Overall mechanical behavior of nanocrystalline materials accompanied by crack initiations and propagations along grain boundaries

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Abstract: In the present research, overall mechanical behaviors of the nanocrystalline materials considering the crack initiations and propagations on the grain boundaries are investigated systematically. A mixed-mode cohesive interface model is used to describe the mixed deformation and fracture process of grain boundaries. Based on the mixed-mode cohesive interface model, the grain boundary damage and crack initiation are defined and characterized. In order to describe the size effect, the strain gradient plasticity theory is used for grain materials and a residual interface energy effect is considered along grain boundary. In the present results, the overall stress-strain relations and corresponding damage evolution curves are obtained and as the functions of several independent parameters, such as the mixed separation strength, the mixed critical energy release rate, residual interface energy density, grain size, Young’s modulus as well as strain hardening exponent, etc. The present results show that both the overall strength and ductility of the nanocrystalline materials are closely depended on the grain boundary strength and the damage evolution behaviors. By means of the damage evolution relations, the features of the overall stress-strain curves can be clearly interpreted.