Energy-Minimizing Microstructures in Multiphase Elastic Solids

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The elastic energy of a two-phase solid is a function of its microstructure. Determining the relaxed energy of such a solid and characterizing the associated extremal microstructures is an important problem that arises in the modeling of the shape memory effect, microstructure evolution, homogenization of composites and optimal design. We compute the relaxation under fixed volume fraction for a two-well linearized elastic energy in three dimensions when the elastic moduli are isotropic (with no restrictions on the transformation strains) and show that there always exist rank-one, -two or -three laminates that are extremal.

Predicting the recoverable strains of shape memory polycrystals is a central open problem in the study of shape memory alloys. This in turn requires an understanding of the possible stress and strain fields that arise in such polycrystals. We show that in some shape memory polycrystals the strains fields associated with macroscopic recoverable strains are related to the solutions of hyperbolic PDE. We also show that stress fields in such polycrystals could be concentrated on lower-dimensional surfaces.

This is joint work with Kaushik Bhattacharya at the California Institute of Technology.