Eötvös Loránd University

Faculty of Sciences

Doctoral School of Physics

super plasticity recorded

in a high-strength ultrafine-grained AlZnMg alloy at low temperature

2st Semester Report

Materials Science and Solid State Physics PhD programme

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Introduction:

It is well-known that ultrafine-grained (UFG) materials which produce by sever plastic deformation (SPD) methods are considered an important materials. However, aluminium alloys which processed by SPD technique have reasonably saturated microstructures amounts associated with steady state dislocation density. Moreover, the grain boundary sliding (GBS) is considered as the main mechanism of superplastic deformation, so it can be expected that a reduction of grain-size should improve the occurrence of superplasticity at relatively low temperatures by keeping grain boundary diffusion. This mechanism cannot provide a super plasticity of more than 200-300% due to cracking Therefore, the role of grain boundaries is improved by controlling fast diffusion in an ultrafine-grained Al-Zn-Mg-Zr alloy with consequence of sever plastic deformation. Nevertheless, most of SPD-processed materials exhibit very limited ductility and low strain rate sensitivity (SRS). As the low ductility at ambient temperature restricts the use of these kind of materials for structural applications. So, the main aims during the current semester were writing a manuscript about how get a higher strength with higher ductility for these often used materials by study the relationship of grain boundary sliding with diffusion speed in a deformed ultrafine-grained Al-Zn-Mg-Zr alloy.

research work:

The alloy with the composition of Al-4.8%Zn-1.2%Mg-0.14%Zr (wt.%) is produced by casting and homogenized in air at 470 °C for 8 hour. After that it processed with high-pressure torsion (HPT) at RT under a pressure of 6 GPa which leading to produce ultrafine-grained (UFG) microstructure with average grain size of 180 nm. This microstructure revel a unique behavior when the sample is annealed to 170 C, its size increased to about 300 nm with high strain rate sensitivity(m) of 0.43, which was determined by using nanoindentation creep in the same temperature region. Indicating that superplasticity can be expected at low temperatures. Tensile samples with a gauge part of 2.0×1.0×0.8 mm were deformed at different strain rates and different temperatures lower than 0.5Tm. Figure (1) shows the typical stress-strain curves of superplastic deformation taken at strain rate of $5*10^{-4}$ s^{-1}at 120, 150 and 170 C^0. It can be seen that the total elongation of almost 200% is obtained at very low temperature of 120 C^0, and a record deformation higher than 500% was observed at 170 C^0 (~0.47 Tm).

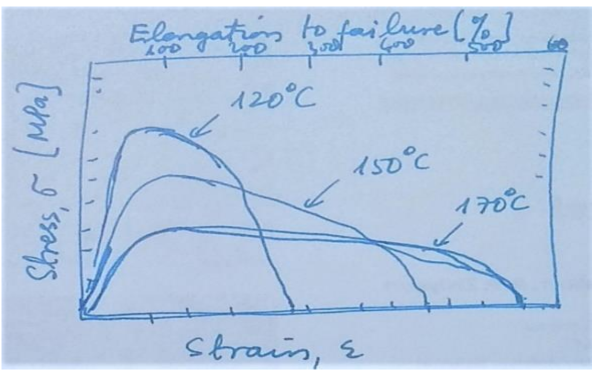

Figure (1)

The value was measured in this work is 68 kJ/mole, this value is smaller than self-diffusion in Al and grain boundary diffusion in Al.

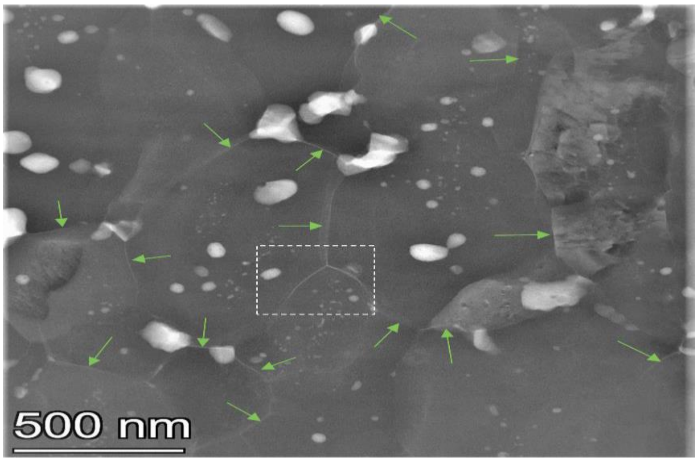

Figure (2)

The magnification of STEM-HAADF image for the microstructure of the sample superplastically deformed at 170 C^0 with strain rate of $5*10^{-4}$ s^{-1}, showing the existence of the Zn containing particles (bright ones) and Zn-rich Al/Al grain boundaries which pointed by the green arrows in Figure (2) with elongation value higher than 500% at 170 C^0. A small area of the image - marked with a white dashed square is analyzed by using energy-dispersion X-ray spectroscopy (EDS) mapping . this analyzes shows solute atoms of Zn increased with 600% at the Al/Al grain boundaries. This phenomenon is known as a segregation of high concentration Zn in a binary system and it considered as a key point of the low temperature superplasticity for UFG AlZnMgZr alloy.

Moreover, diffusion coefficient value D for Zn which is calculated in this work was larger compare with the value of Al and that related into the size grain, when the size grain is smaller the diffusivity is larger.

The important feature of microstructure of the sample which exhibited by the experimental results after superplastic deformation at 170 C^0 it is remain equiaxial and ultrafine with the average grain size of about 400 nm.
Figure 3 shows the hardness values which calculated by Vickers hardness (HV) after T6 treatment without and with annealing procedure. The peak-hardness of the sample after T6 treatment only is 1020 MPa. While the effect of annealing is cleared for 120 C^0 and 170 C^0 as 1560 and 1280 MPa respectively.

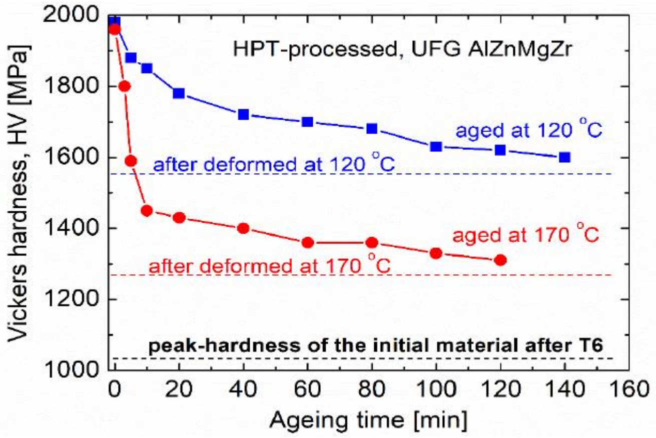

Figure (3)

Finally**,** when the corona virus pandemia broke out **we** could not work in the labs so I worked with my supervisor by email and that was a difficult experiment.

Studies in current semester:

1- FIZ/1/015E Physical materials science I. Dr. Groma Istvan
2- FIZ/1/031E Technology of Materials Dr. Groma Istvan
3- FIZ/1/001E Nanophase metals Dr. Bakonyi Imre