

NON-EQUILIBRIUM CONDENSATION IN THE Mg-Si-O SYSTEM: AN EXPERIMENTAL STUDY.S. Tachibana¹, H. Nagahara¹, K. Ozawa¹, and S. Tamada¹.¹Department of Earth and Planetary Science, University of Tokyo, 7-3-1 Hongo, Tokyo 113-0033, Japan. E-mail: tachi@eps.s.u-tokyo.ac.jp

Introduction: Magnesian silicates are major constituents of dust particles in protoplanetary disks and circumstellar environments. Their sizes, shapes, compositions, and the crystalline/amorphous ratio reflect their formation histories, and thus understanding of formation processes of magnesian crystalline/amorphous silicates leads to estimation of physical and chemical conditions in dust-forming environments. Condensation of magnesian silicate dust particles is one of the most crucial processes for dust-formation, and several experimental studies have been done under plausible low-pressure conditions [e.g., 1-2]. However, quantitative discussion on kinetic processes, such as dependences on partial pressures of condensing gas species and supersaturation ratio, was not made in previous studies due to experimental difficulties. In this study, we carried out condensation experiments in the Mg-Si-O system using infrared vacuum furnace, where partial pressures of condensing gas and supersaturation ratios could be estimated, and discuss non-equilibrium condensation behaviors of magnesian silicates.

Experiments: A single crystal of forsterite was heated at ~1850K by focusing infrared lights from halogen lamps. Gaseous Mg, SiO, and O evaporated from forsterite were condensed on a substrate of molybdenum plate, put at various distances from forsterite to control condensation temperatures from 1145-480°C. The total pressure in the silica glass vacuum chamber was ~10⁻⁵ Pa, and the experimental duration ranged from 24 to 72 hours. Condensates were observed with FE-SEM, and their chemical compositions and crystallinities were determined by EDS and EBSD.

Results and Discussion: Condensation did not occur at >1310 K, Si condensed as molybdenum silicide at ~1130 K, and amorphous magnesian silicates condensed at <840 K. Condensates in the present study are different from those formed in the Mg-Fe-Si-O system [1] and in the Mg-Si-O-H system at a total pressure of 1.4 Pa [2]. Very little condensates were found in [2] at the total pressure of 0.14 Pa and lower, which is consistent with the present study. Partial pressures of Mg and SiO above the molybdenum substrate were estimated to be much larger than equilibrium vapor pressures of forsterite, MgO, and SiO₂, indicating that such mineral phases could be condensed in the present experimental conditions. However, such phases, all of which require encounter of different gas species on the substrate for heterogeneous nucleation, did not condense in this study. SiO condensed as silicide probably due to reduction on the substrate, which required no other gas species. Amorphous magnesian silicates condensed at lower temperatures, which could be because condensation of relatively-volatile SiO was allowed with lowering temperatures, and Mg began to condense once amorphous SiO (or SiO₂) formed. These condensation behaviors could be due to smaller incoming fluxes of Mg, SiO, and O onto the substrate than those in previous studies with condensation of crystalline silicates. Condensation experiments under more-oxidizing conditions will also be reported at the meeting.

References: [1] Nagahara H. et al. (1988) *Nature* 331, 516. [2] Tsuchiyama, A. (1998) *Mineral J.* 20, 50-89.