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Is "metamictization" of zircon a phase transition?

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ABSTRACT

Diffuse X-ray scattering from single crystals of metamict zircon reveals residual crystallinity even at high fluences (up to 7.2×10^{18} α-decay events/g). The experimental evidence does not suggest that radiation-induced amorphization is a "phase transition." The observations are in good agreement with a nonconvergent, heterogeneous model of amorphization in which damage production is a random process of cascade formation and overlap at increasing fluence.

Instead of an amorphization transition, the existence of a percolation transition is postulated. At the level of radiation damage near the percolation point, the heterogeneous strain broadening of X-ray diffraction profiles is reduced whereas the particle-size broadening increases. Simultaneously, the macroscopic swelling of the zircon becomes larger than the maximum expansion of the unit-cell parameters. A suitable empirical parameter that characterizes this transition is the flux, D_s, at which the macroscopic expansion is identical to the maximum expansion of the crystallographic unit cell. In zircon, $D_s = 3.5 \cdot 10^{18}$ α-decay events/g.