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Indentation size effects of mechanical behavior and shear transformation zone in thin film metallic glasses

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Abstract

Indentation size effect of mechanical behavior and shear transformation zone (STZ) in magnetron-sputtered La-Co-Al, Zr-Cu-Ni-Al, Ni-Nb and W-Ru-B thin film metallic glasses (TFMGs) has been systematically investigated with a geometrically self-similar Berkovich indenter. Unlike the crystalline metals and bulk-sized MG, the hardness in TFMGs is smaller in the lower indentation depth, which accords with the lower creep resistance and STZ activation energy. By analogy with the geometrically necessary dislocations in the crystalline materials, here we propose that the "strain-gradient-induced"~~geometrically necessary~~ STZs in MGs underneath a geometrically self-similar tip have the weakening effect instead of strengthening effect. The intrinsic profuse fertile sites in TFMGs limit the strengthening effect from scarcity of STZ nucleation sites and highlight the softening effect from "strain-gradient-induced"~~geometrically necessary~~ STZs, eventually conducing to the reverse ISE in TFMGs.