DEPOSITION OF NON-EVAPORATIVE GETTERS R&D ACTIVITY FOR HEPS-TF

D. Z. Guo, P. He, B. Q. Liu, Y. S. Ma[†], Y. C. Yang, L. Zhang, IHEP, CAS, Beijing, P.R. China

Abstract

Non Evaporable Getter(NEG) coating technology was widely used around the world's ultra-low emittance storage rings. It will provide the distributed pumping which is the obvious solution to solve the conductance limitation of narrow vacuum chamber at small magnet aperture. The HEPS-TF is the R&D project of HEPS (High Energy Photon Source), it will cover all of the key technology for HEPS accelerator system and beamlines. In order to meet the small aperture vacuum chamber distributed pumping requirement, the NEG coating R&D for HEPS vacuum chamber is under the way. Getter films deposited on the inner surface of the chamber would transform the vacuum chamber from an outgassing source into a pump. The coating test bench will be shown here and coating procedure will be presented.

INTRODUCTION

The HEPS-TF is the R&D project of HEPS (High Energy Photon Source), it will cover all of the key technology for HEPS accelerator system and beamlines. To further develop the technologies necessary for diffraction-limited storage rings based light source, it involves many areas: vacuum system/non-evaporative getter (NEG) coating of small chambers, fast injection/pulsed magnets, RF systems/bunch lengthening, magnets/radiation production with advanced radiation devices(insertion devices), high precision power supply, beam diagnostics, mechanical support, and beam physics design(lattice) optimization.

The HEPS 6 GeV storage ring (1296 m in circumference) will be an ultra-low emittance ring (bare lattice emittance below 0.1 nm·rad) based on multi-bend achromat (MBA) magnet concept. Due to the compact lattice design and applied small magnet aperture of 25 mm, so the majority of the vacuum chambers are designed as circular tubes of 22 mm inside diameter and 1 mm wall thickness. This will cause the conductance limitation problem for the vacuum pumping. To reduce ring vacuum pressure, some of the conductance limited chambers are planned to be coated with non-evaporable getter (NEG) film of TiZrV. The use of NEG (Non-Evaporable Getter) thin film deposited onto the components used in a vacuum system has revolutionized the design of vacuum systems. The NEG film brings pumping to sources of gas-loads; it provides distributed pumping in a space-limited environment and has a very low outgassing rate. The coating is deposited by magnetron sputtering method that was developed at CERN [1] and is used in other synchrotron light facilities around the world. In recent years, different getter materials have been investigated [2,3,4].

In this context, our work will focus on the progress of the deposition of NEG coatings in very narrow chambers, as well as engineering and physics challenges they face today.

NEG COATING TEST BENCH

The TiZrV NEG films were deposited using the DC Magnetron Sputtering technique. The DC Magnetron Sputtering technique was employed due to its simplicity and lower sputtering gas pressure. A schematic diagram of the experimental setup for NEG deposition is shown in Figure 1. The vacuum chamber is a 1.5 m long, 22 mm in inner diameter copper cylindrical tube. The cathode was made by twisting three wires of high-purity (99.95%) titanium, vanadium and zirconium, each of 1 mm diameter, using an electric drill machine. Ti-V-Zr type was chosen because of its lowest activation temperature among ternary getters. The tube sample is electrically isolated mounted to the chamber in the direction of gravity. The cathode wire runs through the tube sample and is positioned approximately along the axis of the tube. The bottom end of the cathode wire was connected to a high voltage feed through, and the top end was mounted to a blank flange. Two edge-welded bellows, each with three springs mounted in between its flanges, apply tensile force to the cathode wire to keep it straight, preventing short circuit. Gas inlet was mounted on the top of the system, and the vacuum pumps are mounted in the bottom. A solenoid was mounted outside and coaxial to the sample tube, providing a magnetic field parallel to the tube.

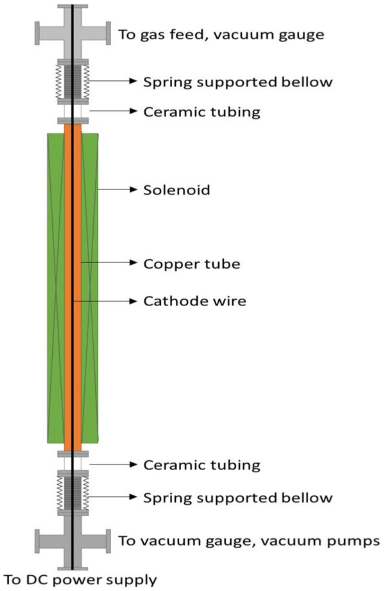

Figure 1: Test bench set-up.

COATING PROCEDURE AND RESULTS

The system was evacuated with a 550 l/s turbo molecular pump backed by an oil-free mechanical pump and baked for 2 days to a base pressure in the 10e-7Pa range. High purity krypton gas was injected using a mass flow controller. Krypton is being used as a discharge gas, even though it's a more expensive gas, because some tests have indicated that argon embeds itself in the NEG film. The embedded argon may reduce the quality of the NEG film. The flow rate could be adjusted up to 10 sccm to obtain the desired operational pressure, which was typically in 10e+1 Pa range. The solenoid is powered by a DC power supply, providing a desired magnetic field in 10e-2 Tesla range. The discharge was powered by a DC power supply, capable of delivering up to 1kV and 1A. Kr was ionized by the electron impact in the discharge plasma and the Kr+ ions were accelerated towards the cathode. Due to energized particles (ions) colliding with the cathode, atoms of TiZrV were freed from the cathode and traveled to the chamber wall to be coated to form thin films. The sputtering parameters were optimized to provide maximum allowable sputtering current at minimum krypton pressure. During deposition, the power was set to be approximately 80W. The deposition time was about 4 h.

Figure 2: Test piece of the copper tube after coating (grey).

As shown in Figure 2, the NEG coating was uniformly deposited on the inner surface of the entire copper tube. The tube was sliced open manually to check the NEG thin film formation.

FUTURE WORKS

The characterization of the surface and bulk properties of the deposited NEG coatings is in progress, including physical and chemical properties of the coating itself, as well as its pumping performance. Scanning electron microscopy (SEM) will be used to study the surface morphology and composition. Rutherford backscattering spectrometry (RBS) or x-ray photoelectron spectroscopic (XPS) will be used to investigate the depth profile of elemental composition of the sample. X-ray diffraction (XRD) has been used to identify the crystalline phase.

CONCLUSION AND PERSPECTIVES

A test bench of NEG deposition inside the small radius copper vacuum tube has been described, which incorporates several novel features. The NEG thin film was deposited using DC magnetron Sputtering onto copper pipe, using krypton as the discharge gas. Further work is foreseen as part of an on-going R&D of this development, with the aim of surface analysis of thin film and pumping performance measurement, simplifying the NEG coating procedures as well as reducing costs. In particular, this includes the NEG coating for the vacuum tube with antechamber (even smaller gap 6~8mm dimension).

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