Size and Stress State Effects on Plasticity Mediated Brittle Fracture

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Brittle to ductile transitions (BDTs) in ceramics might seem like trivial pursuit except for high temperature applications. However, the emergence of nanotechnology devices has changed the horizon. For example, to lower the BDT, one can decrease the component size. This is not the same size phenomenon that has traditionally been associated with Weibull statistics. It is proposed here with experimental evidence and a physically based theoretical model that there are potentially large shifts in BDTs of some device materials based on size and stress state. This would be applicable to many semiconductors, oxides, carbides and nitrides. Both dislocation nucleation (strength) and discretized shielding (fracture) are invoked, partially based on observations in Si, SiC and MgO as provided by nanowire, nanosphere and small volume nanoindentation evaluations. It is proposed that activation volumes for deformation and fracture of silicon nanospheres are the key physical quantity in the scaling of the BDT.