A method for modeling intergranular fracture and grain boundary sliding

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ABSTRACT

Understanding and modeling the interface behavior is an important task for predicting materials response in various applications. To formulate the behavior of an arbitrary interface, one needs to construct the relation between acting tractions and displacement jumps at the interface. In addition to capturing the correct physics of the interface, the so-called traction-separation relation must also be thermodynamically consistent and satisfy the basic balance laws (see [1]). Apart from many attempts in the literature (see [2] and [3]) to address these issues, a new and simple method to capture the complex mechanical behavior at an arbitrary interface is proposed.

A new quantity, called traction density is introduced. By simply integrating the traction density over the interface area, the overall smeared micro-traction at the grain boundary can be obtained. In this approach, the complex interface behavior in different directions is going to be automatically obtained. In other words, setting up complex phenomenological models (e.g. anisotropic plasticity and damage models) for the interface can be avoided. Furthermore, the required number of parameters to control the interface behavior can be significantly reduced.

When it comes to the grain boundary (GB) behavior in the current work, the proposed model is able to represent not only debonding behavior (intergranular fracture) but also grain boundary sliding. The proposed formulation for the interface has the following advantages: (1) there is no requirement of setting up complex phenomenological models (e.g. anisotropic plasticity and damage models), (2) balance of angular momentum is automatically satisfied at large interface opening for anisotropic interface behavior, (3) possible size effects can be captured and explained by means of a healing parameter.

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