PHOTODESORPTION MEASUREMENTS AT ESRF D31

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Abstract

Since 1998 exists at ESRF a dedicated beamline for photodesorption measurement from vacuum chambers - D31. The original goal of this installation was to study the wall pumping effect. When exposed to synchrotron radiation surfaces exhibit strong outgassing of the adsorbed gas layer despite UHV conditions. Long term outgassing leads to the depletion of the adsorbed layer and produces a very clean surface which turns the walls of the vacuum chamber into an active pumping surface.

At D31 have been tested chambers of stainless steel, aluminium and copper, with or without coatings (e.g. NEG, copper), designed by ESRF and other institutes like ALBA, CERN, ELETTRA and Soleil. Here we review some of the results obtained and outline the future plans of D31.

INTRODUCTION

Drawing on the experience of former ESRF vacuum group leader R. Souchet and the photodesorption setup [1] at LURE, Orsay, it was commissioned [2] and installed [3] a dedicated beamline in the ESRF storage ring for photodesorption studies. This installation played an important role in the development of the current generation insertion devices (ID) vacuum chambers used at ESRF [4].

Vacuum chambers, when exposed to synchrotron radiation exhibit strong outgassing from the adsorbed surface layer despite UHV conditions. Outgassing due to photodesorption plays a predominant role when designing the vacuum system of a synchrotron installation. Moreover it limits the performance of ID chamber designs due to bremsstrahlung (BS) radiation constrains [5]. The radiation generated along the chamber is deposited on the first elements of the experimental hutch leading to the requirement of additional shielding and thus reducing the availability of the beamline to the users.

PHOTODESORPTION

The first successful models to describe electron stimulated desorption (ESD) or photon stimulated desorption (PSD) where the MGR model, independently proposed by Menzer and Gomer [6] and Redhead[7], and later the Knotek-Feibelman [8] (KF) model. Briefly, in the MGR model an atom is excited to an anti-bonding state and it may gain sufficient kinetic energy so that it overcomes the lower potential barrier of one of the bonding states in the de-excitation pathway. The KF model is based in an interatomic Auger decay. The original excitation leaves a hole in the core level to be filled by an electron from a neighbour atom and, due to Auger decay, further electrons are ejected from the neighbouring atom. This leads to a final state where the two ions are positively charged and repel one into vacuum.

D31 EXPERIMENTAL SETUP

The current setup allows for the photodesorption measurement on vacuum chambers up to 6m long using the conductance method. It is installed at the exit of bending magnet D31 inside the synchrotron tunnel. This causes limited accessibility during runs allowing for the exchange of the chamber only at the regular shutdowns.

The incident x-ray radiation is defined by the front end slits and intercepts the chamber in a glancing angle. Resulting outgassing is determined by measuring the pressure difference across a known conductance. The chamber is positioned in such way that the incident radiated power is distributed across its length

