Crystallographically Favored Attachment of Just-Nucleated MoO_3 Nanoparticles in Gas Current

*Shinnosuke Ishizuka[1], Yuki Kimura[1], Rikako Satoh[1], Tomoya Yamazaki[1], Tetsuya Hama[1]

1. Institute of Low Temperature Science Hokkaido University

Nucleation and subsequent growth processes via homogeneous nucleation in vapor are enigmatic. To investigate evolution of phases, chemical composition and shape of just-nucleated nanoparticles in cooling evaporant, we developed a noble experimental apparatus that enables in-situ spatial scan of nucleating and growing nanoparticles with transmittance FT-IR spectroscopy. Here we experimentally show direct evidence that molybdenum oxide nanoparticle, just-nucleated from evaporated vapor, grown via attachment with crystallographically favored orientation in a gas current generated by the evaporation source. Just-nucleated nanoparticles showed characteristic IR absorbance of needle shaped MoO_3 and gradually changed into that of cubic and polyhedral shaped MoO_3 in ascending gas current. Each IR feature is consistent with that obtained by ex-situ IR measurements and morphological evolutions of collected nanoparticles. All needle, cubic and polyhedral shaped nanoparticles are attributed to MoO_3 with monoclinic crystal structure. The needle shaped nanoparticles are always elongated to [100] direction. Some particles, collected at growing zone, were partially attached at perpendicular planes to (100). We consider that the needle shape is the result of anisotropic growth of just-nucleated nanoparticles in supersaturated vapor. Then, the attachment between needle shaped particles fortuitously collided with the favorable orientation resulted in formation of cubic and polyhedral shaped particles in a gas current. These findings enrich the view on the pathways in nucleation and growth in vapor and give new insights into inter-particle forces that drive oriented attachment growth.

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