Mechanics of Finite Cracks:
Insights from Two Length Scales

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Fig. 1. The Emperor's New Clothes, H.C. Andersen (1837)

The singular fields at an interface crack tip between two materials play a central role in many problems related to the fracture behavior of engineering materials containing interfaces. The questions associated with the nature of the fields near a crack-tip are of importance in the context of the Irwin fracture criterion (Irwin, 1957) and require a precise knowledge of the local conditions at the crack-tip. The corollary of this assertion is then that any theoretical or computational framework describing interface crack problems shall not only describe the mechanical fields in terms of the "classical" attributes of a bimaterials (elastic constants mismatch, etc) but also incorporate some representation of the interface structure.

Despite the maturity of the field of fracture mechanics, I will illustrate many outstanding challenges associated with the modeling of the mechanics of finite cracks while accounting for the interfacial structure through recent advances at two different length scales.

First the role grain boundary structure and mechanical characteristics in intergranular fracture will be examined when using a statistical approach combined with molecular dynamics simulations. I will then discuss how we can cast some of this information into a continuum formulation to extend the basic notions of interfacial fracture mechanics to include interfacial effects and represent interfacial crack fields and singularities in bimaterial interfaces. While the consideration of the interfacial structure does not affect the order of the singularity, its constructive/destructive interference effect will be clarified. Finally, based on the above, I will conclude this discussion by providing some insights on the physical significance and the obvious coupling between the interface structure and the associated mechanical fields in the vicinity of the crack tip.

[1] Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE--AC04--94AL85000.

BIOSKETCH: Rémi Dingreville is a Principal Member of the Technical Staff in the Structural and Thermal Analysis Department (org. 6233). He holds a Ph.D. in Mechanical Engineering from the Georgia Institute of Technology where his work focused on the mechanical behavior of interfaces in nanostructured materials using atomistic to continuum upscaling theories. Since then, Rémi's research areas center around microstructural effects in materials performance and aging, irradiation effects in structural materials, probabilistic mechanics and uncertainty quantification, and mechanics of generalized continua.