Compression Properties of an Al_{2024} Composite Reinforced with SiC Nanoparticles

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Some dispersion strengthened aluminum alloys exhibit excellent mechanical properties at temperatures approaching their melting point [1]. However, many of the early Al_{2024}-SiC_{NP} (SAP) alloys showed inconsistent mechanical behavior due to the presence of large dispersoids and heterogeneous silicon carbides nanoparticles distributions. These limitations can be improved, but only by complicated processing and consolidation techniques such as perpendicular extrusion. Mechanical alloying (MA) evades many of these complicated processing steps. After powder processing by MA, each individual powder particle should contain a fine and homogeneous SiCNP distribution. MA removes the need of complicated post consolidation work in order to refine and distribute the SiCNP dispersion [2]. The present investigation deals with the formation of $A1_{2024}$-SiC_{NP} composites in form of powder particles by MA, the research was conducted with the purpose of provide a better understanding of this important process, including the studies of: distribution of SiC_{NP} reinforcement, microstructural changes into the Al_{2024} matrix and the mechanical behavior of samples.

Aluminum alloy 2024 powders (Al–4.00 Cu–0.83 Mg–0.21 Fe–0.67 Mn–0.12 Si–0.03 Cr in wt.%) were used as metal matrix. Meanwhile, silicon carbides nanoparticles (SiC_{NP}) were used as nanocomposite reinforcements. Al_{2024}-

nanocomposites were prepared by mixing SiC_{NP} at ratio of 0, 0.5, 1.0, 1.5, 2.0, 2.5 and 5% by weight. The MA process was performed by high-energy ball milling device (Spex 8000M) with three different milling times (2, 5 and 10h). The MA powders of Al_{2024} and SiC_{NP} were cold pressed at 330 MPa. Al2024-nanocomposites were sintered at 500°C under an argon atmosphere for 3 hours in tube furnace. After sintering, the specimens were thermically treated using a heat-treated solution for 1 h at 495°C and quenching in room temperature water. Then, the samples were artificially aged (T6 Temper) for 13h at 191°C. The nomenclature for the nanocomposites pure Al_{2024}, Al_{2024}- 0.5wt%, Al_{2024}-1wt%, Al_{2024}-1.5wt%, Al_{2024}-2.0wt%, Al_{2024}-2.5wt% and Al_{2024}-5.0wt%, was: Al_{2024}, 0.5Al_{2024}, 1.0Al_{2024}, 1.5Al_{2024}, 2.0Al_{2024}, 2.5Al_{2024} and 5.0Al_{2024}, based on their weight percentage in Al2024 matrix, respectively. The microstructure was characterized using a TEM microscope model JEOL-EM 2200FS operating at 200 kV.

The Fig. 1 shows the variation of the 0.2% offset yield strength with the 5.0 wt.% of SiC, with different milling times (2, 5 and 10h). This figure clearly shows that milling time plays a significant role controlling the compression properties of the composites. It is also important to note that the concentration of SiC nanoparticles have a significant effect also. In this summary, only the results obtained with samples with 5.0 wt%., were reported

Figure 2a provides evidence of the interaction between dislocation lines and SiC nanoparticles, which might be the starting point of the mechanism reported by Orowan [3], even though the particle looping by the dislocation line is not clearly observed. During the solution treatment, the alloying elements, such as copper and magnesium, will dissolve into the α(Al) matrix. In the subsequent artificial aging, the needle-shaped precipitates are observed and coarsened remarkably (Fig. 2b). Acknowledgments [4].

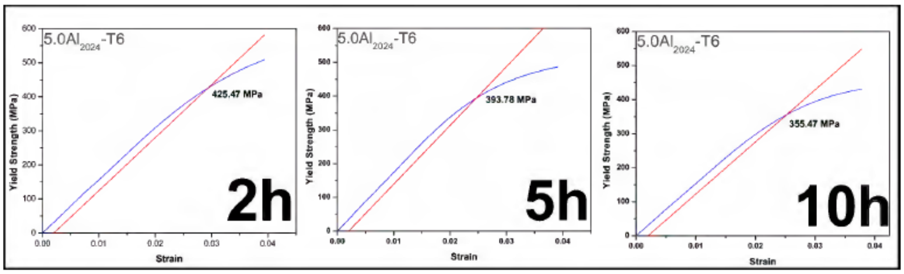

Figure 1. Yield strength variation of composites as a function of the milling time, for a constant concentration of SiC_{NP}.

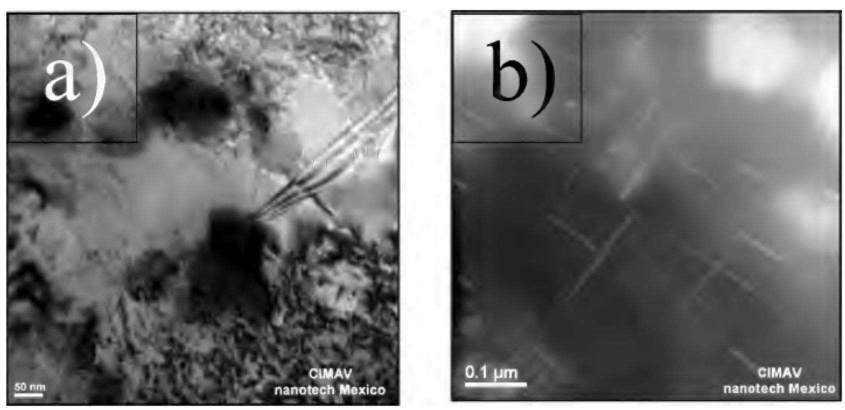

Figure 2. TEM micrographs of $5.0Al_{2024}$ sample showing the interaction between dislocation lines and nanoparticles (a) and precipitate morphology in $5.0Al_{2024}$ composites aged for 13h.

References

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