Interface effects of nanolayered metallic composites

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Future energy and defense applications require high strength as well as robust materials that can maintain their properties under extreme conditions of temperature, strain, and nuclear radiation. Promising material candidates for these applications are nanostructured materials. However, less attention has been paid to nanostructured multi-phase materials, which contain a higher density of heterophase interfaces than grain boundaries. Of particular interest are composites comprised of two phases that do not chemically mix, leading to bimetal interfaces that are sharp and potentially ordered in atomic structure. The ability to achieve such structural order opens up an alternative route for materials design involving tuning the physical properties of the bimetal interfaces rather than those of the phase(s).

In this work, nanolamellar Cu-Nb composites in the form of bulk sheet with high interfacial content are fabricated via accumulative roll bonding (ARB). The composite with a bimetal spacing of 10 nm achieves a hardness of 4.13 GPa and maintains it (4.07 GPa), even after annealing at 500 °C for one hour. The outstanding stability can be attributed to the energetically favourable nature of the atomically well-ordered bi-metal interfaces. Moreover, the atomic structures of bi-metal interfaces in macroscale nanomaterials suitable for engineering structures can be significantly altered via changing the ARB processing pathway. The atomic interface structures, which control the interactions between the interfaces and dislocations, as well as radiation defects, play a key role in tuning mechanical properties and radiation resistance. This discovery sheds light on designing advanced structure materials via interface engineering.

1. S.J. Zheng, I.J. Beyerlein, J. Wang, J.S. Carpenter, W.Z. Han, and N.A. Mara,Deformation twinning mechanisms from bimetal interfaces as revealed by in situ straining in the TEM, Acta Materialia **60,** 5858-5866 (2012).
2. S.J. Zheng, I.J. Beyerlein, J.S. Carpenter, K.W. Kang, J. Wang, W.Z. Han, and N.A. Mara,High-strength and thermally stable bulk nanolayered composites due to twin-induced interfaces, Nature Communications **4,** 1696 (2013).
3. S.J. Zheng, J.S. Carpenter, R.J. McCabe, I.J. Beyehein, and N.A. Mara,Engineering Interface Structures and Thermal Stabilities via SPD Processing in Bulk Nanostructured Metals, Scientific Reports **4,** 4226 (2014).
4. S.J. Zheng, J. Wang, J.S. Carpenter, W.M. Mook, P.O. Dickerson, N.A. Mara, and I.J. Beyerlein,Plastic instability mechanisms in bimetallic nanolayered composites, Acta Materialia **79,** 282-291 (2014).
5. S. Zheng, S. Shao, J. Zhang, Y. Wang, M.J. Demkowicz, I.J. Beyerlein, and N.A. Mara,Adhesion of voids to bimetal interfaces with non-uniform energies, Scientific Reports **5,** 15428 (2015).