 crystallites. The grown Si crystallites disappeared and evaporated by the formation of SiO phase at 900°C. The formation of SiO phase in grain was 200°C lower than the bulk data. When the SiO grains were cooled down, the solid SiO grains were again changed into Si and SiO_2 crystallites. The preferential growth of silicon crystallites at 700 to 500°C was directly captured during the cooling process.

In the case of SiO_2 grain, the Si crystallites were partly produced at 900°C on the surface of grain accompanying the coalescence between SiO_2 grains. The formation of silicon crystallites become the trigger on the formation of partly evaporation as the SiO.

Both spherical crystalline Mg_2SiO_4 grains and amorphous Mg silicate grains were produced by the coalescence growth between MgO and SiO_2 grains. The cooling velocity dependence of the production of crystalline and amorphous was elucidated by the rapid cooling experiment. It becomes evident in the present experimental that amorphous Mg silicate grains were first produced by the coalescence between MgO and SiO_2 grains. The difference of the cooling velocity in smoke formed crystal and amorphous grains.

On the direct observation process of crystallization of amorphous Mg silicate grains, the formation of rim-like layer due to prenucleation was observed between the temperature ranges of 650-750°C. This phenomenon corresponds to the stall idea suggested by Hallenbeck and Nuth by the IR spectroscopy method on the crystallization of silicate. The crystallization to Mg_2SiO_4 started from the grain surface at 800°C.