

Coexistence of twisted and untwisted crystals: An impurity/structural order model with implications for agate patterns

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ABSTRACT

Coexistence of twisted and untwisted crystals is explained via a model that accounts for the coupling of the entropic and energetic effects of impurities and a supra-lattice-scale structural order parameter. It is shown that twisted impure crystals can be in equilibrium with untwisted purer ones. The model explains how coexistence can occur in agates and other systems under hydrostatic stress. The model implies that untwisted crystals grown under one set of conditions could undergo a phase separation that, when accompanied by an imposed compositional gradient, leads to commonly observed, alternating bands of twisted and untwisted crystals and, when occurring in the absence of an external gradient, mossy patterns of crystal texture can emerge. This phenomenon is not related to anisotropic applied stress. Rather coexistence is a consequence of a compositional segregation/twist phase transition. Since twist coexistence is a compositional equilibrium, it arises from the exchange between bulk phases; hence, the detailed nature of the atomic structure within an interface between twisted and untwisted zones is not relevant. The approach places crystal-twist phenomena within the theory of order/disorder phase transitions.

Keywords: Agate, agate banding, free energy model, phase separation, quartz fibers, self-organization, twisted crystals, twisted/untwisted crystal equilibria