Continuum Framework for Dislocation Structure, Energy and Dynamics of Dislocation Arrays and Low Angle Grain Boundaries

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We present a continuum framework for dislocation structure, energy and dynamics of dislocation arrays and low angle grain boundaries which may be nonplanar and nonequilibrium. In our continuum framework, we define a dislocation density potential function on the dislocation array surface or grain boundary to describe the orientation dependent continuous distribution of dislocation in a very simple and accurate way. The continuum formulations of energy and dynamics include the long-range interaction of constituent dislocations, local line tension effect of dislocations and the cooperative motion of dislocations, which are derived from the discrete dislocation model. The continuum framework recovers the classical Read-Shockley energy formula when the long-range elastic fields are canceled out. Applications of our continuum framework are presented for dislocation structures on static nonplanar low angle grain boundaries and misfitting interfaces.