Mesoscale Priority Research Direction

Understanding and Controlling Self-Assembly of Inorganic Nanoparticles through Mass-Selected Ion Deposition

Opportunity

There is a significant gap in understanding the design principles of functional mesoscale materials.

Traditional synthesis approaches yield a distribution of NP sizes/compositions making it difficult to obtain understanding of structure-function relationships.

Mesoscale properties are determined by NP size, composition, density, and interactions. Capabilities are needed to control these parameters in 2D and 3D assemblies.

Directed self-assembly of selected monodisperse NPs into 2D and 3D mesoscale structures is challenging.

Meso Challenge

Controlled synthesis and self-assembly of inorganic NPs into inorganic or mixed organic-inorganic materials is critical for the development of novel mesoscale materials with desirable chemical and physical properties.

Approach

Non-equilibrium synthesis of bare, alloy and core-shell NPs by laser vaporization and magnetron sputtering.

Precise control of the size and composition of NPs using mass-selected ion deposition.

Controlled self-assembly of NPs by tailoring chemical and physical properties of the surface.

Design materials with chemical reactivity and selectivity towards critical fuel products by combining experiments and theory.

Synergistic interactions with applied programs.

Impact

New approaches for the directed self-assembly of functional mesoscale materials with desirable properties from precisely defined NP constituents.

Fundamental understanding of structure-property relationships necessary for further improvement of mesoscale materials.

U.S. DEPARTMENT OF ENERGY | Office of Science

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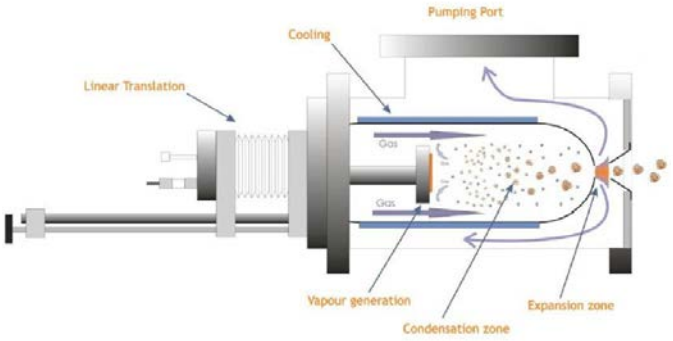
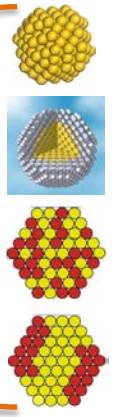
Integration of Synthesis, Characterization and Theory to Understand and Control Nanoparticle Self-Assembly

1. Non-equilibrium NP synthesis





Pure

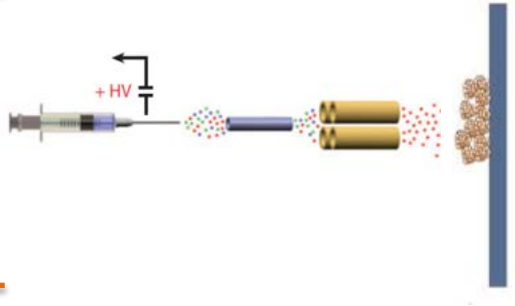
Core-shell

Alloy

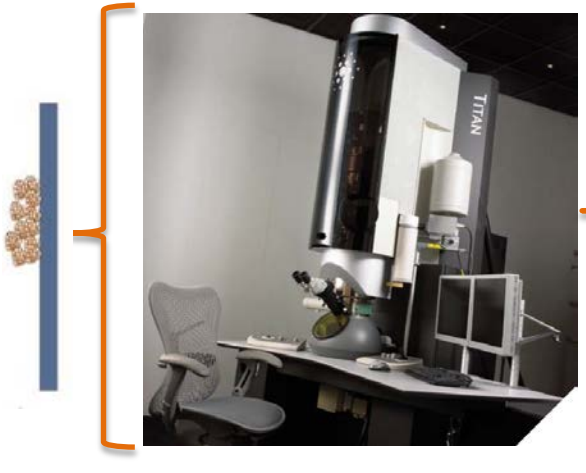
Cluster-in-cluster

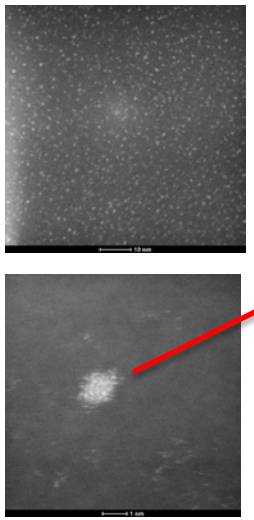
2. Mass-selected NP deposition

3. Mass-selected linker/spacer molecule deposition

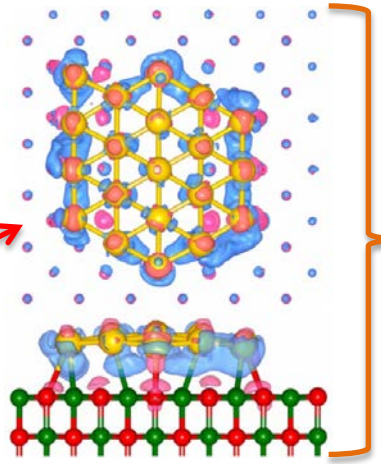


4. Characterization

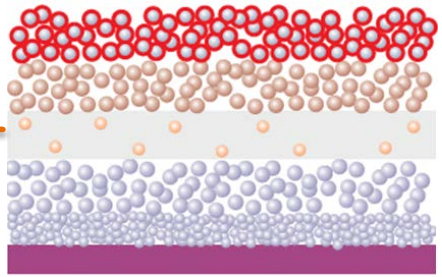




5. Theory



6. Mesoscale material assembled from well-defined NP constituents



References: Johnson. et. al. ACS Nano, 6 (2012) 573.
Johnson. et. al. Ann. Rev. Anal. Chem. 4 (2011) 83.