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Microstructures and mechanical reliability of nanoscale metallic multilayers

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Nanoscale multilayers, which consist of different constituents and layer interfaces, are a prospective candidate for nanostructured surfaces and coatings due to their excellent mechanical performance, such as ultrahigh strength and good wear resistance etc. To control mechanical reliability of the nanoscale multilayers, it is important to understand the relationship between microstructures and mechanical properties. In this talk, we will present two aspects on the relationship between the microstructures and mechanical behaviors in the multilayers, which were characterized by high resolution transmission electron microscope and nanoindentation testing. The first one presents the effects of the length scale and the interface structure on the strength and the strengthening ability of several kinds of nanoscale Cu-X multilayers. The second one reports the relationship between microstructures and plasticity deformation behavior. Our experimental observations and subsequent theoretical analysis clearly reveal that the heterogeneous interfaces dominate the strengthening ability of the multilayers. Plastic instability characterized by shear bands can preferentially occur in the nanoscale multilayers, which is controlled by the interface structures and the layer thickness. Fundamental mechanisms on microstructure-dominated mechanical reliability will be discussed, and the importance of the interface in mechanical behaviors of the nanoscale multilayers is addressed. Finally, several potential strategies for enhancing mechanical reliability of the nanoscale engineering multilayers will be highlighted.