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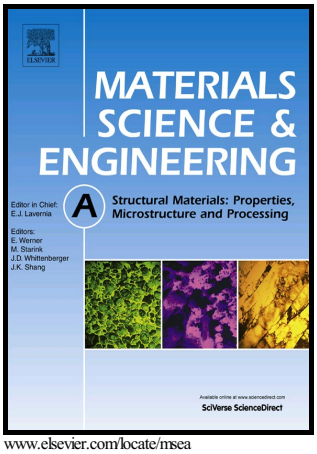

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Strengthening of Mechanically Alloyed Al-based Alloy with High Zr Contents

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Abstract

Al-Cu-Mn matrix alloy in the form of chips with zirconium in amounts of 5, 10 and 20 wt.% was subjected to mechanical alloying. After milling in a ball mill for 20 h the prepared powders were annealed and hot-pressed. X-ray diffraction analysis was used to study the effect of zirconium content on the phase composition and microstructural parameters of the materials. The study showed that mechanical alloying leads to the formation of an Al-based nanocrystalline supersaturated solid solution with a zirconium content of up to 20%. With an increase in the zirconium concentration the microhardness of the powder alloys increases to 440 HV. The subsequent precipitation hardening as a result from the precipitation of metastable Al_3Zr ($L1_2$) phase with a maximum content of 28 vol.% causes an increase in the microhardness to 520 HV. The hot-pressed specimens exhibit very good room temperature and high temperature strength which increases with zirconium content.

Keywords: X-ray analysis; hardness; nanocrystalline materials; aluminium alloys; powder methods; phase transformation

1. Introduction

Zirconium, as one of the metals of the transition group, is an important alloying element in heat resistant aluminum alloys. Its role consists in the formation of metastable Al_3Zr ($L1_2$) phase dispersoids which precipitate from the supersaturated solid solution of zirconium in aluminum and efficiently harden the aluminum matrix at high temperatures [1-6]. The good thermal stability of that phase originates from a low diffusion coefficient and a high melting point. Development of new thermally stable high-strength aluminum alloys requires increasing the content of hardening zirconium aluminide particles which is achievable through solid solution supersaturation. However, the zirconium solubility in aluminum is very low under equilibrium conditions. Its maximum limit at 933.5 K is 0.28 wt.%, the room temperature level being negligible [7]. Optimization of conventional casting modes allows increasing the zirconium solubility to 1 wt.% [8], and the use of the rapid crystallization technique for the