Elementary mechanisms of shear coupled grain boundary migration

In conventional crystalline solid, the plastic deformation is due to the mobility of dislocations. In polycrystalline materials, grain boundaries (GB) are static obstacles to dislocations motion. Consequently, in nano-crystalline materials (grains sizes <100nm), the dislocation-mediated plasticity is reduced or even absent. In such conditions, grain boundary (GB) migration can occur as an alternative vector of plasticity. Among the possible GB-based mechanisms, both experiments and molecular dynamics simulations have evidenced the shear-coupled GB migration (SCGBM) as a dominant plastic mechanism at low temperature, for low- and high angle GB. The application of a shear stress on the GB induces its migration coincidently with the relative in-plane translation of the two grains forming the GB. We report a detailed study of the elementary mechanisms of the SCGBM. Most of the results are theoretical and numerical, but few experimental results mainly using transmission electron microscopy are also shown. We show that the GB migration of a perfectly flat GB occurs through the nucleation of two mobile disconnections with opposite Burger vector and their migration in opposite direction. Disconnections are GB line defects that have both a height and a dislocation character. We show that for a given GB, different disconnections can nucleate corresponding to different GB migration modes. Finally, we address the case of heterogeneous disconnections nucleation. In real materials, the presence few dislocations that can eventually get trapped by a GB under applied stress cannot be avoided. We show the mechanism of migration of a GB that have absorbed a dislocation as an example of heterogeneous disconnection nucleation. We reveal a new SCGBM mechanism through the nucleation of mobile disconnections from an immobile one.