

# Formation process of crystalline enstatite grains by using RF plasma field

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Formation process of silicate grains in space have been recently interested by the increasing amount and quality of observational data by the Infrared Space Observatory (ISO). The observations show that the crystalline silicate grains of olivine and enstatite were existed in interstellar. It was a problem that iron-rich silicates were never observed. In the laboratory experiments, some experiments based on gas-solid condensation yielded various phases without olivine or enstatite crystals [1]. It was also elucidated that films condensed from vapor phases of SiO and Mg or SiO and Fe by co-evaporation were not mixed on room temperature substrate [2]. The direct production of the crystalline forsterite grain was succeeded by the coalescence growth of Mg and SiO smoke particles [3]. But enstatite crystal was hardly produced both the coalescence experiment and condensed film from vapor phase in spite of the existence of crystalline enstatite in interstellar. Therefore, it is important to elucidate the formation process of the crystalline silicate grains and the atmospheric condition on the growth of the silicate grains.

Recently, the effect of plasma on the alteration of metallic smoke particles was found by passing the smoke particles through the plasma field with small amount of reactive gas [4]. Si particles were changed to pre-solar Si<sub>3</sub>N<sub>4</sub> grains in an atmosphere of partial nitrogen gas pressure of 0.25 Torr.

In this study, one of the advanced gas evaporation methods (AGEM) was constructed in a plasma field. Mg evaporation source was set above 10 mm from the evaporation source of SiO. The SiO powder was evaporated from tantalum boat heated at 1500C in helium gas at 80 Torr. Mg evaporation took place simultaneously without heating the Mg boat by the temperature produced by the SiO evaporation source. The convection flow due to the SiO evaporation source was spontaneously mixed with Mg smoke in the plasma field. RF plasma with a frequency of 13.56 MHz was used. The RF power output was 300 W. The color of the plasma field changed from the red-violet to the green around the Mg boat. The collected specimens were examined using transmission electron microscopy (TEM) and high resolution TEM methods.

The electron diffraction pattern showed that the crystalline enstatite grains appeared upon using the plasma field. The shapes of enstatite grains were spherical with the size of 30 nm and needle-like with the length of 200 nm. The high resolution TEM showed that the needle-like grains were composed of coagulation of small enstatite grains with the size of 10 nm. Since SiO grains were passed through the Mg vapor in plasma region, the reaction of SiO grain and excited Mg vapor may be accelerated the formation of the enstatite grains. The growth of the needle shaped by the coagulation grains may be also due to the plasma field effect. By laser ablation of a natural enstatite mineral, enstatite grains with the size of 20-60 nm were produced amorphous enstatite grains [5]. Therefore, the present plasma field with the electron density about 10<sup>9</sup>/cm<sup>2</sup> was important condition on the growth of the crystalline enstatite grains. These result indicated that the plasma effect was very important factor on formation of the silicate compound including Mg (Fe) grains in space.

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