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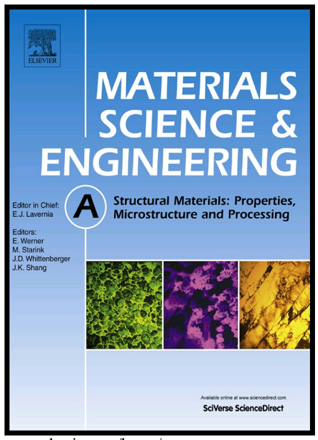

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Grain size effect on the thermally activated twin boundary migration in a zirconium alloy

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Abstract

Zr-4 alloy sheets with two different grain sizes were compressed up to 20% along rolling direction to induce tensile twins. The deformed samples were annealed at different temperatures for 2 h. The microstructures and textures before and after annealing were characterized by electron backscatter diffraction (EBSD) to investigate the effect of the initial grain size on the evolution of the twins. Fewer twins were generated in the fine grained sample than in the coarse grained sample, and twinning was activated at higher stress and larger strain due to size effect. Unexpectedly, it was observed that the twin boundary migration started at higher temperature in the fine grained sample. Based on the indexed EBSD maps, it was found that in the fine grained sample twin boundaries were relatively coherent and the stored energy difference on either side of twin boundaries was lower. On the opposite, in the coarse grained sample, twins were less deformed but twin boundaries lost their coherency. Thus, in fine grained sample, twins had a lower mobility and lower driving force for the twin boundary migration during annealing.

Keywords: grain size effect; twinning; recrystallization; texture; Zr alloy

1. Introduction

As fuel cladding materials, zirconium (Zr) and its alloys have been widely applied in nuclear power industry because of their good corrosion resistance, suitable mechanical strength and formability and small absorption cross-section for thermal neutrons [1, 2]. Texture was reported to have great influence on the performance of Zr alloys, for example oxidation [3], creep [4, 5], mechanical strength [2, 6] and delayed hydride crack [7]. By tailoring the fabrication process, for example the rolling paths [8] or the strain ratio between the tangential and axial direction for Zr alloy tube [4], the texture could be changed.

Deformation twinning is an important deformation mode for hexagonal close-packed (HCP) Zr alloys since they have insufficient easily activated independent slip systems to accommodate arbitrary imposed strain [9]. Four twinning modes, two tensile twinning and two compressive twinning, are often observed in Zr alloys, where tensile and compressive twinning are named for their ability to accommodate the strain along the c-axis [1, 10]. Twinning can cause large texture change, for example {10-12} tensile twinning rotates the *c-axis* by approximately 85° [11] and {11-22} compressive twinning flips the *c-axis* by approximately 64° [1, 12]. Many studies are carried out to investigate the twinning related issues in Zr alloys [13, 14], contributions of