Production and characterization of gadolinium nitrate targets on superhydrophobic surfaces for high-precision mass spectrometry

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Introduction: The TRIGA-TRAP project carries out high-precision mass measurements of neutron-rich fission products and actinide nuclides using a Penning trap [1]. In case of off-line measurements, the investigated elements are ionized and injected into the apparatus using a laser ablation ion source [2]. For this purpose a target, which consists of the element of interest or an appropriate compound deposited on a backing material, is used. Ions are produced by laser irradiation and extracted towards the Penning traps. Up to now, the usual target preparation technique was to evaporate a drop of a solution on the backing, leading to an inhomogeneous deposition of the dissolved material. To obtain improved targets, several different backing materials (zinc, copper, silver, titanium, glassy carbon) were chemically and physically modified to create superhydrophobic surfaces with contact angles $\geq$ 150°. Droplets of aqueous solutions retain their spherical shape on such surfaces, because wetting of the surface is energetically unfavourable. Evaporation of the drop yields a circular, homogeneous spot of the precipitate [3].

Experimental: To produce superhydrophobic surfaces it is necessary to have both, a rough surface and a water-repellent layer [4]. Thus all used metal foils were etched in an appropriate acid, and the glassy carbon backings were sandblasted before further treatment. The next step was the deposition of a thin, hydrophobic layer. For the metal foils the most promising technique was the adsorption of polyfluorinated alkyl chains with an anchor group that binds to the metal surface, so that self-assembled monolayers (SAM) were formed. Heptadecafluoro-1-decanthiol (HDFT) was used for Zn, Cu and Ag, (Heptadecafluoro-decylsulfanyl)-ethyl-phosphonic acid (HDFP) was applied for Ti. Because there are no appropriate anchor groups for pure carbon, it was not possible to create SAMs on glassy carbon surfaces. Therefore a commercially available cyclosiloxane (Tegotop®105) solution was sprayed onto the glassy carbon backings. In a last step a drop of the solution of the element under investigation was put on the hydrophobic surface and evaporated. Gadolinium nitrate was chosen as target material for all test series.

Results: Radiographic imaging is used to check the homogeneity of the deposited material, using Gd-153 as radioactive tracer. As shown in Fig. 1, pre-treatment of the backing material results in a much more homogeneous deposition of the target material. To investigate the improvement in ionization efficiency with the new targets, a MALDI-TOF mass spectrometer (BRUKER Reflex III) was equipped with a laser system similar to that of the TRIGA-TRAP setup, so that a laser

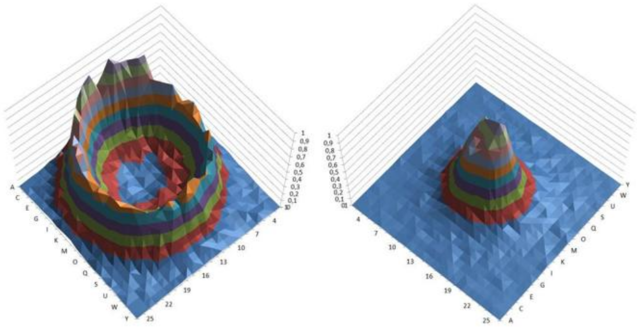

Figure 1. Radiographic imaging of radioactive Gd targets. The target on the left side was prepared on an untreated Ti foil, the one on the right side was prepared on a superhydrophobic Ti foil.

ablation ion source was available for test purposes. The results of the tests with Ti backings are shown in Fig. 2. The yield of ions per laser pulse is significantly increased by using the new targets compared to the two references (non-modified Ti backings). The Tegotop®105 layer is not stable under laser irradiation conditions, and accordingly, no satisfactory results were obtained with the glassy carbon backings [5].

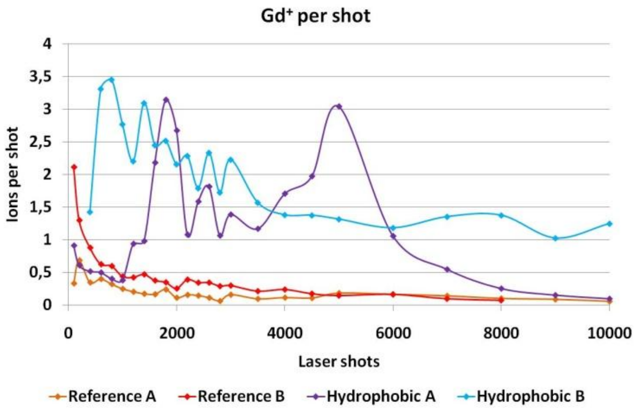

Figure 2. Gd^+ ions per laser shot detected with the modified MALDI-TOF mass spectrometer. The two reference targets were prepared on an untreated Ti foil, the two hydrophobic targets were prepared on a Ti foil which was pre-treated with HDFP.

References

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