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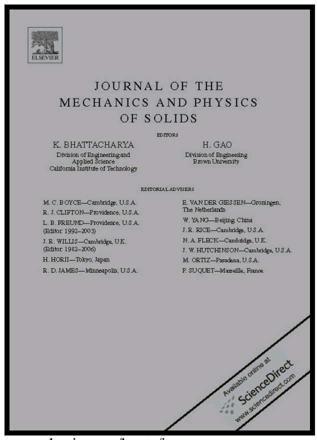

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The fracture toughness of octet-truss lattices

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Abstract

The only engineering materials with both high strength and toughness, and with densities less than 1000 kg m^{-3}, are natural materials (woods) and some plastics. Cellular structures such as the octet lattice, when made from periodic arrangements of strong, low-density metallic trusses, are known to have high specific strengths and elastic moduli. However, much less is known of their resistance to fracture. Here we investigate the fracture toughness of a Ti-6Al-4V alloy octet-lattice truss structure manufactured using a 'snap-fit' method. The samples had densities between 360 and 855 kg m^{-3} (relative densities of 8 to 19%) and free truss lengths between 4 and 15 mm. Their fracture resistance was determined using the *J*-integral compliance method applied to single-edge notched bend specimens. The toughness is shown to increase linearly with the relative density and with the square root of the cell size, while the strength was confirmed to scale only with relative density and the strength of the solid. A moderate increase in resistance with crack length (an R-curve effect) was seen for the higher relative density and larger cell size samples. With a fracture toughness between 2 and 14 MPa m$^{1/2}$ and a compressive strength between 20 and 70 MPa, these structures offer a new lightweight engineering material solution for use at temperatures up to 450°C.