Hierarchical twinning governed by defective twin boundary in metallic materials

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Defects make crystal interesting and bring about huge potential to enhance the properties of materials. As a typical example of defect engineering, dense networks of deformation twins can endow metals and alloys with unprecedented mechanical properties. However, the formation mechanism of these hierarchical twin structures remains under debate, especially their relations with the imperfect nature of twin boundaries (TBs). In this talk, we reveal the intrinsic deformability of defective TBs in face-centered cubic metallic materials via combined trans-scale mechanical testing, in situ transmission electron microscopy (TEM) and atomistic simulations. The inherent kinks on a set of primary TBs tend to facilitate the formation of secondary and hierarchical nanotwins, which is critically dependent on the kink height. Moreover, such defect-driven hierarchical twinning propensity proves to be generally applicable in a variety of metals and alloys with low stacking fault energies. As a geometric extreme, a fivefold twin can be constructed via this self-activated hierarchical twinning mechanism. These findings differ from the conventional twinning mechanisms, enriching our understanding of twinning-mediated plasticity in metallic materials.