A.8: Initial results from titanium film coatings on MACOR substrate by magnetron sputtering

Thin film coatings are popularly used on inner surfaces of vacuum chambers of an accelerator for lowering specific outgassing rate, pumping purpose and also give electrical continuity in case of MACOR chambers. Titanium/titanium nitride (Ti/TiN) metallic thin film coatings are commonly used on inner surfaces of particle accelerator vacuum system components like MACOR kicker chambers, RF Windows, metal beam pipes to minimize beam impedance and secondary electron (SE) yield. Ultra-High Vacuum Technology Section (UHVTS) at RRCAT has initiated the development of titanium thin film coating on the surface of the alumina substrate for its application on spare kicker chambers of Indus-2 storage ring.

Thin films may be deposited either through sputtering, evaporation, chemical vapor deposition (or) through hybrid processes. Sputtering is a natural choice of deposition films on the inside surface of a vacuum chamber due to the following reasons: (a) good film adhesion with substrate, (b) uniformity of the film thickness on the substrate, (c) high temperatures can be avoided, an important aspect for coating finished chambers having welds and braze joints. In addition to UHV compatibility, the adhesion of the film is extremely important to avoid the generation of small particles in the accelerator vacuum system for kicker chamber application. The coating material and thickness are chosen based on the following requirements: (i) external magnetic fields must penetrate the coating, (ii) the rise time of the external field must be preserved, (iii) electrical continuity to the adjoining vacuum chambers must be provided, (iv) the film must tolerate magnet pulsing (without arcing and remain adherent to the substrate) mainly.

In initial attempt, flat MACOR button coupons of 10 mm diameter and 1 mm thickness were used to coat titanium thin film using cylindrical stainless steel chamber as envelope. Magnetron sputtering based existing getter coating system was slightly modified for titanium thin film deposition. Standard ultra-high vacuum practices like chemical cleaning of sample coupons followed by baking of the entire coating system was followed prior to sputter deposition and an ultimate vacuum of the order of 1.0×10^{-10} mbar was achieved with the help of a 70 l/s sputter ion pump. Magnetron sputter deposition was performed in the presence of argon gas (99.999% pure) pressure of 2.0×10^{-2} mbar with a magnetic field strength of 210 gauss (generated with the help of a water-cooled electromagnet) at 500 V, 100 mA discharge voltage and current respectively using a turbo molecular pumping system. About 0.9 µm thick titanium film was obtained on the inner surface of the stainless steel chamber and on MACOR substrate coupons in 6 hours of coating duration. The ultimate vacuum of the order of 5.0×10^{-11} mbar was achieved in 24 hours after the discharge coating (without baking) with the help of sputter ion pump. Characterization of thin film coated MACOR coupons was performed using EDS measurement technique for chemical composition information. Chemical composition in atom% was found to be titanium: 99.39, aluminum: 0.13, silicon: 0.41 and magnesium: 0.08. Figure A.8.1 presents the EDS spectrum obtained from the sputter coated titanium film on MACOR coupon. SEM examination of the surface of the thin film revealed nano sized conical shaped particles distributed on the entire coating with surface porosity (refer Figure A.8.2).

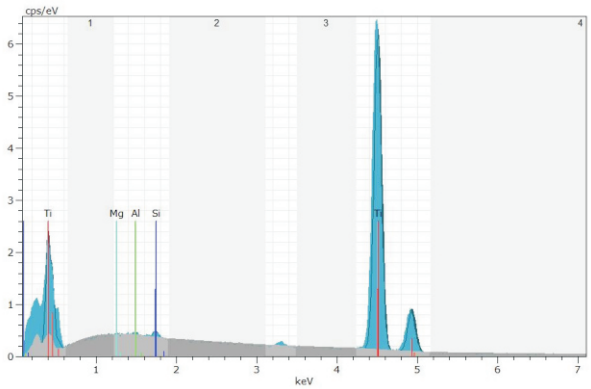

Fig. A.8.1: EDS spectrum of DC magnetron sputter coated Ti film on MACOR coupon.

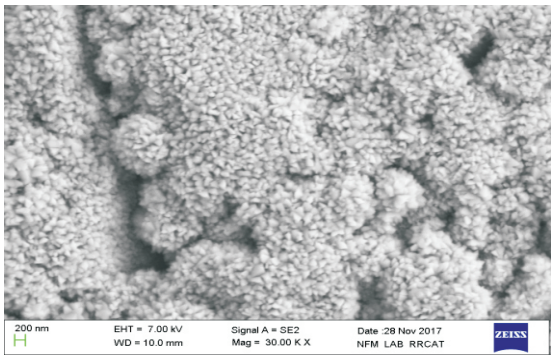

Fig. A.8.2: Surface topology and features of the DC magnetron sputter coated Ti film on MACOR coupon.

Using the co-centric circular probe, the thickness of the film was found to be between 0.7841 to 0.9341 µm along the 150 mm length of the glass substrate. The obtained thickness is found to be matching with the Ti film coated on installed kicker chambers of Indus-2. Further coating process optimization is in progress.

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