Eötvös Loránd University

Faculty of Sciences

Doctoral School of Physics

Investigation of mechanical and microstructural properties of ultrafine-grained Al-30Zn and Al-Zn-Mg_Zr alloys

3st Semester Report

Materials Science and Solid State Physics PhD programme

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1. Introduction

Ultrafine-grained (UFG) materials have a distinctive technological and practical importance over many materials, which can be characterized by their distinguished high and stable plastic deformation. in form of unique plastic flow associated with unusually high ductility value. The unusually high ductility deformation may be the consequence of the intensive role of grain boundary sliding (GBS). Therefore, in this semester, microstructure samples of Al-30Zn are deformed plastically by using nano compression to examine the role of grain boundary sliding (GBS).

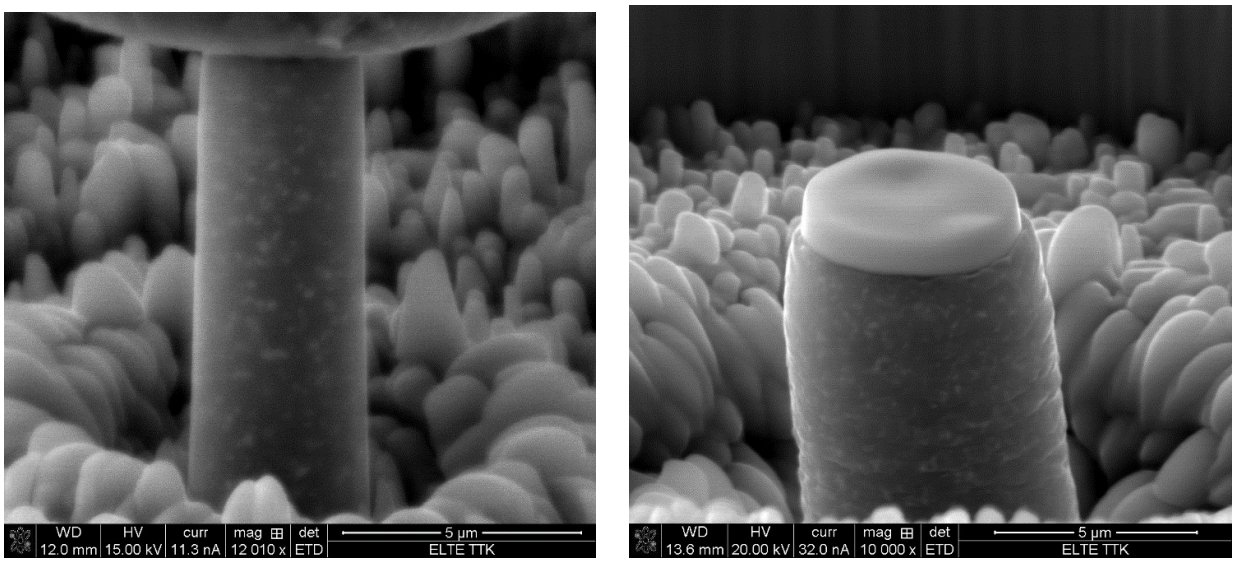
2. Research work:

In this semester the following experimental works were carried out:

1) Investigation of mechanical properties of ultrafine-grained (UFG) Al-30Zn alloy by compressing micro-pillars using indentation and scanning electron microscope (SEM) combined with acoustic emission (AE) measurements.

2) Investigation of microstructures of UFG Al-Zn-Mg-Zr alloy by applying differential scanning calorimetry (DSC) method.

