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Ion-Beam Induced Structural and Chemical Changes in Targets Used for Superheavy Element Production

C.-C. Meyer[1,2], E. Artes[1,2,3], Ch.E. Düllmann[1,2,3], R. Haas[1,2,3], S. Herz[1], E. Jäger[3], B. Kindler[3], B. Lommel[3], F. Munnik[5], M. Rapps(†)[1,2], D. Renisch[1,2] C. Trautmann[3,4], I. Tzifas[3], A. Yakushev[3]

[1] *Johannes Gutenberg University Mainz, Dept. of Chemistry - TRIGA site,* [2] *Helmholtz-Institute Mainz, Dept. SHE,* [3] *GSI Helmholtzzentrum für Schwerionenforschung,* [4] *Technical University of Darmstadt, Institute of Materials Science,* [5] *Helmholtz-Zentrum Dresden-Rossendorf, Ion Beam Center*

Superheavy elements are produced via heavy-ion fusion reactions, using high-energy ion beams. Target production, especially of actinides as they are used to generate the heaviest elements in hot fusion reactions, relies mainly on the Molecular Plating (MP) method [1,2], an electrochemical deposition from alcoholic solution. [2] The lanthanides and actinides are very electropositive elements, reacting with water to form hydrogen and metal hydroxides or oxides. Therefore, the pure metals cannot be deposited electrochemically from an aqueous solution. [1,2,7] Nonetheless, in MP [2], the lanthanides and actinides are added to the alcoholic solution (typically isobutanol and/or isopropanol) in aqueous inorganic acids. [1] Details of layers produced by MP are still under study. Long-term stability of MP pro-duced targets is typically achieved in a so-called "baking-in" procedure, in which the fresh target is exposed to suc-cessively increasing beam intensities. This leads to non-trivial structural and chemical transformations, which have hitherto mostly been described by studies using microscopic methods [2,3] like atomic force microscopy (AFM) and scanning electron microscopy (SEM).

MP targets of the same thickness of different lanthanides were prepared and characterised by Raman spectroscopy, which provided new insights into the systematics of the MP process. To improve our understanding of the baking-in processes, comparative tests were carried out using Coulomb barrier heavy-ion beams provided from the UNILAC accelerator at GSI Helmholtz Centre for Heavy Ion Research Darmstadt, Germany. Thulium MP targets, serving as analogues to targets of heavy actinides, were irradiated at the UNILAC with Au ions at 8.6 MeV/n, and fluences, ranging from 10^{10}- 10^{13} ions$\cdot$cm^{-2} to systematically characterize their phase behaviour under these conditions. To prevent heating of the samples, the ion flux was kept below 2×10^9 ions$\cdot$cm$^{-2}\cdot$s^{-1} for the Au beam [4]. This fluence series was analysed by SEM, and confocal Raman spectroscopy.

As a next step to support the Raman data Ion Beam Analysis [5,6] (IBA) was conducted at the Helmholtz-Zentrum Dresden-Rossendorf, Germany, to obtain depth-resolved changes in the thulium-oxygen-carbon-ratios in the MP thin films. At the workshop preliminary new insights into MP thin films and their behaviour under irradiation will be presented.

References

[1] Parker, W. & Falk, R., Nucl. Instr. Meth., 16. Jg. (1962).
[2] Vascon, A. et al., Nucl. Instr. Meth. Phys. Res. A **696**, 180-191 (2012).
[3] Watson, P. R. et al., Nucl. Instr. Meth. Phys. Res. B **226**, 543–548 (2004).
[4] Tracy, C. L. et al. Physical Review B, 92, **17**, 174101 (2015).
[5] Pohjalainen, I et al., Nucl. Instr. Meth. Phys. Res. B **463** (2020): 441-448.
[6] Stodel, C. "Methods of targets' characterization." EPJ Web of Conferences. Vol. 229. EDP Sciences, **2020**.
[7] Choi, J. et al., J. Nanomater. **2016**, 5140219, (2016).