Influence of elastic and fracture anisotropy on architectured materials using coupled criterion and matched asymptotic approach

T. Duminy[1]*, A. Doitrand[1], S. Meille[1]

[1] Univ Lyon, INSA de Lyon, UCBL Mateis UMR CNRS 5510 7 Avenue Jean Capelle, 69100 Villeurbanne, FRANCE,
thomas.duminy@insa-lyon.fr

Architectured materials are materials for which the structure is configured across the scales in such a way that it exhibits attributes not exhibited by any of the constituents alone [1]. They encompass a large variety of applications, e.g. shock absorption, insulators. Some particular architectures enhance fracture resistance. For instance, 3D-printed-induced polycarbonate architecture can generate anisotropic toughness [2]. Nacre-like alumina (NLA) is composed of stiff alumina platelets along with a glass secondary phase presents at the platelet interfaces. The alumina platelet arrangement over the length scales induces anisotropic elastic and fracture behavior [3]. In both cases, the microstructure anisotropy plays a bivalent role on fracture behavior. On one hand, it induces anisotropy in the elastic and fracture properties, that themselves influence the fracture behavior. On the other hand, microstructure anisotropy can trigger different fracture responses [4]. Consequently, it is possible to play on both aspects to optimize microstructures with respect to toughness. Thus, a finite fracture mechanic implementation of the coupled criterion [5] is used to assess the effect of elastic and fracture parameter anisotropies on crack initiation in a notched homogeneous bending sample.

Then, the effect of elastic and fracture parameter anisotropy on crack propagation is assessed using cohesive zone models. Thus, guidelines to improve the material behavior through elastic and fracture properties optimization with respect to both crack initiation and propagation can be defined. Finally, this approach is applied on a model accounting for NLA microstructure. The effect of platelet dimensions, orientations and distribution on crack initiation and propagation is assessed. Using both a homogenous model and a model accounting for the microstructure allows to differentiate fracture reinforcement caused by solely the microstructure, or the material elastic and fracture parameters.

References

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