High-pressure torsion triggered diffusive phase transformation in a twinning-induced plasticity steel

An, X.[1]

[1] School of Aerospace, Mechanical and Mechatronic Engineering, University of Sydney, Australia

By recourse to a series of advanced characterization techniques including X-Ray diffraction, scanning electron microcopy-electron backscatter diffraction (SEM-EBSD), SEM-transmission kikuchi diffraction (SEM-TKD), transmission electron microscopy and atom probe microscopy, the microstructural evolution of twinning-induced plasticity (TWIP) steel during high-pressure torsion (HPT) processing at 573 K was systematically explored. Due to the high processing temperature, the formation of a homogeneous nanostructure was primarily dominated by complicated dislocation and grain boundary activities in lieu of deformation twinning. Apart from the grain refinement process, phase transformation took place at late stages of deformation, resulting in the microstructural fingerprint of equaxied nanograins with multiple phases in the steel. On account of remarkable elemental redistribution, the diffusion-controlled nature of the transformation was convincingly identified. During the transformation, although the cementite also initially formed, austenite eventually decomposed into ferrite and Mn-riched M23C6 carbide, implying that Mn is the pivotal alloying element for the transformation kinetics. Owing to the sluggish bulk diffusivity of Mn, it is proposed that a high density of defects, nanostructures and the HPT processing play a crucial role in promoting the elemental diffusion and segregation and in stimulating the phase transformation. Such diffusional phase transformation may be employed to hierarchically manipulate the microstructures through adjusting the processing conditions to design advanced steels with superior mechanical properties.

Acknowledgement: The authors are grateful for the technical support from the Australian Microscopy & Microanalysis Research Facility node at the University of Sydney. This work is financially supported by the Australian Research Council (DE170100053).

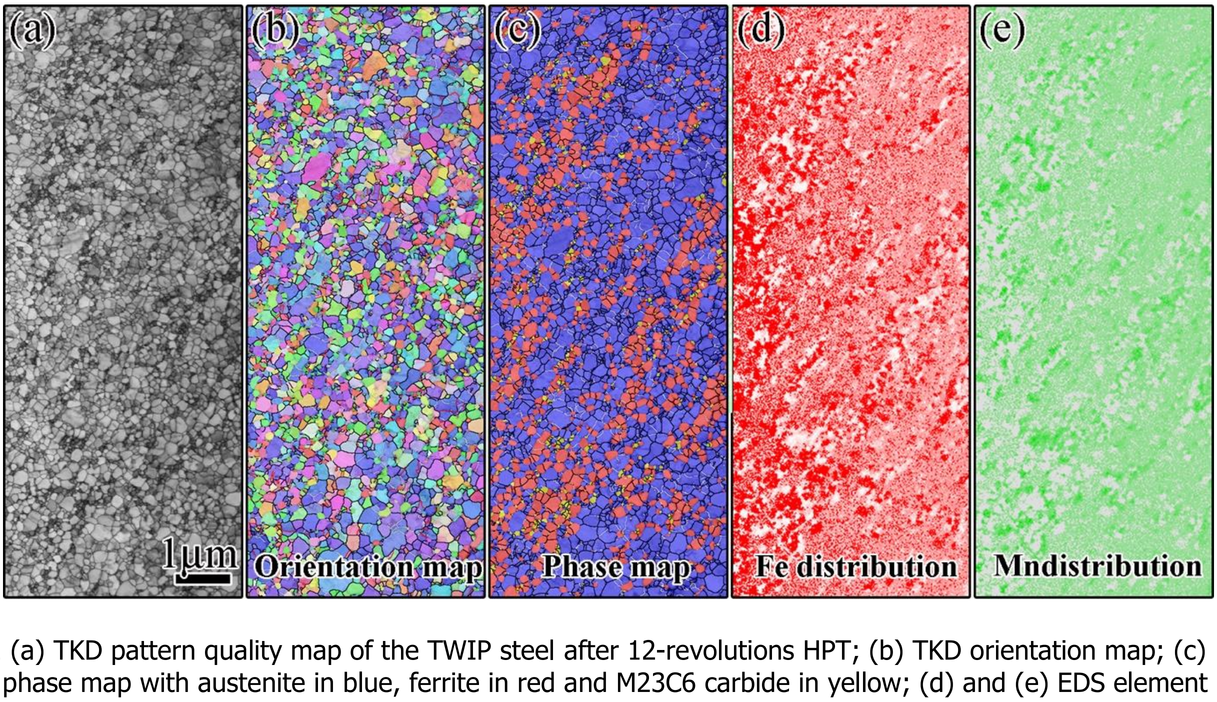

Fig.1 (a) TKD pattern quality map of the TWIP steel after 12-revolutions HPT; (b) TKD orientation map; (c) TKD phase map with austenite in blue, ferrite in red and M23C6 carbide in yellow; (d) and (e) EDS element maps showing Fe and Mn Kα X-ray counts, respectively.