Smart microstructures by non-ergodic martensitic transitions

Jörg Neugebauer, Fritz Körmann, Ivan Bleskow, Tilmann Hickel
Max-Planck-Institut für Eisenforschung, Max-Planck-Str. 1, 40237 Düsseldorf, Germany, neugebauer@mpie.de

A novel design route to achieve structural materials with superior mechanical performance is the incorporation of a dynamic microstructure that adapts to local mechanical loads. Rather than having a fixed grain size the new materials form above a critical load extended defects that effectively reduce the grain size leading to reduced free dislocation paths length and thus hardening. These adaptive mechanisms ensure that hardening sets in only in regions where strain and thus potential failure are largest. A popular way to realize such an adaptive mechanism are martensitic transitions which induce in the bulk material extended defects such as stacking faults or twins. This strategy is e.g. successfully employed in modern TRIP (transformation induced plasticity) and TWIP (twinning induced plasticity) steels that combine ultra-high strength with good ductility.

To design such materials it is critical to know how the energetics to create such extended defects depends on the chemical composition, local strain, and temperature. These dependencies, however, are difficult to obtain from experiment. Combining accurate first principles calculations with mesoscopic/macroscopic thermodynamic and/or kinetic concepts allows now to address this issue and to accurately determine these energies. In the talk fundamental ideas behind these approaches [1, 2], their predictive power as well as applications in modern steel design will be presented [3, 4].

References


