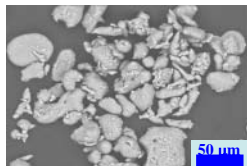


# Al based Ultrafine/Nanostructured Composites by Back Pressure Equal Channel Angular Consolidation

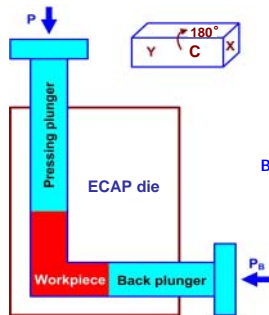
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Back pressure equal channel angular (BP-ECA) processing was successfully utilized to consolidate metallic powders into fully dense bulk materials of pure Aluminium and Al based metal matrix composites containing 2-5 wt.% carbon and 10 vol.%  $Al_{63}Cu_{25}Fe_{12}$ , respectively. The reinforcing particles were either mechanically or ball-mill mixed, and the mixed powders were BP-ECA processed at 250 to 400 °C for multiple passes following route C. The resulting composites exhibited enhanced mechanical properties.

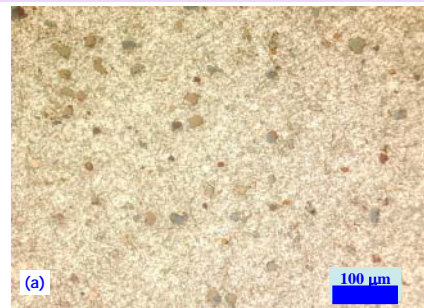


Typical Aluminium powder used during BP-ECA consolidation



BP-ECA set up

BP-ECA consolidation of Al-based composites containing 10 wt%  $Al_{63}Cu_{25}Fe_{12}$  particles at 250 °C for 8 passes, a) ambimilling for 10hrs and b) ambimilling for 20hrs.



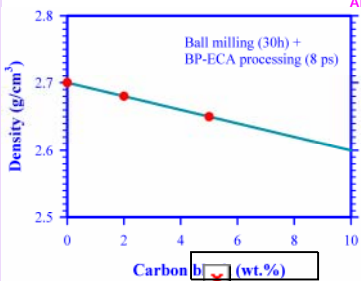
(a)



(b)

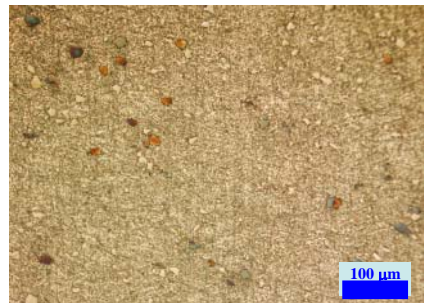
The prolonged ball milling induced refinement of the  $Al_{63}Cu_{25}Fe_{12}$  particles, and a homogeneous distribution of these particles in the aluminium matrix was achieved by combining ball milling with BP-ECA consolidation, two severe plastic deformation processes.

BP-ECA consolidation of Al-based composites containing 2-5 wt.% carbon at 400 °C from ball-milled particles (Carbon particles were pre-milled for 50 h before mixing with Al)



Density of Al-C composites decreased with increasing carbon content, in agreement with the rule of mixture.

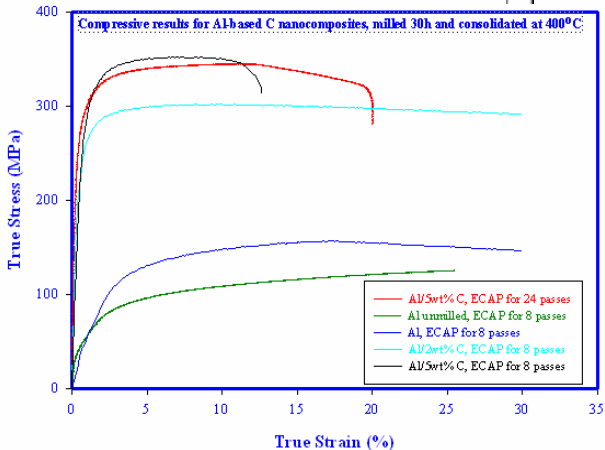
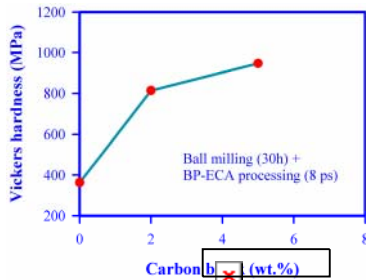
BP-ECA consolidation of Al-based composites containing 10 wt%  $Al_{63}Cu_{25}Fe_{12}$  particles at 250 °C for 8 passes, cryomilling for 10hrs.



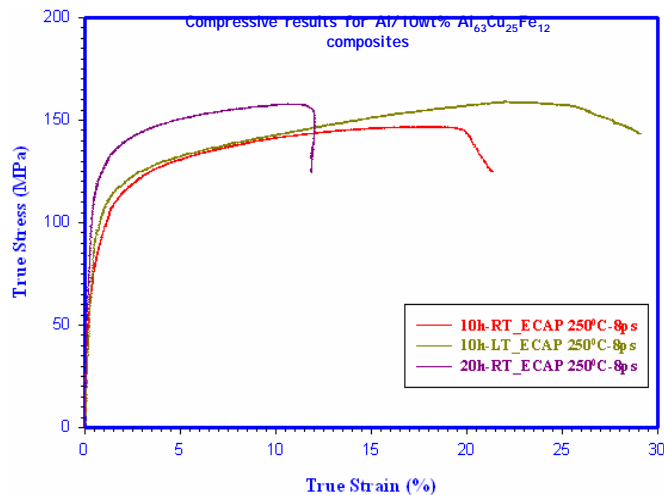
More refinement of the  $Al_{63}Cu_{25}Fe_{12}$  particles was achieved in low temperature milling with many particles of the order of 1 µm. This confirms the efficiency of low temperature milling in refining and homogenizing the size of reinforcement particles.

It is believed that when increasing the time of milling to 20 hours, more refinement will be achieved.

The introduction of a small amount of carbon remarkably enhanced the strength and hardness of pure Al. For instance, 2-5 wt% of C resulted in a hardness as high as 946 MPa.



The Al/2wt% C composite exhibited good combination of strength and ductility with true yield strength over 250 MPa and compressive fracture strain reaching 50%. Increasing the number of ECAP passes resulted in significant increase in ductility without sacrificing strength. In the example of Al/5wt% C, the ductility increased from 10% to 20% with increasing the number of passes from 8 to 24.



Samples	Density (g/cm³)	HV (kgf/mm²)	$\sigma_{0.2}$ (MPa)	Strain to fracture (%)
10h ball milled -30°C ECAP 250°C	2.797	47.5	98	28
10h ball milled RT ECAP 250°C	2.7892	50.1	77	21
20h ball milled RT ECAP 250°C	2.7879	46.8	84	12

Strength enhancement was realized through BP-ECA processing in combination with ball milling in the Al-AlCuFe composites. Better strength was achieved by increasing the ball milling time. By using cryomilling, the ductility of the composite was improved with no decrease in strength.