Fracture Behavior of Al/Alumina and Al/Boron Carbide Metal Matrix Composites

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ABSTRACT

This project was aimed at the manufacturing of pure aluminum matrix composites reinforced with about 50 %vol. of Al_2O_3 and B_4C particles (30μm average diameter). The two materials have reported to be the measured ultimate tensile strengths of 120 and 200 MPa, respectively, for the Al/Al_2O_3 and AL/B_4C composites. Internal damage of these composites was monitored in terms of elastic modulus and density. These data are related to microstructural observations which indicate two distinct damage mechanisms: (i) particle fracture predominant in the Al/Al_2O_3 composite, and (ii) nucleation and growth of voids in the matrix of the Al/B_4C composite.

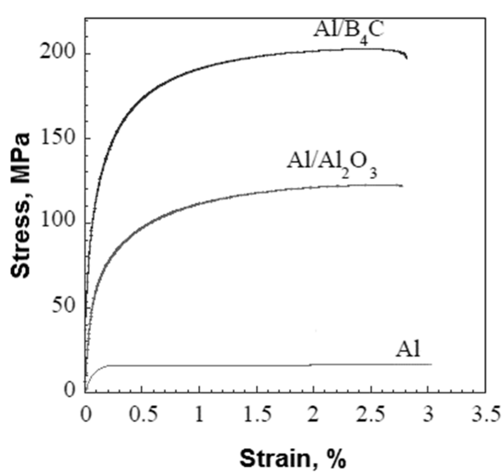

Figure 1: Stress-strain curves of (a) pure aluminum, (b) Al/Al_2O_3 composite, and (c) Al/B_4C composite.

The damage parameter as determined from strain-induced degradation of Young's Modulus,
D_e, is classically defined as

$$D_e = 1 - E/E_o \qquad (1)$$

where E_o is the initial Young's modulus of the composite and E is the instantaneous modulus
measured after each unloading.

The density-derived damage parameter, D_r, is a direct measure of void content and is defined as

$$D_e = 1 - E/E_o \qquad (2)$$

where r_0 is the initial density of the composite and r is the instantaneous density after each level of plastic straining.

The two measurement techniques reveal different trends that can be correlated with the micro-mechanisms of damage in the two materials.

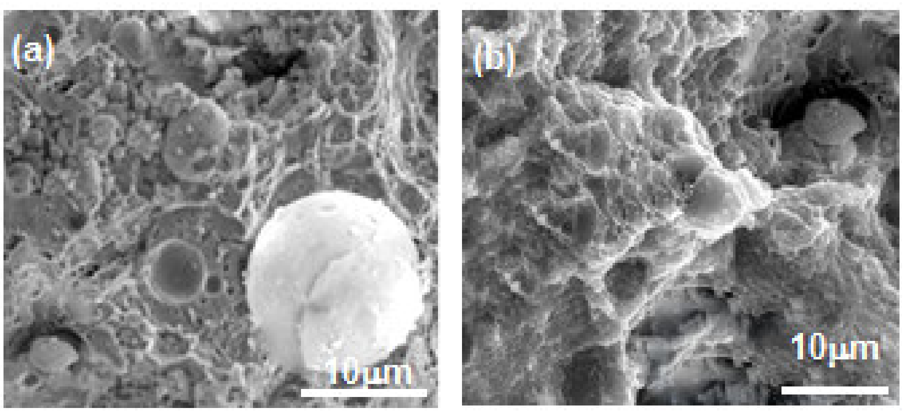

Figure 2: Fracture Mechanism in: (a) Al/Al_2O_3 composite, and (b) Al/B_4C composite.

In the Al/Al_2O_3 composite, metallographic examination reveals that damage takes two forms: (i) particle fracture which is the dominant damage mode, and (ii) matrix voiding. Damage in the Al/B_4C composite is in the form of matrix voids, most often nucleated at or near the particle-matrix interface.

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