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Thermal stability of a nanostructured aluminium alloy

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Abstract

The microstructural changes taking place in a hydrostatically extrusion-processed nanostructured aluminium alloy during annealing were evaluated quantitatively, by measuring the size and shape of the grains. It was found that the grain size is stable up to an annealing temperature of 300 °C. Within this temperature range, the microstructural evolution proceeds through the annihilation of dislocations in the interior of the grains. At higher annealing temperatures, the recovered grains begin to grow and the microstructure becomes more homogeneous in terms of the grain size. The possibilities of an improvement of alloy thermal stability are discussed.

Keywords: Aluminium alloys; Grain growth; Nanostructure; Thermal stability

1. Introduction

Nanostructured materials attract attention due to their attractive mechanical properties, such as a high flow stress combined with sufficient ductility. The growing interest in these materials has brought about rapid development of various methods of their fabrication, e.g., by severe plastic deformation (SPD). Recently, it was shown that among the SPD methods, hydrostatic extrusion (HE) allows one to obtain bulk nanocrystalline materials, e.g., aluminium alloys [1] in a variety of forms (rods and tubes of various cross-sections).

SPD materials have microstructures containing small equiaxed grains with a large fraction of high angle grain boundaries [2–4]. They also may contain a considerable density of dislocations in the grain interiors and low angle grain boundaries. These microstructural features indicate high values of stored energy per unit volume and as a consequence a high instability of the microstructure. On the other hand, from the applications point-of-view, one of the fundamental requirements is that the nano-sized microstructure and the resultant attractive properties should be retained for a desired period of time and within a significant temperature range. This rationalizes studies of the thermal stability of nano-metals.

The aim of the present work was to apply stereological techniques to describe quantitatively the microstructural changes that occur in a nano-structured aluminium alloy during annealing and to discuss the possible methods for improving the thermal stability of such materials.

2. Experimental

The material used in this study was an Al–4Cu–Mg–Mn (2017) aluminium alloy. Samples in the form of

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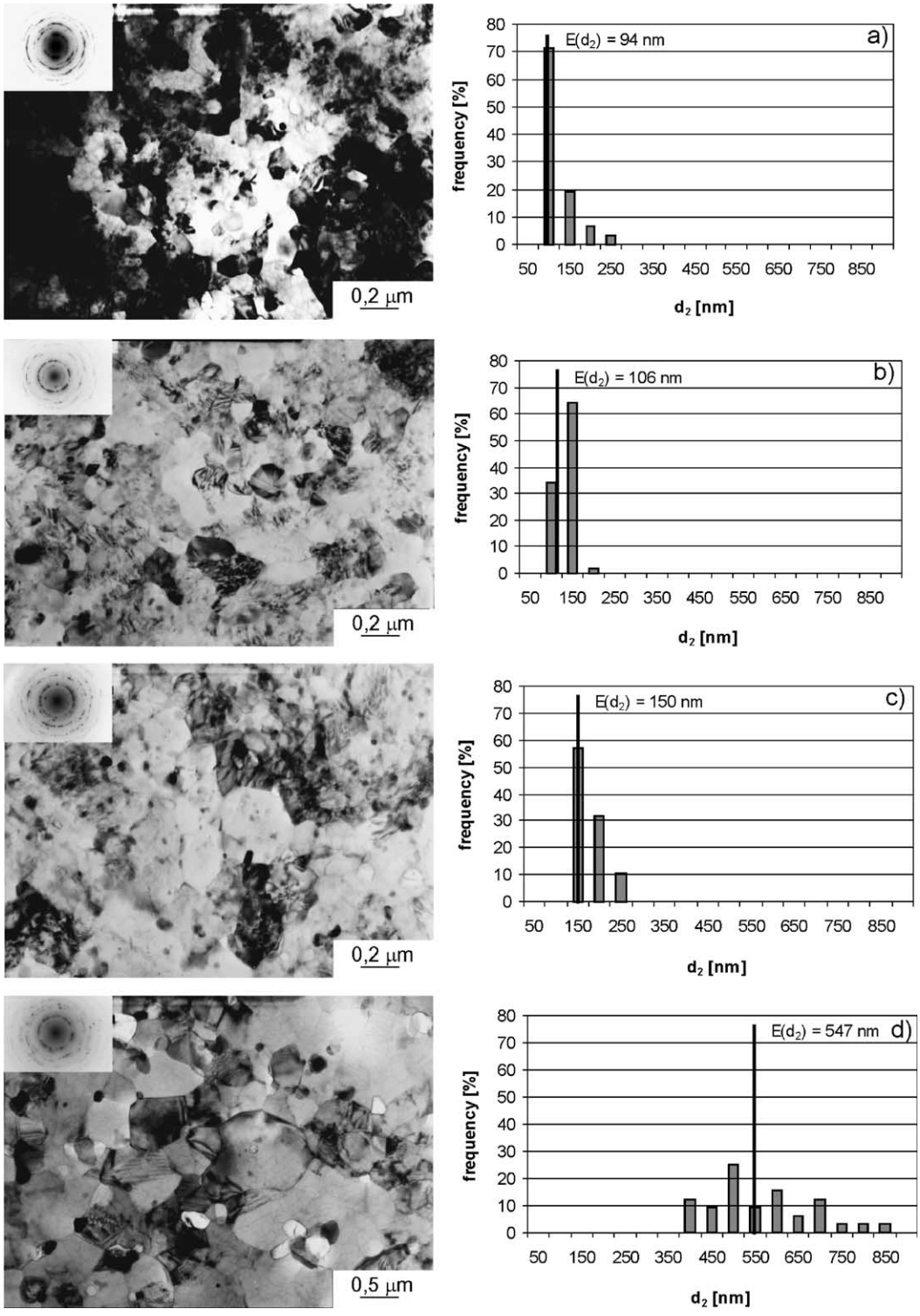

Fig. 1. Microstructures and the respective grain size distributions in the as-deformed state (a) and after subsequent annealing at various temperatures: 100 °C (b), 200 °C (c) and 300 °C (d).