
Novel Transrotational Solid State Order Discovered by TEM in Crystallizing Amorphous Films and New Model of Amorphous State Based on Nanocrystals with Curved Lattice

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Abstract

Exotic thin crystals with unexpected **transrotational** micro-, nanostructures [1] have been discovered by transmission electron microscopy (TEM) for crystal growth in thin (10-100 nm) amorphous films of different chemical nature (oxides, chalcogenides, metals and alloys) prepared by various methods. The unusual phenomenon can be traced ***in situ*** in TEM column during local e-beam heating, Fig.1a-b, or usual annealing): dislocation independent regular internal bending of crystal lattice planes in a growing crystal. It can take place also during aging like self-organization. Such **transrotation** (unit cell **trans**lation is complicated by small **rotation** realized round an axis lying in the film plane) can result in strong regular lattice orientation gradients (up to 300 degrees per μm) of different geometries: cylindrical, ellipsoidal, toroidal, saddle, etc. Transrotational microcrystal resembles ideal single crystal enclosed in a curved space. Some crystal types have bending of atom/lattice planes similar (but much lower) to that of nanotubes and nanonions. Complex skyrmion-like lattice orientation texture is observed in some spherulite crystals, Fig.1b. Transrotation is strongly increasing as the film gets thinner. Transrotational micro crystals have been eventually recognized by other authors in some vital thin film materials, i.e. PCMs for memory [2-3]. Atomic model and possible mechanism of the phenomenon, Fig.1c, are discussed. New nanocrystalline models of amorphous state are proposed: fine-grained structures with lattice curvature (in particular - transrotation), Fig.1d. Thus the great variety of different transrotational lattice geometries inside fine crystal grains (e.g., complying with different conformal transformations described mathematically for 2D case) in the static model corresponds to different amorphous structures hardly distinguished by usual methods but inevitably resulting in distinct physical properties. Going to 3D clusters of positive or/and negative curvature and dynamics we propose the hypothesis of "dilatons" and "contractons" pulsating or/and circulating in amorphous/glassy solids.

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