3.semester report

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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 continued my work on CoCrFeNi HEA thin layers. I investigated the phase transition on the surface of the sample as the function of the change in the chemical composition.

- We finished the software that could produce many simulated x-ray spectrums with specific microstructural parameters. This big data were used to develop the machine learning software for the CMWP analysis.

Publications:

- Sabbaghian, M.; Fakhar, N.; Nagy, P.; Fekete, K.; Gubicza, J. Investigation of shear and tensile mechanical properties of ZK60 Mg alloy sheet processed by rolling and sheet extrusion. Mater. Sci. Eng. A 2021, doi:10.1016/j.msea.2021.142098.

- Sidor, J.J.; Chakravarty, P.; Bátorfi, J.G.; Nagy, P.; Xie, Q.; Gubicza, J. Assessment of dislocation density by various techniques in cold rolled 1050 aluminum alloy. Metals (Basel). 2021, doi:10.3390/met11101571.

Conferences:

- OATK2021-XIII Országos Anyagtudományi Konferencia – Oral lecture „Nagyentrópiás ötvözet kombinatorikus vékonyréteg előállítása és karakterizálása”

- 2nd World Congress on High Entropy Alloys (HEA 2021) Oral lecture „Preparation and characterization of a HEA thin film combinatorial sample.”

Studies in the current semester:

subject code	subject name	course type	number of classes	number of credits	Lecturers	Grades
FIZ/1/040E	Bulk nanostructured materials	Lecture	2	6	Gubicza Jenő	Excellent (5)
FIZ/1/021E	Transmission electron microscopy and electron diffraction	Lecture	2	6	Kovácsné Kis Viktória	

Teaching in the current semester:

subject code	subject name	course type	number of classes
applphysf17lm	Methods of Applied Physics Laboratory	Laboratory	4