Hibonite phase formation by the solid-solid interaction between alumina particle and Ca film

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Corundum (Al2O3) is one of the most refractory phases predicted by equilibrium thermodynamic calculations to condense first during cooling of a hot gas of solar composition [Grossman, 1972]. Corundum, Hibonite (CaAl12O19), spinel (MgAl2O4) and rutile (TiO2) have been interested materials in astromineralogy. In order to study the mineralogy or environment of dust, the laboratory infrared (IR) spectra become much important. Laboratory dust experiment also gives important suggestions about the formation process of these cosmic dusts.

In a previous paper, we demonstrated that the spinel phase can be produced by solid-solid reactions between Al2O3 and MgO [Kaito et al., 1994]. On the other hand, we recently produced delta-Al2O3 grains and showed their characteristic spectra which quit differ to the reported gamma phase or corundum phase [Kurumada et al., 2005]. The delta-Al2O3 phase is one of the polymorphs of alumina, and we found them to be able to use as the indicator of the thermal history of dust.

In the present experiment, we tried the formation process of hibonite by solid reaction of the calcium and alumina grains. The Ca thin film with about 20 nm thickness was produced by vacuum evaporation of Ca metal. However it have spontaneously changed to Ca(OH)2 as soon as exposing to the air. The reaction between Ca and alumina has explosively started by heating at about 1000 degree C. Since the differential scanning calorimeter (DSC) curve indicated the exo-thermal peak at 930 degree C, it is consider that the formation of hibonite have occurred at that temperature. Mid-IR spectrum for the grain heated also showed 11.7, 12.8, 13.5, 14.1, 16.1, 16.5, 17.7, 18.8, 21.2 and 22.1 micron feature which resemble to the hibonite [Hofmeister et al., 2004], although the feature and intensity around the 12.5 micron are different.

Electron microscopic observation of the specimen showed the growth of hibonite. The spherical shape of alumina was hardly seen. Thin film and polyhedral crystalline of hibonites have been distributed on the Ca(OH)2 film. Since the DSC peaks showed the high exo-thermic reaction, the oxidation of Ca taking in oxygen from Al2O3 grain accelerated the growth of the hibonite. Therefore various morphology such as thin film and polyhedral shape grains were obtained by the reaction promoted by high temperature due to exo-thermic oxidation reaction of Ca.

Reference

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