Abstract Submitted
for the MAR05 Meeting of
The American Physical Society

Fracture Toughness of Nacre PHANI NUKALA, SRDJAN SIMUNOVIC, ORNL — Nacre exhibits phenomenal fracture strength and toughness properties despite the brittle nature of its constituents. For example, its work of fracture is three orders of magnitude greater than that of a single crystal of its constituent mineral. This is surprising because it is a ceramic composite made up of about 95% brittle inorganic phase (aragonite mineral) and only a few percent of the soft organic material, and polymer-matrix composites with such high levels of ceramic fillers do not possess these exceptional combinations of stiffness, fracture strength and toughness. This study investigates the fracture properties of nacre using a simple discrete lattice model based on continuous damage random thresholds fuse network. The discrete lattice topology of the proposed model is based on nacre's unique brick and mortar microarchitecture, and the mechanical behavior of each of the bonds in the discrete lattice model is governed by the characteristic modular damage evolution of the organic matrix that includes the mineral bridges between the aragonite platelets. The numerical results obtained using this simple discrete lattice model are in excellent agreement with the previously obtained experimental results, such as nacre's stiffness, tensile strength, and work of fracture. The analysis indicates that nacre's superior toughness is a direct consequence of ductility (maximum shear strain) of the organic matrix in terms of repeated unfolding of protein molecules, and its high fracture strength is a result of its perfectly ordered brick and mortar architecture with significant overlap of the platelets, and shear strength of the organic matrix.

Phani Nukala
Oak Ridge National Laboratory

Date submitted: 08 Dec 2004 Electronic form version 1.4