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High-dose ion implantation: hardening behavior in AlCoCrFeNiTi0.2 high-entropy alloy

Piotr Jenczyk*[1], Dariusz Jarząbek[1], Michał Milczarek[1], Neonila Levintant-Zayonts[1], Elżbieta Gadalińska[2], [1]Institute of Fundamental Technological Research, Polish Academy of Sciences, Poland,[2]Łukasiewicz Research Network – Institute of Aviation, Materials and Structures Research Center, Poland

Introduction: Nuclear plants demand a stable performance from structural components. Next-generation plants significantly increase the requirements to be sustained by materials. Especially, the dose of radiation goes up to 200 dpa. To safely imitate such conditions, ion implantation can be employed to study impacts on the structural and mechanical characteristics of the material. On the other hand, high entropy alloys (HEAs) have already been proven to be a promising solution for such environments. However, there is still a gap in understanding high-dose irradiation's influence on the crystallographic structure, phase transformations, and hardening behavior of HEAs.

Results [1]: In the presented work, high-dose nitrogen ion implantation (up to 200 dpa) was conducted to study the changes in mechanical behavior in two-phase AlCoCrFeNiTi0.2 HEA. σ-to-BCC phase transformation and crystallographic structure change were observed. Additionally, an increase in both nano-hardness and hardness-to-Young's modulus (H/E) ratio was obtained.

Experimental: Nitrogen ion implantation was conducted with semi-industrial IMJON implanter with ion fluences up to $5 \cdot 10^{17}$ ions/cm2. Nanohardness was studied with an in-situ nanoindenter which allowed to measure hardness for two constituting phases separately (grain size around 60 nm) as well as to conduct multi-indentation for in-depth measurements of hardness.

Future prospects: Ar, He ion implantation, thermal treatment

[1] Jenczyk P., Jarząbek D.M., Lu Z., Gadalińska E., Levintant-Zayonts N., Zhang Y., Unexpected crystallographic structure, phase transformation, and hardening behavior in the AlCoCrFeNiTi0.2 high-entropy alloy after high-dose nitrogen ion implantation, Materials & Design, ISSN: 0264-1275, DOI: 10.1016/j.matdes.2022.110568, Vol.216, pp.110568-1-11, 2022