BARC–TIFR Pelletron Linac Facility Beam Time Request @2024

Title of the Experiment: Irradiation of Zr-2.5Nb alloy with Cl 35 beam

Principle Investigator: Dr Parag Ahmedabadi, SO/H, MP&CED, BARC

Local Collaborator / Spokesperson: Mr S. C. Sharma, NPD, BARC (TIFR)

Collaborators Name: Dr Sai Karthik Nouduru

Motivation of the experiment: To study the effect of Cl 35 implantation on nodular corrosion behaviour of Zr-2.5Nb alloy

Beam details: Cl 35 beam, 70-75 MeV, Beam current 500 nA, Beam Port 6M/30N.

Buncher requirement: Yes/ No

Number of shifts (1 shifts=8 hr.) required: 6

Experiment details:

1. **Objective of Experiment:**

Zirconium alloys are used in pressurized heavy water reactors (PHWRs) for components like fuel cladding (Zircaloy-4), pressure tubes (PT, Zr-2.5Nb) and calandria tubes (CT, Zircaloy-4). Recent incidence of nodular corrosion of pressure tubes in KAPS-1&2 reactors led to systematic studies on the feasibility and mechanism of nodular corrosion of zirconium alloys in gaseous phase. It was demonstrated that the Zr-2.5Nb pressure tube alloy undergoes nodular corrosion in a CO_2 + 2 vol. % O_2 mixture in the presence of contaminants like chlorine, hydrochloric acid, nitric acid, and formic acid. This was the first observation of gaseous-phase nodular corrosion, attributed to localized attack on the oxide film due to contaminants. Chlorine and hydrochloric acid, in particular caused extensive nodular corrosion on the Zr-2.5Nb alloy in a relatively short duration. However, these experiments could not quantify the amount of chloride ions deposited on the specimen surface, and their relation to the extent of nodular corrosion.

In this context, it is planned to perform exposures of Zr-2.5Nb specimens to Cl 35 beam for various durations (1h, 8h, etc) at the pelletron facility to achieve different levels of Cl ion implantation in the specimens. These specimens will then be subjected to nodular corrosion experiments at MP&CED to study the effect of different levels of Cl ion implantation. Further, the proposed mechanism for nodular corrosion in gaseous phase attributes the initial of nodules to the defects present in the oxide film. Therefore, it is also planned to generate various defects in the oxide film by Cl ion irradiation and study their effect on the gas phase nodular corrosion.

2. **Description of Experiment:**

Specimens of Zr-2.5Nb pressure tube with and without oxide layer shall be exposed to Cl 35 beam at the pelletron facility for various durations ranging from 1 h to 72 h. Assuming a bam current of 500 nA and the average charge of Cl as +8.23, the approximate number of Cl ions that will be deposited on the specimen surface and the accumulated charge (C) after various durations are given in the table below:

Time (hours)	1	4	8	16	24	72
Ions deposited	1.3662 x 10^{15}	5.4648 x 10^{15}	1.0929 x 10^{16}	2.1858 x 10^{16}	3.2787 x 10^{16}	9.8361 x 10^{16}
Charge deposited (Coulombs)	1.79 x 10^{-3}	0.0071	0.0143	0.0286	0.043	0.129

- **Whether the experiment is part of PhD /Post Doc. work**
  The experiment is in continuation to the experiments done by Dr Sai Karthik Nouduru as a part of his PhD on Nodular Corrosion of Zr alloys in gas phase.

- **Details of Beam time availed of in recent past on this experiment and / or by the PI: NA**
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- **Details of papers published / presented in journals / symposia, etc. based on recent experiments: NA**