Design of Materials for Exceptional Fracture Resistance

The resistance of a material to failure can be thought of in terms of strength, and toughness. Strength refers to the maximum stress the material can sustain before it cracks. Toughness refers to the energy absorbed in the fracture process. Ideally a material has both high strength and high toughness. Sometimes one characteristic is traded off against the other.

Recent research shows that by breaking up the uniformity of a material the overall energy absorption needed to drive a crack forward can be increased. One example is the addition of soft particles to a glassy polymer. Rather than adding soft materials this project will involve using geometry to design, test and model meta-materials with high toughness. My idea is to work with polymer sheets and to cut patterns in the sheet in a way that will increase toughness, although likely decrease strength. For example a uniform or non-uniform pattern of holes in the sheet could be used. Or a pattern of holes bridged by initially slack ligaments that gradually take up some of the load could be used. Elements of this project will include (1) literature review and study of the basic theory, (2) design and perform sheet tearing experiments on the baseline material and with patterned sheets and (3) finite element simulations of failure.

I envision taking one or two students on for a two semester project. One student's primary responsibility would be for the experiments, the other for computational simulation. Outstanding work may be lead to an article in a referred journal.

Qualifications of Student: Strong background in mechanics of materials and structures, basic understanding of materials science, working knowledge (or ability and willingness to learn) of mechanical testing procedures and finite element analysis.

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