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Analytic treatment of metallic multilayer strength at all length scales LAWRENCE FRIEDMAN, LEI FANG, Pennsylvania State University, Dept. of Engineering Science and Mechanics — Metallic multilayers can be used as ultra-high strength coatings. They exhibit a very pronounced size-effect where the mechanical strength depends on the layer thickness. Traditionally, the Hall-Petch Relation is used to describe the size effect. The Hall-Petch Relation is based on dislocation pileup theory, which states that the macroscopically observable strength is determined by dislocation obstacles and stress multiplication from pileups. However, more rigorous application of dislocation pileup theory as applied to multilayers predicts significant deviation from the Hall-Petch Relation due to elastic inhomogeneity, discreteness of dislocations and dislocation source operation. The necessary modifications to the Hall-Petch Relation are presented. An analytic formula accounting for these effects can only be obtained in a piecewise fashion. The variation of strength with layer thickness must be broken down into four length-scale regimes, and a simple analytic formula is obtained for each regime. This formulation allows one to bridge the length scales and predict multilayer strength from microscopic parameters (interface strength and dislocation source characteristics) and fundamental material parameters (elastic moduli, layer thickness and crystal structure). Finally, the theory is applied to Cu/Ni multilayers and theory prediction is compared with experimental data.

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