# Material state and damage evolution in dynamic loading

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A comprehensive understanding of microstructure-based heterogeneity and its consequences for materials damage & failure and phase transformation initiation is presently lacking. Concentration and spatial variability in compositional and dissipative defects add to the difficulty of understanding dynamic effects in polycrystalline microstructures. Dislocations can be activated / nucleated and phase boundaries can be crossed during dynamic deformation. Many materials also produce twin or slip band structures with deformation which produce further heterogeneity within individual crystals. Future tools will need to probe the physics of dynamic solid-solid phase transformation and damage at length scales approaching those at which they nucleate in order to gain a detailed understanding of this process and the influence real material microstructure has on these events. The extreme conditions encountered under dynamic loading provide the setting to explore the interplay between mechanical and thermal processes in these complex systems. Such studies of interest would include the determination of melt curves, crystal structures, phase stability and metastabilty, microstructures and mechanical strength, and chemical bonding, over a broad range of pressure, temperature, and time. Several examples will be described briefly. The high explosive organic material cyclotrimethylene trinitramine will be discussed in more detail as it exhibits suspected phase and defect evolution behavior that are prime targets for probing with next-generation hard x-ray tools. Throughout, the discussion will be framed by how these tools fit into the landscape of future needs in understanding materials in extreme environments.

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