【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Interdisciplinary Science and Engineering)

Title of Project： Nucleation

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Research Area：　Nano-science
Keyword：　Nano, Transmission electron microscopy, Crystal growth, In-situ observation, Hydrated layer

【Purpose and Background of the Research】

Since “nucleation” is a fundamental process to form a material from atoms or molecules and has been believed to be determined characters of the products, understanding of the mechanism of nucleation is essential for material science. However, the detail of the process is still unknown since the modelling by Gibbs (1876). Recent years, new nucleation models have been proposed and actively debated.

In this project, we will perform in-situ transmission electron microscope (TEM) observation using a liquid cell and show the direct evidence of a relationship between nucleation and precursor. We believe that the keys to understand nucleation are characteristic properties of nanoparticles and hydrated layer. Therefore, physical properties (surface free energy and sticking probability) of nanoparticles will be determined by nucleation experiment from a vapor phase and the results of nucleation in water solution and in ionic liquid solution will be compared to know how hydrated layer works during nucleation. As the result, a new model of nucleation will be constructed.

【Research Methods】

Recently, we succeeded to make a system to observe a phenomena and a reaction of nanoparticles in a water solution. This system is a most powerful for visualization of nucleation process, which will be progressed in meso-scale. Individual nanoparticles can be observed and analyzed its crystal structure by electron diffraction. In vapor phase experiments, physical properties of nanoparticles will be determined based on supersaturation at the nucleation, which determined by double wavelength Mach-Zehnder-type interferometer (Fig. 1). The results will be compared with that obtained by molecular dynamics simulation or global reaction route mapping. As the result, we will construct an advanced nucleation model.

【Expected Research Achievements and Scientific Significance】

Current view of nucleation based on microscale phenomena by optical microscope will be nanoscale view by TEM. Our results will be contribute to the field of biomineralization and formation of biomaterial in near future.

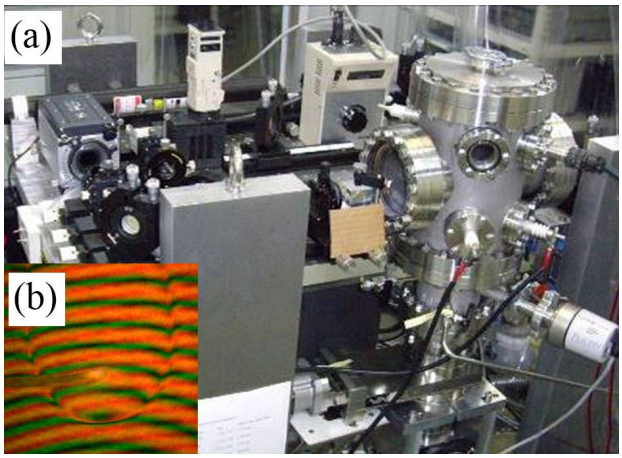

Figure 1. (a) Nucleation chamber with highly sensitive double wavelength Mach–Zehnder- type interferometer and (b) a typical example of the interference fringe at the moments of nucleation. The deviation of the fringe is a result of changing in refractive index of only $10^{-5}$by nucleation.

【Publications Relevant to the Project】

Y. Kimura, H. Niinomi, K. Tsukamoto, J., M. García-Ruiz, *Journal of the American Chemical Society*, 136 (2014) 1762-1765.
Y. Kimura, K. K. Tanaka, H. Miura, K. Tsukamoto, *Crystal Growth & Design*, 12 (2012) 3278-3284.

【Term of Project】 FY2015-2019

【Budget Allocation】 134,100 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.lowtem.hokudai.ac.jp/astro/