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High-speed polarized in-situ observation in a nucleation process of nanoparticles produced by the gas evaporation method

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The gas evaporation method has been investigated for more than half a century since the Kubo effect was reported (1962). There have been many studies on the produced nanoparticles mainly using a transmission electron microscope, which have elucidated the different physical properties of nanoparticles from those in bulk. On the other hand, there have been almost no reports on nucleation in smoke related to crystal growth. Recently, we achieved in-situ observation of the nucleation process in smoke using a double-wavelength Mach-Zehnder-type interferometer, which can determine the temperature and pressure at the nucleation simultaneously. A series of experiments clearly showed that smoke particles condense homogeneously only in a very high supersaturated environment [1-3]. In a preliminary experiment using tungsten trioxide, the smoke particles condensed with a degree of supersaturation as high as $\sim 10^6$. In this process, since evaporant is continuously supplied into the surrounding of the evaporation source, the flow of smoke after the nucleation and growth of nanoparticles has been simply considered as a consecutive process. The nucleation and growth of smoke particles should be a rapid process (ms order) due to high supersaturation, so the concentration of the evaporated vapor drastically decreases. However, the details of the formation process remain unknown.

In this study, we attempted to visualize the nucleation of nanoparticles and motion of smoke using a high-speed polarization image sensor (Photron Inc.) to clarify the details of the nucleation process of smoke particles. Since the sensor itself has pixels with micro-polarizers, a phase shift interferogram can be obtained in less than a millisecond because of the lack of mechanical movement free, and can therefore be applied to rapid phenomena such as nucleation in vapor phase. Here, we show the preliminary results of homogeneous nucleation of tungsten oxide from vapor phase.

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