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In-situ neutron diffraction and multi-scale modeling of mechanical behavior of the CNT/Al composite

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Aluminum matrix composites (AMCs) today are widely used in in automobile, aerospace and other engineering industries. Single-walled or multi-walled carbon nanotubes (CNTs) are attractive reinforcements for fabricating high performance AMCs, because of their extremely high strength and modulus, low density and good physical properties. So far, many works have shown that the CNTs can improve the strength and the stiffness of the composites. However, they can have adverse influences on the ductile failure properties like ductility and fracture toughness.
In many literatures, the strengthening mechanisms of CNT/Al composites have been analyzed via analytical method [1-3]. However, in these analyses, the experimental evidences for the Orowan and the thermal mismatch strengthening mechanisms were not well established. Meanwhile, the analytical method cannot give deep insight into the micro-mechanism of strengthening of CNTs and deformation behavior of CNT/Al composites.
In this study, a CNT/Al composite and a corresponding unreinforced Al alloy were manufactured via friction stir processing and rolling techniques. The in-situ neutron diffraction (performed at FRM II) during tension of the CNT/Al composite and the Al alloy was conducted. The crystal lattice strains were determined. A crystal plasticity finite element model was also developed to quantitatively predict the micro-mechanical behaviors of the composite and the alloy. The micro-mechanism of strengthening of CNTs and deformation behavior of CNT/Al composite were analyzed and discussed.

References

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