Mesoscale Priority Research Direction

Self-organization of Materials under Irradiation

Opportunity

Materials self-organization under extreme conditions of energetic particle irradiation occurs on their surface (e.g. nano-dot/ripple patterns) and in their bulk (e.g. defect clusters and void superlattices). From application perspective, this is a cost-efficient bottom-up approach to synthesis of novel materials: (1) patterned surfaces can be decorated with functional attachments, (2) restructured bulks can be injected with functional dopants. But for relevant physical phenomena, fundamental relationships between their evolving structural, physical and chemical parameters/observables are poorly understood.

Approach

Unite experimental structural, physical and chemical information in the framework of one theoretical model. Conduct theory-inspired multi-modal experiments (i.e many observables) in concert with multiscale simulations (i.e. atomistic to continuum). Perform materials processing and synthesis in combination with in-situ multi-dimensional characterization (e.g. imaging mass spectrometry in conjunction with electron microscopy and/or synchrotron-based X-ray probes). Synergistically link the great variety of data from different experimental techniques with results of simulations.

Meso Challenge

Identify irradiation conditions, particle species (atomic, cluster and molecular ions, neutrons, electrons, photons, and/or their combinations) and attachments/dopants, that predictably and reproducibly lead to targeted mesoscale structures and functionalities, then synthesize the desired architectures by directed self-organization and look for new phenomena and emerging applications.

Impact

Understanding the surface and bulk self-organization under irradiation promises to enable "materials by design" approach for a wide range of material classes (inorganic /organic /biological/hybrid) and over a wide dimensional scale (nanometers to meters), and to find working recipes for template assisted self-assemblies and radiation-resistant /self-healing materials.

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