Mesoscale Priority Research Direction

Damage Accumulation in, and Lifetimes of Materials

Opportunity

Most structural materials are limited by damage accumulation

Examples: gas turbine engines, bridges, automobiles, planes, medical devices

The key defect is the dislocation

- **Collective behavior of dislocations is key**
- **Difficult to identify and understand mechanisms**
- **Defects can evolve dynamically**

Mesoscience to predict the performance of new materials & structures

Meso Challenge

Mesoscale systems are typically dynamic and aggregated (often massively)

"Functional" defects and their evolution (reliability) limit value of nano/meso scale systems

How can we identify, locate, and characterize the collective behavior of defects?

How can we correlate and recognize mechanisms (process, structure) that cause the damage initiation?

Can we optimize materials to postpone damage initiation?

Approach

New 3-D mesoscale microscopies

Structural, Mechanical, Chemical, electrical, thermal, ...

Large-scale computation at multiple levels, e.g. dislocation dynamics, e.g. microstructurally accurate deformation simulations

New science for models of collective behavior of defects, e.g. stat. mech. of dislocations, constitutive relations for mesoscale modeling, interfaces

Exploit statistical approaches to understand large data sets while exploiting our knowledge of mechanisms

Impact

Defects are known to be the prime limitation on lifetime for both established *and* new materials

Identifying and understanding defects in mesosystems is a significant driver for advances in instrumentation and facilities

Stimulate a focus on defects-process-structure-properties paradigm

Improved materials, new materials for transportation, energy, medical applications

References:

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