Formation processes of nano-minerals via nucleation in vapor

YUKI KIMURA[1]

[1] Institute of Low Temperature Science, Hokkaido University, Kita-19, Nishi-8, Kita-ku, Sapporo, 060-0819, Japan. ykimura@lowtem.hokudai.ac.jp

To understand the early stages of formation of nanometer sized minerals, we have studied using originally developed *in-situ* experimental systems, such as nucleation apparatuses with interferometer [1,2] and that with infrared spectrometer [3,4] for vapor phase nucleations and fruid reaction transmission electron microscopy [5,6] for solution phase nucleations. Our nucleation apparatuses have several advantages; “nanoparticles nucleate homogeneously under extremely high supersaturation”, “the interferometer simultaneously determines nucleation temperature and pressure”, “infrared spectrometer determies crystalline phases and morphological changing during nucleation and growth of an infrared active material such as oxide and carbide”, “the nucleation process is directly comparable to that of cosmic dust particles in the gas outflow of evolved sters” and “direct evaluation of the experimental results is possible using nucleation theories because of no hydrated layer, which makes complex nucleation pathway”.

These advantages in our homogeneous nucleation experiments in vapor phase have revealed a part of the mysterious nucleation processes: The size of the critical nuclei can be as small as dimer or even smaller suggesting a possibility of particle formation through spinodal decomposition rather than nucleation. The initial phase of the particle is melt in many cases and crystalline phases form from the supercooled nano-droplet via secondaly nucleation [3-4]. Sticking probability of iron atoms to make a dimer (nuclei) is extremely small [2], surface tention of a Mn nanoparticle is 30% larger than that of the corresponding bulk [1]. Based on these recent sudies, we recognized that the nucleation process is not simple even in the vapor phase. In this presentatin, I will show about our recent nucleation works in vapor phase.

[1] Y. Kimura, et al., *Crystal Growth & Design* 12 (2012) 3278. [2] Y. Kimura, et al., *Science Advances*, 3 (2017) e1601992. [3] S. Ishizuka, Y. Kimura, et al., *Chemistry of Materials*, 28 (2016) 8732 [4] S. Ishizuka, Y. Kimura, et al., *The Astrophysical Journal*, 803 (2015) 88. [5] Y. Kimura, et al., *JACS*, 136 (2014) 1762. [6] T. Yamazaki, Y. Kimura, et al., *PNAS*, 114 (2017) 2154.