Microdynamics modeling for kink deformation and delamination in multilayered solid

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Abstract

Multi-layered solids show strong anisotropy in mechanical properties that originate in intrinsic structures along stacking and transversal directions. Mostly, both the interlayer glide and interlayler delamination easily occur. However, such anisotropy sometimes yields surprising ability for deformation. For example, the material group in ceramics named MAX phases invented by [Barsoum and El-Raghy (1996)] shows superior mechanical properties that are closely related to the interlayer deformation[Barsoum and El-Raghy (2001); Eklund et al. (2010); Tromas et al.(2011)].
The interlayer deformation mechanisms divided into two classes. One is kink deformation and the other is delamination. Both are commonly observed in some multi-layered solids, e.g. hexagonal close-packed metals [Hagihara et al.(2014)]. From viewpoints of damage and fracture mechanics, the strength of materials with debonding decreases. However, the micro cracking which is related to relaxation process of strain energy sometimes improve the toughness.
In this paper, we focus on the interlayer deformation of multilayered solids. First, we assume the full compatibility of displacement and we establish the concept of lattice defect model. With considering the geometrical nonlinearity of deformation, kinking and delamination are related to lattice rotation and debonding, respectively. The former corresponds to the component of disclination dipole proposed by Volterra [Das et al. (1973)], and the latter corresponds to the misfit perpendicular to slip-plane, i.e., the component of in-plane edge Somigliana dislocations. A boundary-value problem of hyperelastic-plastic material is also studied in the context.
The microdynamics simulation of compression parallel to basal planes in Mg alloy with long period stacking ordered structure is carried out using spring-mass model. According to the parametric studies with stiffness of pair term and angular dependent term, both ridge-shaped kink structure and ortho-shaped kink deformation [Gilman (1954)] have been observed. The result agrees well with experimental studies [Hagihara et al. (2014)]. The delamination also have been observed. The deformation process is related to energy release and it is expected that we obtain knowledges for the improvement of toughness in the further study.

Keywords: Computation, Auckland, Warm Winter-in-July, Natural Beauty, Natural comfort

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