Mechanical Properties of Nanometric Particles Reinforced Aluminum Composites

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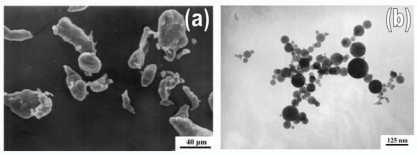
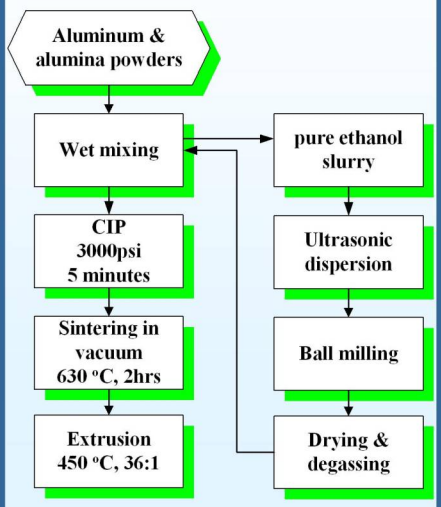
Introduction

- Metal matrix composites with discontinuous reinforcement are mostly isotropic. They usually have a better strength/density ratio as compared to their monolithic counterparts.
- Their strength tend to increase, and the toughness and ductility decrease, with increasing volume fraction of particles or decreasing particles size.
- Fractographic studies demonstrate that the cracking morphology is closely related to the reinforcement size.
- In the present work, aluminum matrix composites (AMCs) with different volume fractions of nanometric Al_2O_3 particles were fabricated by P/M. The effect of nano-reinforcement on the tensile behavior, as well as the strengthening mechanisms were investigated.

Experimental



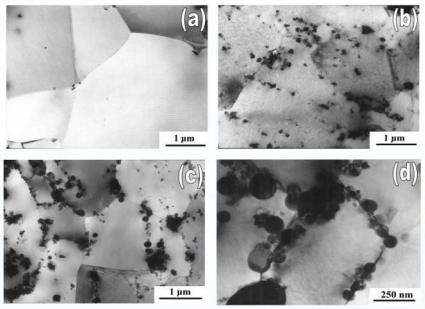
Microstructure of starting materials (a) pure aluminum powder (b) nano-alumina powder



P/M fabrication process for nanometric Al_2O_3 reinforced pure Al

Results

Microstructure

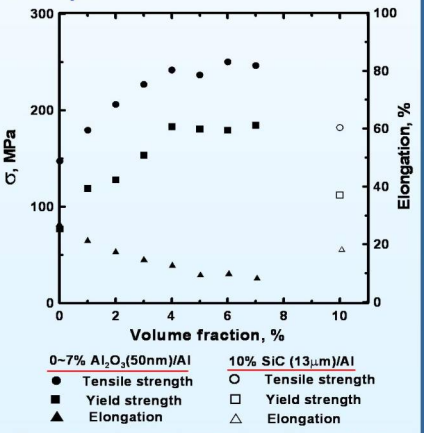


TEM micrographs of
(a) pure aluminum (b) 1vol.%Al_2O_3/Al (c) 4vol.%Al_2O_3/Al (d) 5vol.%Al_2O_3/Al

Particles distributed quite evenly in the matrix when the amount of nano-alumina powder was less than 4%. Particle aggregation tended to increase to form coarse clusters if > 4%.

The particulates could pin grain boundaries and gave rise to grain-refinement.

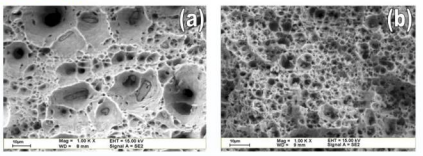
Tensile Properties



The composites with nanometric particulates exhibited much higher yield and tensile strength than that of the monolithic aluminum. Tensile strength of the 1vol.%Al_2O_3/Al composite was similar to that of the 10vol.% SiCp(13 μm)/Al composites.

However once the volume fraction of the nano-particulates in the composites exceeded 4%, the strength of composites was similar.

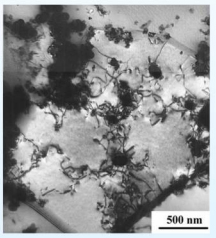
Fractography



SEM micrographs of the tensile fracture surfaces of (a) pure aluminum (b) 1vol.%Al_2O_3/Al

There was a large difference in the appearance of fracture surfaces. For the composites, dispersed shallow dimples of much smaller sizes were found in the matrix.

Strengthening Mechanisms



TEM micrographs showing the particles and dislocations of the 2vol.%Al_2O_3/Al after tensile test.

The strengthening mechanisms include grain boundary strengthening and Orowan strengthening by effective dispersed nano-Al_2O_3 particles.

Conclusions

The nanometric particles were much more effective in enhancing mechanical properties of the monolithic aluminum than the micrometric particles.

Under the present fabrication method, when nano-particles content exceeded 4vol.%, the agglomerations reduce the amount of 'effective' nano-particles available, and the particles strengthening effect diminishes.

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