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FORMATION OF ALUMINUM MATRIX COMPOSITES CONTAINING Fe-BASED ALLOY@INTERMETALLIC CORE-SHELL REINFORCING STRUCTURES BY SPARK PLASMA SINTERING

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Aluminum matrix composites are a promising class of materials possessing a high strength to weight ratio, high corrosion and wear resistance and appreciable electrical conductivity. One of the modern trends in the AMC area is to avoid ceramic reinforcements and utilize alternative materials instead. These alternatives are metallic alloys (high-entropy alloys, quasicrystals or metallic glasses) [1-3]. This group of reinforcements should show better adhesion to the aluminum matrix than the ceramic particles due to the same nature of bonding (metallic bonding) in the metal-alloy systems.

In the present work, particles of $Fe_{66}Cr_{10}Nb_5B_{19}$ metallic glass <45 μm in size were used as a reinforcement for aluminum matrix composites. The choice of the reinforcement was dictated by the attractive properties of amorphous alloys – high hardness, strength, wear and corrosion resistance [4].

The sintering behavior of mixtures containing a crystalline or a glassy Fe-based alloy was first investigated to determine the influence of the crystalline state of the alloy on densification. Consolidation of the mixtures was carried out by heating under pressure above the glass transition temperature of the $Fe_{66}Cr_{10}Nb_5B_{19}$ alloy in a spark plasma sintering (SPS) facility. It was shown that the glassy state of the alloy is for beneficial for densification when particles of the alloy form chains.

The phase composition, microstructure and mechanical properties of composites produced from mixtures containing 20 vol.% and 50 vol.% of $Fe_{66}Cr_{10}Nb_5B_{19}$ by SPS at 540 °C and 570 °C were studied. Microstructure investigations together with the X-ray diffraction phase analysis revealed that a chemical reaction between matrix and the reinforcement occurs during sintering at 540 °C. The reaction products were observed at the Fe-based alloy/Al matrix interface and formed a shell. The thickness of the shell increased with increasing sintering temperature and soaking time. The shell was $Al_{13}Fe_4$ after SPS at 540 °C and a mixture of $Al_{13}Fe_4$ and Al_5Fe_2 after sintering at 570 °C. In these composites, the reinforcing role was played by Fe-based alloy@intermetallic core-shell structures.

Compression tests of the samples sintered from mixtures containing 20 vol.% $Fe_{66}Cr_{10}Nb_5B_{19}$ demonstrated that partial reaction between the components of the composite is beneficial for increasing its strength. Shells of small thickness helped increase the yield strength without deteriorating plasticity of the composite. The formation of thick shells led to a dramatic increase in compressive strength and limited the deformation at fracture of the composite to 2% [5].

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