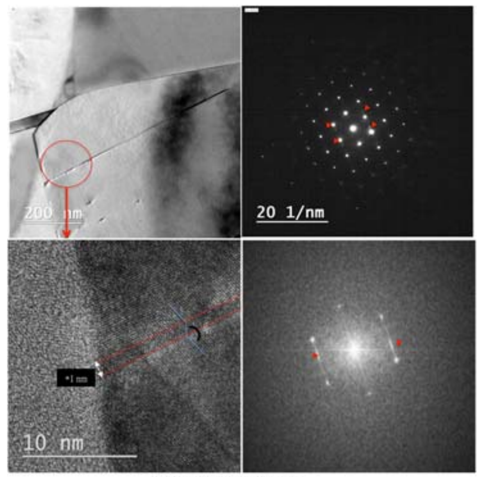
2019.2.8

The grain size effect on deformation twinning mechanism for Twin-induced plasticity (TWIP) steel

Chang-Yu Hung, Yu Bai, Nibuhiro Tsuji and Mitsuhiro Murayama

MSE Virginia Tech, MSE Kyoto University

Abstract



Deformation Nanotwin

The trade-off between strength and ductility for ultrafine-grained alloy design is a long-standing issue in materials science and engineering. Most approaches for increasing ductility often sacrifice the strength. In the past decades, several design principles for improving strength and ductility simultaneously have been proposed to satisfy specific industry needs, for example, severe cold rolling at liquid nitrogen temperature, then followed by single recovery heat treatment for acquiring bimodal grain size and tailoring stacking fault energy by alloying, etc. Among these methods, lowering stacking fault energy (SFE) by alloying is generally believed to be an efficient way to improve both mechanical properties because twin-induced plasticity (TWIP) effect can take place when the SFE is in the range of 12 mJ/m^2 to 55 mJ/m^2. Deformation twins can act as obstacles to dislocation movement, reducing the mean free path of dislocations and resulting in a strong strain hardening that leads to increase strength and ductility simultaneously. Due to the importance of deformation twins in ultrafine-grained materials, the formation mechanism of twins with different grain size needs to be revealed and examined with a proper experimental setup. In this study, a TWIP steel (Twin-induced plasticity steel) with relatively low SFE (40mJ/m^2) was selected as a model to elaborate the effect of grain refinement on twinning behavior by using electron back-scattered diffraction (EBSD) and transmission electron microscopy (TEM). In a coarse-grained TWIP steel, the interaction between pile-up dislocation and certain characteristic of grain boundary plays a critical role in twinning process. Pre-existing twin boundaries appear to be the most possible boundary for the nucleation of deformation twins in the early stage of plastic deformation. On the other hand, when average grain size decreases to less than 1 μm, the nucleation mechanism of deformation twins is altered. Deformation twins are still nucleated from grain boundaries in the onset of plastic deformation but the interaction between pile-up dislocations and grain boundaries is not observed. It seems that the deformation twinning process for the ultrafine-grained TWIP is initially observed at grain boundary; but the role of the grain boundaries during deformation is still unclear. More detailed characterization such as in-situ TEM will be applied to clarify this.

Biography

Chang-Yu Hung is a Ph.D. candidate advised by Dr. Murayama in the MSE department. He received his bachelor and master's degree in Materials Science & Engineering from National Chung Hsing University, Taiwan, in 2011 and 2015, respectively. He also served in the army from 2011 to 2012 as a combat engineer. Before starting his Ph.D. in VT, he was a research associate in National Taiwan University, Taiwan, and was responsible for the studies of dye-sensitized solar cell. He is currently working on the deformation behavior of TWIP steel with TEM.