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Thermally Stable Nanocrystalline Aluminum Alloys Processed by Mechanical Alloying and High Frequency Induction Heat Sintering

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Abstract : The as-received metal powders were used to synthesis bulk nanocrystalline Al; Al-10%Cu; and Al-10%Cu-5%Ti alloys using mechanical alloying and high frequency induction heat sintering (HFIHS). The current study investigated the influence of milling time and ball-to-powder (BPR) weight ratio on the microstructural constituents and mechanical properties of the processed materials. Powder consolidation was carried out using a high frequency induction heat sintering where the processed metal powders were sintered into a dense and strong bulk material. The sintering conditions applied in this process were as follow: heating rate of 350°C/min; sintering time of 4 minutes; sintering temperature of 400°C; applied pressure of 750 Kgf/cm2 (100 MPa); cooling rate of 400°C/min and the process was carried out under vacuum of 10-3 Torr. The powders and the bulk samples were characterized using XRD and FEGSEM techniques. The mechanical properties were evaluated at various temperatures of 25°C, 100°C, 200°C, 300°C and 400°C to study the thermal stability of the processed alloys. The bulk nanocrystalline Al; Al-10%Cu; and Al-10%Cu-5%Ti alloys displayed extremely high hardness values even at elevated temperatures. The Al-10%Cu-5%Ti alloy displayed the highest hardness values at room and elevated temperatures which are related to the presence of Ti-containing phases such as Al3Ti and AlCu2Ti, these phases are thermally stable and retain the high hardness values at elevated temperatures up to 400ºC.

Keywords : nanocrystalline aluminum alloys, mechanical alloying, hardness, elevated temperatures
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