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Elemental distribution between crystal and amorphous phases in crystallization process of silicate

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According to the recent astronomical observations, it is obvious that both of amorphous and crystalline dusts exist in circumstellar regions of evolved stars and young stars. While in the interstellar region, dust does not contain crystalline phase, and almost all the interstellar dust is consist of amorphous materials (Kemper et al. 2004). It is considered that circumstellar dust of young stars is what amorphous materials which are originated from such interstellar dust are accumulated. Observations of young stars (e.g.T-Tau stars) show that some fraction of the amorphous materials is crystallized (e.g. Honda et al. 2003). Moreover, from many other observations we know that chemical composition of circumstellar silicate dust is extremely Mg-rich and Fe content is scarcely found (Molster et al. 2002).

If it is supposed that such circumstellar dust was condensed from its parent gas of which chemical composition typically represent the solar abundance, the depletion of iron in circumstellar crystalline silicate is one of the most enigmatic problems since the first observational detection of the crystalline dust.

While, in general, it can be considered that circumstellar crystalline dust of young stars was formed by some heating events, it is expected that the behavior of Mg and Fe in the crystallization process results on the final chemical composition of the crystalline dust.

Therefore, in this study, we examine the behavior of the Mg and Fe in the crystallization process of amorphous silicates which contain both of magnesium and iron. The amorphous material which consists of MgO-SiO_2-FeO was synthesized by the Sol-Gel method. Its elemental composition ratio was Mg:Si:Fe=1.07:1.0:0.39. This composition is between olivine and pyroxene. The amorphous material was heated at 700 ^oC under controlled oxgyen-fugacity by use of H_2-CO_2 mixed gas. We obtained some samples of which crystallinity is different by heating for various durations. These partial crystallized samples were analyzed by FT-IR spectrometer and X-ray powder diffractometer. The crystallinity (mass ratio between crystal and amorphous) and chemical composition were derived from IR and XRD analyses, respectively.

As a result, it was found that chemical composition of the final material is that of olivine. Moreover, from the correlation between the crystallinity and the chemical composition, we found that magnesium is preferably distributed to the crystalline phase and iron is to the amorphous phase in the crystallization process.

These experimental results are very crucial to verify the fact that the chemical composition of circumstellar silicate is extremely Mg-rich.