Mechanical Properties of Nanometric Particulate Reinforced Aluminum Composites

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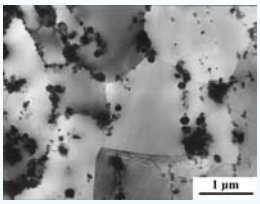
Introduction

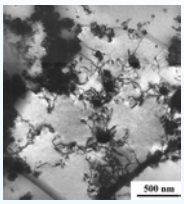
For a metal matrix composite (MMC), its tensile strength tends to increase, and the toughness and ductility decrease with increasing volume fraction of reinforcing particles or decreasing particles size.

In the present work, we fabricated 7075 Aluminium matrix composites with different volume fractions of nanometric SiC particles via modified powder metallurgy route. The effect of nanometric reinforcement on some mechanical properties of nanometric particles reinforced MMC has been studied.

Previous work:

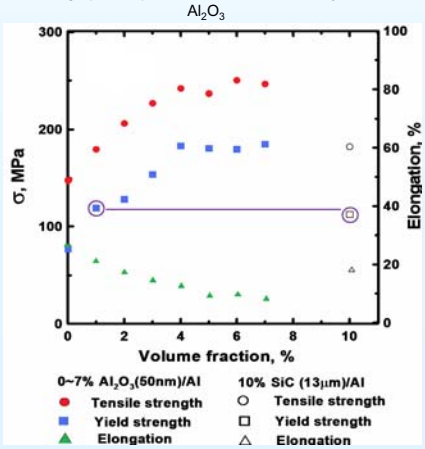


4vol % Al_2O_3/Al

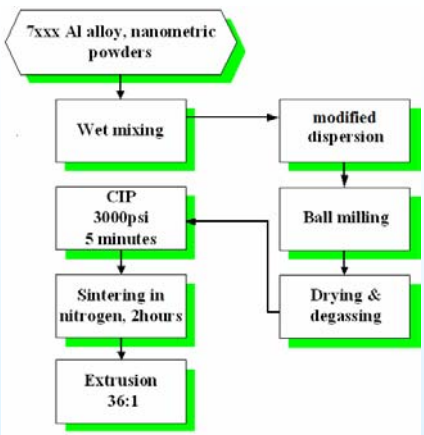


2vol % Al_2O_3/Al after tensile test

TEM micrographs of pure aluminum reinforced by nanometric Al_2O_3



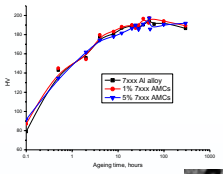
Experimental



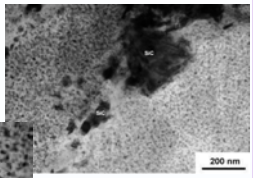
P/M fabrication process for nanometric SiC reinforced 7075 Al

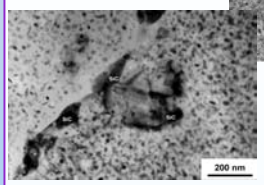
Results

Ageing Behaviour



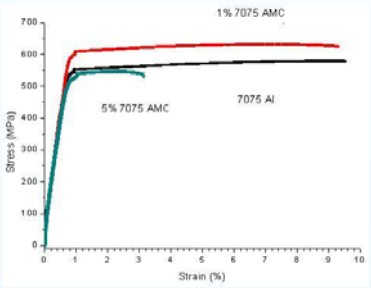
1 vol% SiC (50nm)/7775 Al Peak-aged →



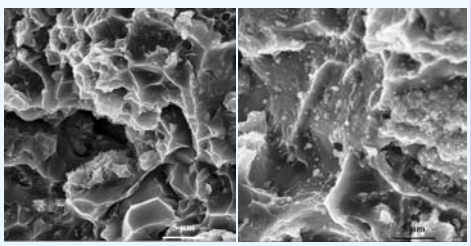


1 vol% SiC (50nm)/7775 Al ← Over-aged

Tensile properties

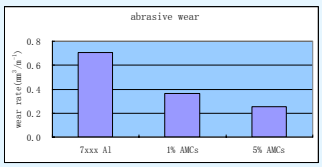


Fracture surface

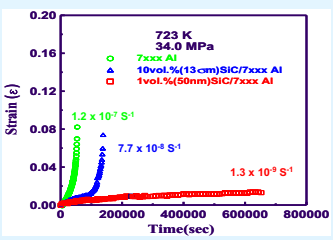


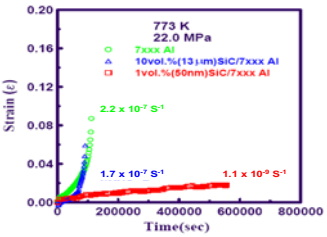
1vol.%SiCp(50nm)/7075Al 5vol.%SiCp(50nm)/7075Al

Abrasive wear



High -temperature Creep Test





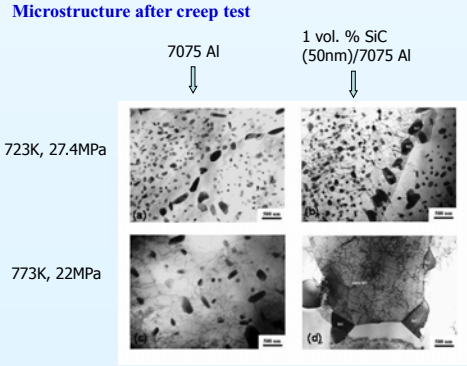
Threshold stress (MPa) of creep for different samples

	673 K	723 K	773K
7075 Al	14.7	11.8	6.0
10vol.%SiCp(13σm)/7075 Al	25.9	17.8	11.4
1vol.%SiCp(50nm)/7075Al	36.7	28.5	19.3

Our result compared with other works

Materials	Temp.	Applied Stress (MPa)	Creep Rate	Threshold Stress (ω_b)/MPa	Activation Energy(Q_a) kJ/mol
1vol.%SiC(50nm) /7075Al	773K	22	1.1×10^{-9}	19.3	406 *
Al-1vol%S_3N_4(15nm)	673K	34	2.0×10^{-6}	14.2	221
PM2124 Al alloy	678K	50	1.0×10^{-2}	7.3	185
Al6061-20vol%Al_2O_3(p)	773K	6.9	3.0×10^{-4}	1.7	275

Microstructure after creep test



At high temperature (723K and 773K) all the precipitates coarsen or even disappeared, but the nanometric ceramic particles were still effective in strengthening the matrix, as well as holding the grains together.

Conclusion

- Using a modified powder metallurgy technique, nanometric particulates can be introduced to the aluminum matrix.
- Although hardness and tensile strength of the nanometric particulate-reinforced AMC were similar to those of 7075 alloy, there was a significant improvement in abrasivewear resistance and especially in high temperature creep resistance.
- The composite reinforced with only 1vol.% of 50nm SiC was very stable even at 500 ºC (~0.85 of the melting point) which could be the platform technology for high temperature aluminium composites.

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