P.2. Optimization of NEG coating process for SWLS chamber of Indus-2: Findings of second experimental run

In the INDUS-2 storage ring, a Superconducting Wavelength Shifter (SWLS) is planned to be installed in the long straight section LS-4 to extract synchrotron radiation through the 0° port downstream of the dipole chamber for beamline experiments. The proposed aluminium alloy SWLS chamber is 1400 mm long with a racetrack cross-sectional profile of 20 mm × 100 mm. Due to the very low conductance of this narrow chamber and space constraints along its length, pumping using only lumped pumps at the ends is insufficient to maintain the required vacuum level in the central region. To address this limitation, distributed pumping using a Ti–Zr–V non-evaporable getter (NEG) coating of approximately 1 µm thickness has been proposed. NEG coatings provide distributed pumping, reduce outgassing rate, and enhance vacuum performance. As part of coating process optimisation study, the second experimental run was undertaken to study the effect of increased sputtering power on film microstructure, elemental composition, and coating duration required to achieve the target thickness.

NEG-coated chambers and flat aluminium samples were coated using an in-house cylindrical DC magnetron sputter deposition system. Intertwined Ti–Zr–V wires of 1 mm diameter were used as cathodes. Considering the racetrack cross-section of the vacuum chamber, three targets were employed to minimize thickness non-uniformity along the perimeter [1]. Thickness uniformity along the chamber length and periphery was studied with the first experimental run carried out last year. Flat aluminium samples of size 10 mm x 30 mm were simultaneously coated for characterization purposes. Surface morphology and chemical composition were analyzed using scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS), respectively.

The deposition parameters for the second experimental run are listed in Table P.2.1.

Table P.2.1: Deposition Process Parameters

Process Gas	Kr
Target	Ti -Zr -V
Sputtering Power (W)	100
Solenoid Current (A)	90
Coating Duration (hrs.)	9

With 100 W sputtering power, a deposition rate of 19 Å/min was achieved. In comparison, the first run was conducted at 55 W and yielded a deposition rate of 9.8 Å/min. The increase in deposition rate with sputtering power is attributed to the higher discharge current and increased number of atoms ejected from the target.

SEM analysis of samples coated in the second experimental run is shown in Figure P.2.1. The films exhibit a cauliflower-type morphology (similar to first run) but with comparatively larger grain size than those obtained in the first run (Figure P.2.2).

EDS analysis was performed on coated aluminium samples to determine elemental composition. The measured atomic percentages were: Ti: 37%, Zr: 23% and V: 40%.

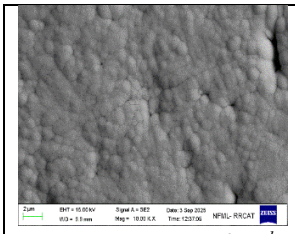

Fig. P.2.1: SEM of 2nd Experimental run

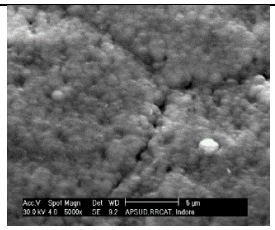

Fig. P.2.2: SEM of 1st Experimental run

Figure P.2.3 shows the representative EDS spectrum. The measured composition falls within the suitable range for low-temperature activation (~180°C), meeting the requirements of INDUS-2 aluminium vacuum chambers.

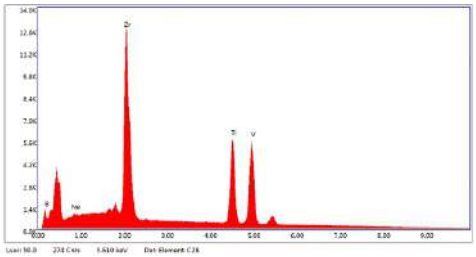

Fig. P.2.3: EDS spectrum of DC Magnetron sputter coated TiZrV film on Aluminium sample

Vacuum performance of 350 mm long SWLS-profile NEG-coated chambers was evaluated using a 35 l/s sputter ion pump. After activation at 180°C, an ultimate pressure of 2×10^{-10} mbar and a CO partial pressure of 3×10^{-11} mbar were achieved, demonstrating effective distributed pumping.

Results indicate that increasing sputtering power improves deposition rate but leads to increased grain size due to higher adatom mobility. Comparative analysis of the first and second runs suggests that lower sputtering power is more suitable for producing finer-grained NEG films desired for enhanced pumping speed.

The effect of increased sputtering power and gas flow rate on NEG coating characteristics was investigated during the second experimental run. Higher power resulted in increased deposition rate and larger grain size, while the elemental composition remained within the desired range. Effective ultra-high vacuum performance was achieved after activation. The study indicates that lower sputtering power is preferable for obtaining finer-grained NEG coatings. Further experimental run will focus on the repeatable performance of the coating process.

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