Crystalline and amorphous Ca silicate grain formation by coalescence growth

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In 1996-1998, the Infrared Space Observation (ISO) project discovered infrared bands due to crystalline and amorphous silicates around certain stellar sources (Waelkens et al. 1996; Waters et al. 1996). Although no iron-rich silicates were observed, both forsterite and clino-pyroxene crystals were observed. The formation of crystalline Mg silicate grains and the crystallization of amorphous Mg silicate grains interest in astrophysical field and, we studied these problems from the viewpoint of laboratory analogy.

In previous works, we have demonstrated that Mg_2SiO_4 (forsterite) crystalline grains containing Si crystals could be produced by the coalescence of Mg and SiO smoke grains (Kaito et al. 2003). We have also suggested that single crystalline Mg_2SiO_4, polycrystalline Mg_2SiO_4 and amorphous Mg-bearing silicate grains are produced by the coalescence of MgO and SiO_2 smoke grains (MgO-SiO_2 system) (Kamitsuji et al. 2005). These findings suggest that the observed crystalline Mg_2SiO_4 grains and amorphous Mg-bearing silicate grains could be produced by the coalescence and growth of MgO and SiO_2 grains in Red Super Giant (RSG), Asymptotic Giant Branch (AGB), post-AGB and planetary nebula (PNe). The crystalline grains produced in these experiments did not have the characteristic shape of crystalline, but both of grains had the same spherical shape. This indicates that amorphous Mg silicate grains were produced and then the crystallization of amorphous Mg silicates to Mg_2SiO_4 occurred in rising smoke. This crystallization without alteration of the amorphous grain shape was confirmed at observing the grain in situ while heating in a transmission electron microscope (Kamitsuji et al. in press). The appearance of crystalline and amorphous grains reflected slight differences of the cooling rate in the smoke due to the temperature gradient above the heaters. The average cooling rate of the produced grains in the MgO-SiO_2 system was on the order of 10^4 K/sec (Yatsuya et al. 1984).

In this study, we focused on Ca silicate grain. Ca is relatively high abundance in cosmic elements, and we will study Mg and Ca silicate grain i.e. Melilite ($Ca_7MgSi_2O_7$) and Diopsaido ($CaMgSi_2O_6$). Melilite and Diopsaido are known as a silicate material which has equilibrium of condensation at relatively high temperature under a typical solar nebulas pressure, and Melilite commonly occurred in CAIs (Ca- and Al- rich inclusions) of primitive chondrites. In order to prepare Melilite and Diopsaido grains, we started to produce Ca silicate grain. We applied the technique of MgO-SiO_2 system to the production of Ca silicate grains, and we succeed producing crystalline and amorphous Ca silicate grains using the coalescence growth of CaO and SiO_2 (CaO-SiO_2 system). Both crystalline and amorphous grains had spherical shape similar to MgO-SiO_2 system. The structure of produced crystalline Ca silicate grains were Ca_2SiO_4.

We will show the result of the coalescence growth among CaO, MgO and SiO_2 grains.

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