In the task 1, micro-pillars as cylindrical samples having diameter and length of 3 and 10 micrometers, respectively, were prepared on the surface of UFG Al-30Zn sample. The micro-pillars were then compressed by indentation unit using flat-ended tip, located in a SEM equipment. Different micro-pillars were compressed by different strain, at different velocities. Figure 1 shows a pillar under the tip (Fig. 1a) and a pillar after a high compression of about 100% (Fig. 1b), indicating a stable deformation process in ultrafine-grained Al-30Zn alloy. Some preliminary results are shown in Figure 2, where three stress-strain ($\sigma - \varepsilon$) curves obtained at different velocities and at room temperature can be seen. The experimental results have shown that the flow stress of the UFG Al-30Zn alloy is sensitive to the deformation velocity. Taking the stress value at strain, $\varepsilon = 0.1$, for instance, a strain rate sensitivity of about 0.27 can be obtained, which is unusually high, also confirming the stable ductility of this sample. During the compression, the AE signals coming from the deformed sample were also recorded. We hope that the analysis of both the SEM images and of the AE signals will give important information about the deformation mechanism of the UFG Al-30Zn.



a) b)

Figure 1: Compressing UFG Al-30Zn micro-pillars by using an indentation unit located in SEM, demonstrating as a) a pillar under the tip, and b) a pillar compressed by about 100%

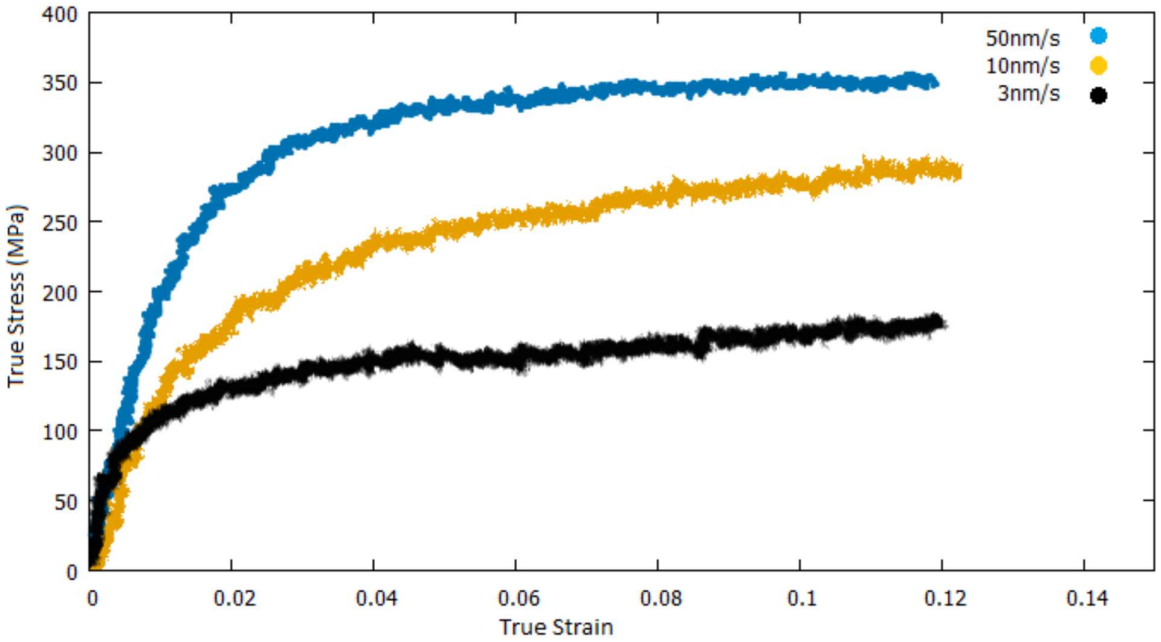


Figure 2: True stress - true strain curves obtained on UFG Al-30Zn micro-pillars compressed at different velocities at room temperature.

In the task 2, differential scanning calorimetry (DSC) measurements were performed on for ultrafine-grained UFG Al-Zn-Mg-Zr samples, which were processed by different evolutions in high pressure torsion (HPT) process, in order to study the microstructure of these samples. Unfortunately, because of the Covid-19 pandemic, I was not able to evaluate the measurements. This work is planned to be done in the next semester.

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3. Learning activities - Course taken during this semester:

Subject name	Subject code
Physical materials science II.	FIZ/1/016E
Lattice defects I.	FIZ/1/024
Transmission electron microscopy and electron diffraction	FIZ/1/021E