1.semester report

Nagy Péter (nagyp@student.elte.hu)

PhD program: Materials science and solid state physics

Supervisor: Gubicza Jenő

Thesis title: Correlation between processing, microstructure and mechanical properties of novel multicomponent thin films

Introduction:

In the last decades, several novel multicomponent materials comprising 3-5 different chemical elements were developed. For instance, high-entropy alloys (HEAs) contain at least four components, usually with equal fractions. These structures are stabilized by the large configuration entropy. Due to the severe lattice distortion and the sluggish diffusion, HEA materials exhibit high strength, good ductility as well as excellent corrosion resistance and thermal stability. Therefore, HEAs are considered as advanced structural materials with outstanding mechanical properties. HEAs are intensively studied materials due to their impressive mechanical properties, such as very high strength even at high temperatures. HEAs with many different compositions have already been successfully processed in bulk form. The synthesis of HEA materials exploits many different methods such as melt spinning, electromagnetic stirring, vacuum arc melting, or mechanical alloying. However, there is a demand for the production of these materials in the form of thin films as they can be used as hard coatings in many practical applications. During my MSc, I worked on the production of HEA thin films and participated in an elaboration of a novel physical vapor deposition method to produce HEA thin films. In this work, we demonstrated that HEA thin films can also be processed using a multiple beam sputtering system in PVD, which does not require preliminary manufacturing of HEA targets, but rather uses commercially pure metal targets. This study also demonstrated the capability of this new multiple beam sputtering technique for the production of compositional gradient samples with a wide range of elemental concentrations, enabling combinatorial analysis of multiple elements high-entropy alloy. The effect of the chemical composition on the structure and properties of HEA films can be studied on combinatorial samples. We used synchrotron X-ray diffraction to create a diffraction map for one of these gradient samples, thereby we can examine the changes of the microstructure as a function of the chemical composition.

Research work in the current semester:

I have investigated the microstructure of a CoCrFeNi HEA thin film combinatorial sample. 13 points on the sample's surface were selected, and different measurements were carried out. Such as nanoindentation, EDS, and the CMWP analysis of the synchrotron X-ray diffraction measurements. We identified different phases in the sample. The points where we identified multiple phases were further investigated with TEM.

I collaborated on two other projects. I carried out the microstructure investigation of a ZK60 and an AA5083 sample series. I did the sample preparations, the X-ray diffraction measurements, and the measured data evaluation.

I also helped the work of another PhD student. In this case, I investigated the microstructure of an AA1050 sample series with X-ray diffraction and evaluated the measured data.

Publications:

There are two articles in preparation. The following one will be published in Material Science and Engineering A:

- N. Fakhar, M. Sabbaghian, P. Nagy, K.H. Fekete, and J. Gubicza "*Superior low-temperature superplasticity for fine-grained ZK60 Mg alloy sheet produced by a combination of repeated upsetting process and extrusion"*

And the following will be published in the special issue of Materials:

- P. Nagy, N. Rohbeck, Z. Hegedűs, J. Michler, L. Pethö, J. Gubicza *"Composition dependence of the microstructure and hardness in a multibeam sputtered nanocrystalline Co-Cr-Fe-Ni compositional complex alloy film"*

Studies in the current semester:

subject code	subject name	course type	number of classes	number of credits	Lecturers	Grades
FIZ/1/038E	Diffraction methods in Materials Science I.	Lecture	2	6	Gubicza Jenő	Excellent (5)
FIZ/1/024	Lattice defects I.	Lecture	2	6	Gubicza Jenő	Excellent (5)

Teaching in the current semester:

subject code	subject name	course type	number of classes
applphysf17lm	Methods of Applied Physics Laboratory	Laboratory	2