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A comprehensive microstructural analysis of Al–WC micro- and nano-composites prepared by spark plasma sintering

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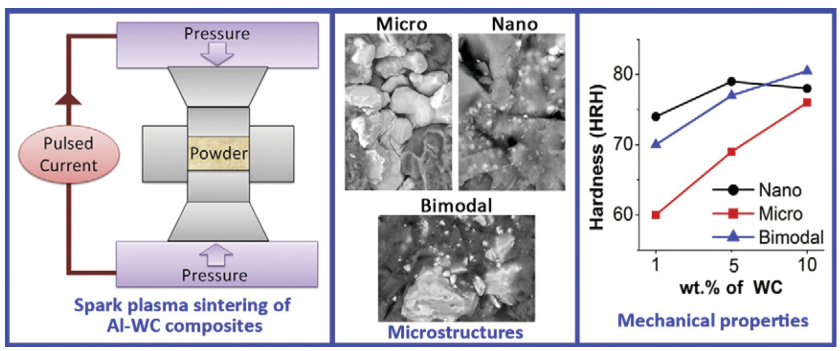
HIGHLIGHTS

- Aluminum matrix composites containing 1–10 wt.% WC micro-, nano- and bimodal-particles are consolidated by spark plasma sintering (SPS).
- The highest and lowest densification levels are obtained in 1 wt.% microcomposites (99.8%) and 10 wt.% nanocomposites (94.4%), respectively.
- Hardness increases by SPS temperature (400 → 500 °C) in 5 and 10 wt.% microcomposites, but slightly decreases in 1 wt.% microcomposites.
- Nanocomposites achieve largest hardness at 5 wt.% WC concentration, but micro- and bimodal-composites are hardest at 10 wt.% WC concentration.
- Interplay between WC particles distribution homogeneity and composite compressibility during SPS dictate the hardening level achievable in the composites.

GRAPHICAL ABSTRACT



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ABSTRACT

There have been many investigations on metal matrix microcomposites produced by conventional casting routes; however, in the past decade, the focus has shifted more toward nanocomposites produced via solid state routes. To have a realistic view of performance prediction and optimum design of such composites, in this work Al matrix composites (AMCs) reinforced with WC microparticles, nanoparticles, and bimodal micro-/nano-particles were prepared by spark plasma sintering. The effects of particle size and concentration, and process variables (i.e. sintering temperature, duration, and pressure) on the evolution of microstructure, density and hardness of the composites were studied comprehensively. Full densification of AMCs with high particle concentration was problematic because of ceramic cluster formations in the microstructure. This effect was more emphasized in AMCs containing nanoparticles. AMCs with microparticles were more easily densified, but their hardness benefits were inferior. On the other hand, the mixture of micro- and nano-particles in Al-WC bimodal composites led to better matrix reinforcement integrity and an overall improvement in the microstructural properties. Finally, increasing the sintering temperature improved the microstructural features

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