Electrochemical Deposition of Short-lived Pb Isotopes on a Pd Coated Ni Tape

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The coupling of the ALOHA system to an electrolytic cell was successfully used to transfer Pb recoil nuclei from a ^{219}Rn emanation source into the liquid phase with subsequent electrodeposition on Pd electrodes [1].

So far, the transport of the electrodes from the electrolytic cell to the α-detector was performed manually. However, in an experiment with superheavy elements, an automated transport is necessary, preferably by using a metal tape as the electrode. For the deposition of Pb as the homolog of element 114, the electrode material of choice is Pd [1], but the production of several meters of Pd tape is too expensive. As a cheap and withstanding material, Ni tape is available, but the deposition of Pb on Ni was found to be slow and reversible. To combine the advantages of both materials, Pd was deposited onto a Ni tape (2 cm x 500 cm x 100 µm), which was wound onto a PE holder to ensure complete contact with the solution. The deposition was carried out in 1.5 L of 0.1 M HCl containing 50 mg/L Pd at -1000 mV vs. Ag/AgCl for 15 min. As counter electrode, a Pt gauze was used.

An electrolytic cell for electrodeposition experiments with tape shaped electrodes was constructed. The metal tape was sealed with two FEP coated o-rings to prevent the liquid from entering the detector system and to ensure a low frictional resistance for a smooth tape transport. A high volume magnetic stir bar was used for agitating the electrolyte. The α-detector system consisted of three PIN diodes, with (1 x 2) cm active surface, each. The detectors were mounted at 5 cm distance in an Al-case and were kept under He (see Fig.1).

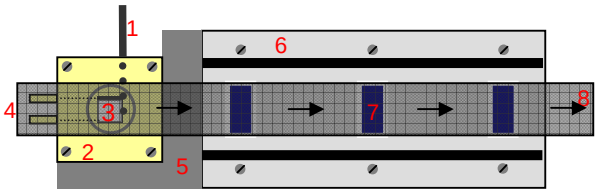

Fig. 1: Schematic of the electrolytic cell with the α-detection system for electrodeposition and detection of accelerator produced short lived isotopes. 1 Ag/AgCl reference electrode, 2 electrolytic call with o-rings, 3 high volume magnetic stir bar, 4 electrolyte in- and outlet, 5 spacer, 6 Al-case for detector system, 7 (1 x 2) cm PIN diodes, 8 Pd coated Ni-tape, arrows: stepping direction

The α emitting ^{188}Pb ($t_{1/2}$ = 25.5 s) was produced in the reaction ^{152}Gd (^{40}Ar, 4n). A ^{152}Gd (30% enrichment) target with a thickness of 300 µg/cm² on 15 µm Be backing was used. The recoil nuclei were swept out of the recoil chamber by a He/KCl cluster gas-jet at a flow rate of 1.5 L/min and transported through a PE capillary to the ALOHA device. To determine the overall deposition yield for ^{188}Pb, the activity was impacted for 3 min on a Kel-F disc. At this collection time, the activity of ^{188}Pb was nearly in radioactive equilibrium.

After impaction, the disc was switched to the dissolution position and the activity was transferred to the electrolytic cell by continuous cyclic pumping of the electrolyte (0.1 M HCl, T = 65°C).

The rest potential of the Ni(Pd) tape was -250 mV vs. Ag/AgCl. At this potential, Pb deposits spontaneously, so no external potential had to be applied.

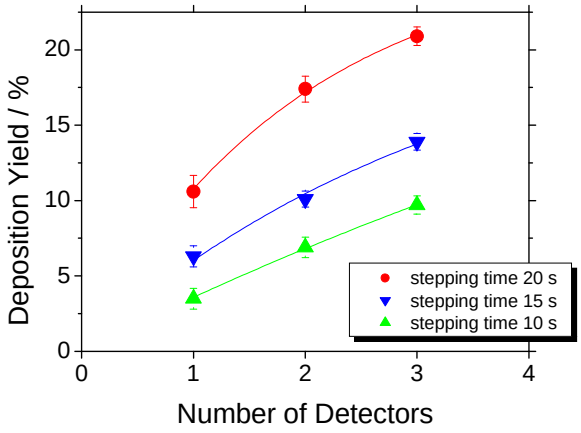

Fig. 2: Deposition yield vs. the number of detectors for various stepping times of the Pd coated Ni tape

The tape was stepped in intervals of 10, 15, and 20 s for several minutes. The deposition yield was calculated by comparing the count rates for each detector with a direct catch on a 0.1 µm nucleopore filter. A maximum deposition yield of 21 % was achieved for a stepping time of 20 s (see Fig. 2).

In this set-up, only three detectors were used. Especially for fast stepping times a big amount of activity was stepped out of the detection system. In a superheavy element experiment, up to 20 α detectors will be available. The yield may be increased significantly by using a pump system with a lower dead volume (now 250 µl) and a higher electrode surface. The latter can be achieved by using two tapes.

After improving the overall yield, the proposed set-up may be successfully used in aqueous chemistry with element 114. Experiments with homologs suggest, that also the electrochemical deposition of element 108 - 111, 113, 115, and 116 should be possible.

References

[1] Hummrich et al., *GSI Scientific Report 2004*, p. 189