Ultra-Low Synchrotron Radiation-Stimulated Desorption from Pd/TiZrV Coated Cu Tubes

Gas desorption stimulated by synchrotron radiation (SR) is the main outgassing source in electron storage rings including SR sources. For a future SR source ring, coating non-evaporable getter (NEG) materials on the inner walls of the vacuum chambers is being considered. We found for the first time that covering the NEG films, such as TiZrV, with a Pd thin film further reduced the SR-stimulated gas desorption. The Pd films also protect the TiZrV films from O_2 and H_2O adsorption and improve the pumping speed. These results demonstrated the advantage of applying Pd films to the future SR source ring.

In the operation of a particle accelerator, most of the SR generated in the bending magnets is received by absorber and vacuum tubes and the gas desorption due to the SR stimulation is the main outgassing source. It is necessary to reduce this desorption to shorten the commissioning time and ensure safe operation. One approach is to coat the vacuum chambers with a thin film of a NEG material. NEG films, such as TiZrV [1], exhibit high pumping performance and low SR-stimulated desorption after activation, whereas TiZrV films show quick degradation after atmosphere exposure due to sorption of too much O_2 and H_2O. To protect the getter films from O_2 and H_2O, the formation of a Pd layer on the TiZrV film has also been proposed [2] and developed. However, there has been no report on SR-stimulated desorption for Pd/TiZrV films. In the present study, Pd/TiZrV films were prepared and desorption properties in response to SR were studied.

Coatings were applied to Cu tubes using a cylindrical magnetron sputtering apparatus at KEK, employing intertwined 1-mm diameter Ti, Zr and V wires or dual intertwined 0.8-mm diameter Pd wires. Each tube had an inner diameter of 25 mm, thickness of 1.5 mm and length of 450 mm. The typical coating parameters included a magnetron field of 200 G, cathode voltage of 500 V and substrate coating temperature of 100°C. Two samples were prepared: Cu tubes coated with TiZrV 1.7 μm or Pd 25 nm/TiZrV 2 μm.

Beamline BL-21 was used for the present PSD experiments, as shown schematically in **Fig. 1**. An SR collimator with a width of 10 mm and height opening of 5 mm was positioned between the experimental chamber and the rest of the BL vacuum system. The pressures in the chamber on either side of the orifice with a width of 11 mm and height of 6 mm were measured using calibrated Bayard–Alpert gauges (BAGs). The critical energy of SR is 4 keV and the incident angle of the synchrotron light for the tube surface is around 4 mrad. After installing the sample, the coated tubes were heated at 250°C for 4 h. For comparison, the PSD of the bare Cu tube was also measured. Prior to PSD measurement, the Cu tube was heated at 150°C for 24 h. The PSD yield is defined as the number of desorbed molecules per incident photon. The calculation methods were as described in detail in Ref. [3].

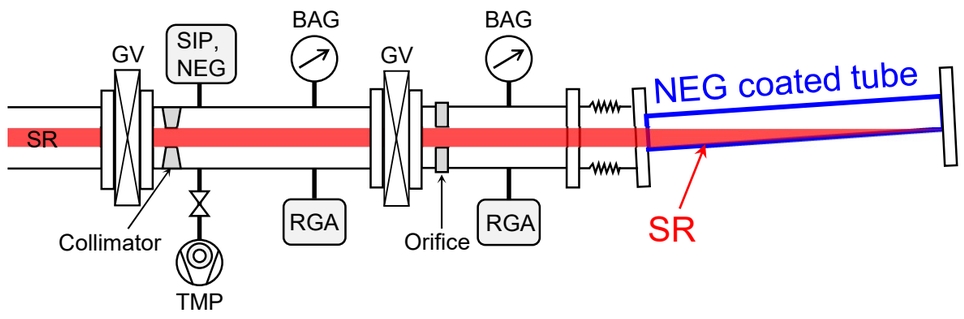

Figure 1: A schematic diagram of BL-21.

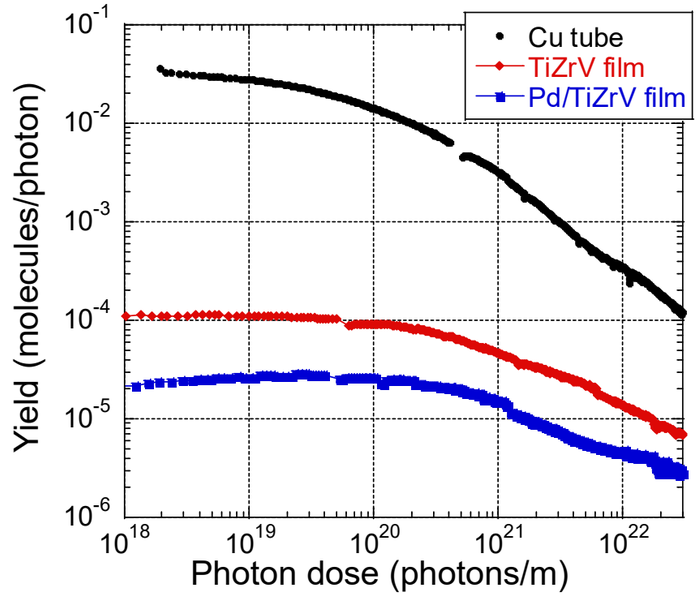

Figure 2: Dependence of the desorption yield on the photon dose.

The dependence of the desorption yield on the photon dose is shown in **Fig. 2**. The initial total yields for the coating films are over two orders of magnitude lower than that from the bare Cu tube. After a photon dose of 3×10^{22}, the yields for coating films are also over one order lower than that for the Cu tube. The desorption is due to an initial electron excitation and the subsequent transformation of the excitation energy into the kinetic energy of desorbed atoms and molecules. After activation, the surface of the coating films becomes cleaner with resultant lower gas desorption. In addition, the coating films have pumping performance after activation while the Cu tube does not. The released gases were resorbed by the coating films while passing through the tubes.

The yield of the Pd/TiZrV film is also lower than that of the TiZrV film by a factor of 1/5. Thermal desorption measurements revealed that the Pd released more gases and thus retained fewer impurities during heating. In addition, Pd could not be oxidized at room temperature. This indicated that the Pd layers limit the accumulation of carbon and oxygen on or near the surface. Regarding the pumping rate, Pd films have higher pumping rates for H_2 than the TiZrV films [4]. These different characteristics are considered to have further reduced the SR-stimulated desorption of the Pd layer.

In summary, we newly found that the Pd surface significantly reduced the SR-stimulated desorption yield. This result is ascribed to the high pumping rate of Pd and the higher release of gases from this material during activation. In particle accelerators in the future, vacuum tubes and other components such as absorbers and collimators will be coated with Pd films to reduce the release of gases.

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BEAMLINE

BL-21

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