Mesoscale Priority Research Direction

# Nanomaterial-Based Complex Architectures for Structural and Functional Heterogeneity

## Opportunity

By harvesting and building on recent advances in nanomaterial science and engineering, we have the opportunity to design new materials for energy efficiency and high energy environments.

**Why?** Commonly used materials have limited functionalities and inferior properties (dictated by their microstructure: interfaces, grain boundaries, defects). Nanoscale structured composites (e.g. nanolaminates, composite nanowires, nanofoams), exhibit remarkable mechanical & electrical properties with excellent thermal stability and resistance to harsh environments.

**Current-state-of-the-Art:** Materials science and engineering has made significant advances in understanding and identifying of the fundamental mechanisms that control the behavior of nanoscale structured materials: control of material heterogeneity, interfacial topology and chemistry, as well as designing layers with different functions.

## Meso Challenge

Understand how targeted mesoscale functionalities, phenomena and properties materialize from the nanoscale.

## Approach

- Develop mesoscale steps to bridge the length-and-time gaps: Atomistic; microscale (discrete systems); mesoscale (complex large-scale architecture composed of nanoscale-based units).
- Develop statistical approaches to understand large data sets while exploiting our knowledge of mechanisms.
- Develop models for collective behavior of interfaces, grain boundaries and defects.
- Develop new algorithms to integrate the hierarchical structure into multiscale models for complex self assembled architecture.

## Impact

The potential of nanostructure-based materials with controlled architecture can be transformational from a technological point of you. Surface coatings of exceptional wear or fatigue/radiation resistance, MEMS devices with high performance and reliability, and lightweight panels for automotive and aerospace industries, can lead to new performance level not achievable with current materials and as such can have a significant energy and economical impact.

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