# Multi-Dimensional Liquid Phase TEM for Studying Nanomaterials

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Most of nanocrystal synthesis and their uses are developed empirically with a limited mechanistic understanding. It is mainly because of their size and heterogeneity in structures and physical properties which cannot be easily accessible by conventional analytical methods. Liquid cell TEM (LTEM) has been introduced recently for in-situ study of chemical reactions occurring in liquid. Liquid cells allow an opportunity to utilize high spatial and temporal resolution of TEM in studying reactions of colloidal nanoparticles. Achieving sub-nm spatial resolution by adjusting the thicknesses of window materials and the encapsulated liquid, important steps in growth trajectories of different types of nanoparticles have been directly observed at high-resolution of TEM. Along with computational analysis we develop in our group and its application to analyzing in situ LTEM image series, we study growth trajectories of ensemble number of nanoparticles. We also observe the 3D atomic structure of individual particles freely moving in liquid.