In situ Microscopy Studies of 0D, 1D, and 2D Structures – Small Clusters, Nanowires, and Graphene

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Progress in nanoscience and technology depends on the ability to systematically organize, manipulate, and characterize matter at the nanoscale. This can only be achieved through a detailed atomic-level understanding of the kinetic processes, mass transport mechanisms, chemical reaction paths, and material thermodynamics controlling the synthesis and stability of materials.

Our group focuses on *dynamic* characterization of materials as a means to identify the factors influencing the structural, morphological, and compositional evolution of materials *during* synthesis. We use *in situ* characterization tools such as variable-temperature and variable-pressure scanning and transmission electron microscopies (SEM and TEM), scanning tunneling microscopy (STM), and low-energy electron microscopy (LEEM), to investigate: thermal/chemical stability of nanocrystals (0D), nucleation and growth of one-dimensional (1D) nanowires, and 2D graphene thin films.

In this talk, I will present a brief overview of our ongoing research efforts in all these areas. Specific examples include:

(1) *in situ* high-resolution, temperature-dependent (25 - 1000 ^{o}C) TEM observations of changes in morphology, structure and composition of TiO_2/C core/shell structures,

(2) *in situ* TEM studies of Si and Ge nanowire nucleation and growth kinetics, and

(3) *in situ* STM studies of graphene growth on Pd(111) during chemical vapor deposition at temperatures between 450 and 750 ^{o}C.