Solid-Gas Reaction Experiments between Forsterite and Si-rich Gas

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Magnesium and silicon are the major rock-forming elements to form silicate dust in space. The Mg/Si ratio is ~1 in the solar system elemental abundance, and equilibrium condensation models for the solar abundance predict that forsterite reacts with Si-rich gas to form enstatite at lower temperatures. This solid-gas reaction determines the extent of Mg/Si fractionation since the atomic ratio of Mg/Si in the solid changes from 2 of forsterite to 1 of enstatite, and may have caused the Mg/Si fractionation between dust and gas. Imae et al. [1] carried out reaction experiments between forsterite and Si-rich gas at 1378-1550℃, which is much higher than the temperature range for enstatite formation in space.

In this study, we carried out reaction experiments between forsterite and Si-rich gas at temperatures close to those in proto-solar disk and circumstellar environments. A single crystal of quartz was heated by a tungsten-coil heater to generate Si-rich gas. The Si-rich gas was reacted with a chip of single crystal of forsterite, which was put ~250 mm above the gas source and was heated at ~800 or ~900℃ by an infrared heating system, for <10-48 hours. Some of reaction products were further heated at 1 atm and 800 or 900°C to see the effects of annealing.

EDS analyses indicate that the surface of forsterite was covered with a very thin layer consisting of Si and O. The EBSD analyses at the accelerating voltages of 3-5 kV showed that the reaction layers formed at ~900°C for 48 hours were amorphous. On the other hand, the surface of the layer additionally heated at 900°C for 48 hours at 1 atm showed crystalline features, which could be attributed to quartz.

Although we cannot exclude a possibility of crystallization at the interface between forsterite and the amorphous condensates, our preliminary results imply that enstatite formation by a reaction between forsterite and Si-rich gas or by annealing of forsterite and Si-rich amorphous may not be expected at temperatures in mass-loss winds from evolved stars.

Keywords: Enstatite; Forsterite; Solid-gas reaction; Kinetics

1. References: [1] N. Imae et al. , *EPSL.* 118, 21-30 (1993).