

# Strengthening, toughening and micromechanism of laminated composites with HCP metal: an example of Ti/Nb multilayers

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**Abstract.** Heterophase interfaces play a crucial role in deformation microstructures and thus govern mechanical properties of multilayered composites. In such materials, the load transfer, redistribution, and strong constraints of the heterogeneous interfaces between constituent metals directly affect macroscopic mechanical properties. On the other hand, the appearance of shear bands also plays a crucial role in the co-deformation of different metals. Here, we fabricated Ti/Nb multilayers by accumulative roll bonding (ARB) where shear bands became predominant with increasing rolling cycles. To explore correlation between micromechanical behavior and mechanical properties of the composites with various lamellar morphologies, in-situ high-energy X-ray diffraction tensile tests were performed. The results quantitatively reveal that the rapid strengthening of the composites with increasing ARB cycles mainly originates from the Nb layers strengthened by dislocations, grain boundaries and heterophase interfaces, and the {211} grains mostly contribute to the global strain hardening. The softer Ti grains also extend global strain hardening to a wide range and postpone necking. Furthermore, complete stress state analysis shows that in the presence of extensive shear bands, significant load partitioning between the neighboring metals leads to triaxial stresses in each constituent and dislocations tend to slip along the shear direction. This promotes dislocation multiplication and motion, which is conducive to overall strength enhancement while maintaining a satisfactory ductility. Deformation incompatibility in the Ti/Nb composites under uniaxial tension was also revealed by in-situ neutron diffraction, showing that the hetero-deformation induced (HDI) hardening and interphase stress had the similar evolution trend. This is an indication that HDI hardening is directly related to deformation incompatibility between the constituent metals, and thus the interaction between dissimilar metals can be used as an important indicator for evaluating HDI strengthening and hardening.

**Keywords:** Ti/Nb multilayers, micromechanical behavior, high-energy X-ray diffraction, lattice strain

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