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Pressure-induced amorphization and polyamorphism: Inorganic and biochemical systems

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A B S T R A C T

Pressure-induced amorphization (PIA) is a phenomenon that involves an abrupt transition between a crystalline material and an amorphous solid through application of pressure at temperatures well below the melting point or glass transition range. Amorphous states can be produced by PIA for substances that do not normally form glasses by thermal quenching. It was first reported for ice I_h in 1984 following prediction of a metastable melting event associated with the negative initial melting slope observed for that material. The unusual phenomenon attracted intense interest and by the early 1990s PIA had been reported to occur among a wide range of elements and compounds. However, with the advent of powerful experimental techniques including high resolution synchrotron X-ray and neutron scattering combined with more precise control over the pressurization environment, closer examination showed that some of the effects previously reported as PIA were likely due to formation of nanocrystals, or even that PIA was completely bypassed during examination of single crystals or materials treated under more hydrostatic compression conditions. Now it is important to understand these results together with related discussions of polyamorphic behavior to gain better understanding and control over these metastable transformations occurring in the low temperature range where structural relaxation and

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equilibration processes are severely constrained. The results will lead to useful new high-density amorphous materials or nanocrystalline composites containing metastable crystalline varieties and the experiments have driven new theoretical approaches to modeling the phenomena. Here we review the incidence and current understanding of PIA along with related phenomena of density- and entropy-driven liquid–liquid phase transitions (LLPT) and polyamorphism. We extend the discussion to include polymeric macromolecules and biologically-related materials, where the phenomena can be correlated with reversible *vs* irreversible unfolding and other metastable structural transformations.

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