Structure and Properties of Nanocomposites Prepared from Ball Milled 7475 Aluminum Alloy with ZrO_2 powders

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Aluminum alloys-matrix composites combine the metallic properties of ductility, toughness and environmental resistance with the ceramic properties of high strength and high modulus. The composites possess superior wear resistance and high temperature properties, however the room temperature strength is usually lower than that of common 7XXX alloys. Therefore attempts have been made to increase strength of composites by application of ceramic nanoparticles, nanotube reinforcement of aluminum, spray forming of the matrix what allowed to improve the strength in comparison a base alloy. Considering growing interest in the development of nanocrystalline composites in the present work the high strength 7475 aluminum alloy was ball milled with ZrO_2 nanoparticles to obtain hard nanocrystalline powders, which were subsequently hot pressed at such temperature not to increase substantially grain size, but to obtain nanocomposites, hardened not only by added ceramic nanopowders, but also by the aluminum alloy nanograin matrix material. Nanocomposites were prepared from 40 hours ball milled 7475 alloy powder with addition of 2 % Zr and 10 or 20 wt. % of ZrO_2, Y_2O_3 stabilized powders. Two types of ZrO_2 powder additions were used; one of size near 30 nm and the other in the range 300-500 nm to compare the strengthening effect. TEM studies confirmed grain size refinement after milling, down to about 40 nm of aluminum solid solution within powder's particles asshown in Fig. 1. The milled powders were consolidated using uniaxial hot pressing in vacuum at 380oC and pressure of 600 MPa. The hardness of consolidated samples was higher for nanocrystalline ceramic powder addition near 320 HV for 20 % of ZrO_2 addition in comparison to 280 HV for 20 % of coarser powder addition. TEM studies allowed to determine the grain size of aluminum solid solution near 100 nm after hot pressing and homogeneous distribution of ZrO_2 fine particles. The fraction of monoclinic ZrO_2 was similar in the milled powder and in the hot pressed samples. It appeared that ZrO_2 nanoparticles did not retard grain boundaries movement, however addition of 2 % of Zr has a more pronounced effect in the prevention of grain growth. The compression tests showed 1000 MPa of ultimate compression strength of samples with ZrO_2 nanoparticles, what was slightly higher than with ZrO_2 with a larger particles addition.

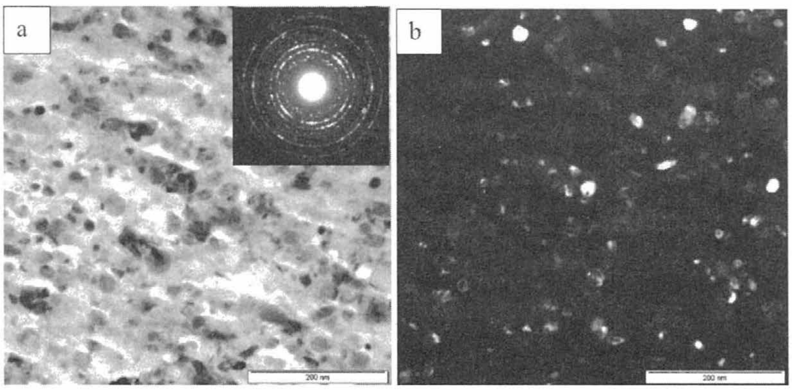

Fig. 1. TEM micrgraph in the bright field (a) and the dark field taken using ZrO_2 reflection (b) from a thin section of the ball milled 7475 alloy powders milled 40 hours with 20 % of nano ZrO_2.