A study on ^{100}Pd ion regeneration using electron beam for VECC Cryogenic Ion Trap Project

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Introduction

Among several experiments planned using VECC Cryogenic Penning Ion Trap facility being developed, we plan to trap radioactive ^{100}Pd ($T_{1/2}$=3.7d) for mass measurement and beta decay studies [1]. In this cryogenic trap facility, radioactive ions of interest would be produced at an accelerator facility and carried inside the trap implanted in a catcher or deposited on a substrate. Subsequently the ions of interest would be regenerated from the catcher or the substrate i.e. the host carrier by impinging with electrons. An experiment is being done to study and to find an efficient regeneration method of ^{100}Pd inside the cryogenic trap.

Setup for ion regeneration study

A setup for studying the ion regeneration from different host carrier has been designed and fabricated and shown in Fig. 1. The setup has electron source (Energy :100 eV to 10 keV, Beam current 10nA to 100μA). The electrons generated from this electron source would impinge on the host carrier placed on the holder shown in Fig 1 and the positive ions pushed out of the carrier would be collected on aplate placed behind the host carrier. The host carrier would be at a maintained at a positive bias while the plate behind at a negative bias .

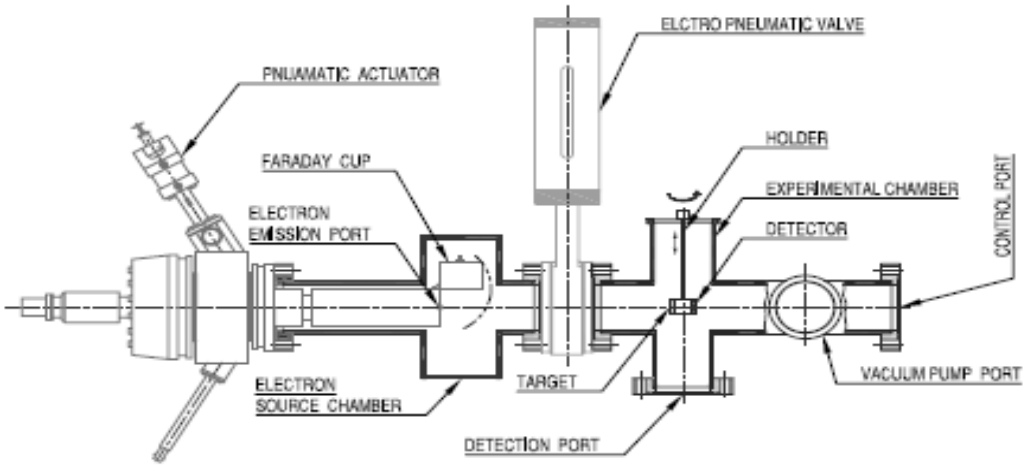

Fig1. Setup for ion regeneration study

It is expected that the energetic electrons would bombard the positively charged carrier and as a result the radioactive ions loosely bound to the surface of the carrier and would come out in at least 1+ charge state.

Production and Radiochemical separation of ^{100}Pd

The radioactive ^{100}Pd was produced by α-induced reaction of natural ruthenium. A thin ruthenium target (~800 μg/cm^2) was prepared by electrodeposition on an aluminum backing (~7 mg/cm^2). This was irradiated with 40 MeV α-beam from VECC, Kolkata to get ^{100}Pd, mainly by the ^{99}Ru(α,3n)^{100}Pd reaction. The recoiled products (namely, Pd, Ru & Rh) from the target were collected in an aluminum catcher. The varying behavior[2] of these ions in an anion-exchange column was used in the separation of ^{100}Pd from the catcher. The catcher was dissolved in hydrochloric acid and the solution was made into an acidity of 2M HCl. The solution was loaded into a Dowex 1X8 (100-200 mesh) anion exchange column conditioned at 2M HCl. The column was then washed thoroughly with 2M HCl when inactive Al and other product activities like Ru, Rh etc. came out. The column was subsequently washed with sufficient water till it was free from HCl acid. It was then eluted with 10% NH_4OH solution when only palladium activity was obtained within two column volumes of eluate. The active solution of ^{100}Pd was evaporated repeatedly with water to remove ammonia from the medium. It was taken to a very small volume of water and spread on the surface of a copper foil. It was dried under an IR lamp and thus the carrier with ^{100}Pd deposited was ready for the ion regeneration study.

Results and Conclusion

A γ-spectrum ^{100}Pd radioactive ions deposited on copper carrier was recorded and found to be contamination free, shown in Fig 2. The amount of ^{100}Pd deposited was found to be ~3.4×10^7, estimated from 74.8 keV and 84 keV γ-lines. We first fixed the carrier with ^{100}Pd deposited on the holder of the regeneration study setup and evacuated the chamber. First the carrier was placed directly facing the electron source and it was bombarded with electron beam having 2 keV energy for one hour. The carrier with ^{100}Pd was then taken out of the regeneration setup and counted. We found no change in ^{100}Pd activity in the carrier after this run. We again placed the carrier on the regeneration setup holder. Now the carrier was placed at an angle so that the electron beam would make a 30 deg angle with the surface of the carrier. The carrier was placed at +12V bias. Electrons having 5 keV energy was bombarded on the carrier for 90 min. The current measured at the electron source head was 6μA.

As we find no loss of activity even after the second impingement, it seems ^{100}Pd is too strongly bound with the copper host. We plan to deposit ^{100}Pd on other inert substrates like Pt or Au and keep the carrier at a higher voltage and the study is in progress.

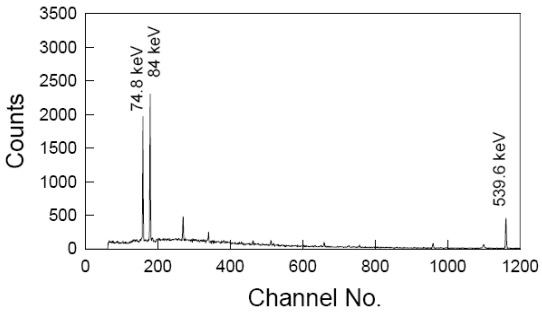

Fig. 2 γ-ray spectrum of ^{100}Pd deposited carrier

References

[1] P. Das et al. Proc. Of the National Symp. On Nucl. Inst-2010, **33** (2010)

[2] Z. Chunfu et al. Appl. Rad. Isot. 55, 441 (2001) .