Crystallization experiments of amorphous enstatite dust in protoplanetary disks

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Silicate dusts is one of the main solid components in astronomical environments. Infrared spectroscopic observations of young and evolved stars, silicate dusts in circumstellar regions is partially crystallized [e.g., 1, 2]. On the other hand, interstellar silicate dusts is almost completely amorphous [3]. These observations indicate silicate dusts in protoplanetary disks undergo heating processes and are rearranged from amorphous into crystalline structures [e.g., 4 and references therein].

In this study, we aim at understanding the crystallization behavior of amorphous enstatite ($MgSiO_3$), of which Mg/Si ratio is close to the solar ratio (1.074; [5]). We performed crystallization experiments on amorphous enstatite in the presence of water vapor because H_2O is one of the most reactive gas in protoplanetary disks and promotes the crystallization of amorphous forsterite [6].

Amorphous enstatite powder synthesized by induced thermal plasma method (provided by A. Tsuchiyama) were heated at 780-850°C in air or at the water pressure (P_{H_2O}) of ~0.65 bar. We found that crystallization of amorphous enstatite in the presence of water was a few times faster than that in air, suggesting that water molecules absorbed into amorphous structure cut the bonding of atoms and promoted the crystallization as in the case of amorphous forsterite [6].

The FTIR and XRD analyses of run products heated both in air and at P_{H_2O} of ~0.65 bar showed that the crystalline enstatite existed as a final product. However, the amorphous heated at P_{H_2O} of ~0.65 bar were transformed into crystalline forsterite and SiO_2-rich amorphous before turning into crystalline enstatite. This is probably because the mobility of atoms in the amorphous increased due to water molecules and forsterite formed like as a liquidus phase from enstatite melt.

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