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Role of microstructural heterogeneities on rupture of polycrystalline materials

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Grain boundary networks are the dominant heterogeneity in many polycrystalline materials, and their performance may be dramatically improved by increasing the fraction of boundaries which have either low grain boundary misorientation or which are special boundaries, such as coincident site lattice boundaries. Significant improvement in properties such as corrosion resistance, critical current in superconductors and mechanical strength and toughness occur, provided special percolating grain or grain boundary structures can be engineered. Nevertheless, grain boundary network correlations constrain the extent to which property improvements can be achieved. A common deleterious effect is that degraded boundaries have a tendency to cluster in linear chains leading to unexpected reductions in performance. After an introduction to the area, scaling laws and the results of large scale simulations of percolation, critical manifolds and rupture in polycrystals will be presented. In particular, deleterious effects due to grain boundary correlations will be elucidated and strategies for their mitigation will be discussed.