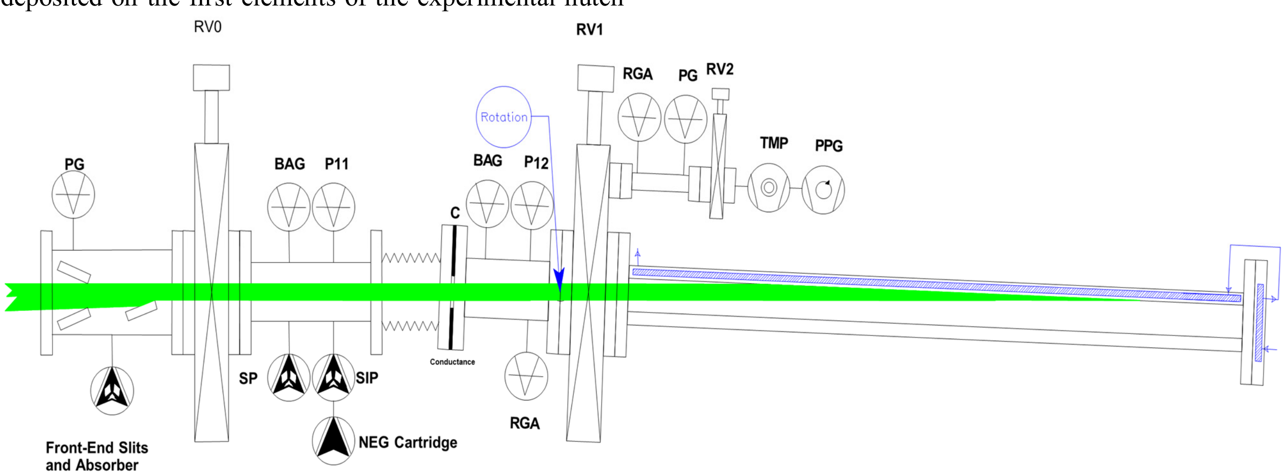

Figure 1: D31 schematics. PG – Pirani gauge; RV – Remote Valve ; SIP – Sputter Ion Pump; BAG – Bayard-Alpert Gauge ; P – Penning Gauge; TMP – Turbo Molecular Pump; PPG – Primary Pumping Group

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In Figure 1 it is presented a schematic of the installation. The incident radiation is collimated by the front end slits and absorber. The well defined radiation fan is then deposited across the length of a water cooled chamber. The vacuum envelope is closed by a water cooled stainless steel flange. The vacuum chamber is mounted in the high pressure side of remote valve 1 (RV1). This valve allows the pre-pumping of the chamber as well as its replacement without compromising the vacuum on the rest of the installation. The outgassing is pumped by an ion pump and a getter cartridge. For measuring the outgassing flow, Bayard-Alpert (BA) gauges and Penning gauges are available. Usually Penning gauges are preferred due to the difficulties of operating BA gauges in the harsh environment of the SR tunnel. An RGA is also available to determine the outgassing composition.

MEASUREMENTS

The breakthrough work of Chiggiato and Kersevan at D31 measuring the photodesorption yield of TiZrV NEG coatings lead to the development of improved ID chambers [4]. The low activation temperature of TiZrV allows its use on extruded aluminium chambers and the distributed pumping allows for the chambers increasingly smaller dimensions. At ESRF the current ID chamber section is a 57x8mm ellipsis. Institutes like Soleil [9], ELETTRA [10] and Alba profited from the availability of D31 to further improve their designs. In Figure 2 the activation characteristics of an ALBA and an ESRF ID chamber are compared. The chambers are 2 meter long aluminium extruded vessels which have been coated with NEG.

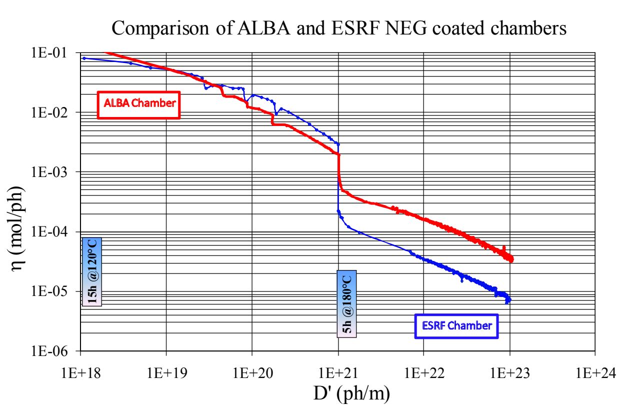

Figure 2: Activation of an ALBA chamber coated by SAES Getters and an ESRF chamber coated at ESRF

Recently we tested a gold coating on a 2m long ID chamber. It is reported that thin gold coatings have lower yields than aluminium [11]. In our results, Figure 3, that was not verified. We suspect that there was a gold aluminium diffusion, which could not yet be verified. We foresee to repeat this test, using and interlayer of nickel to block diffusion.

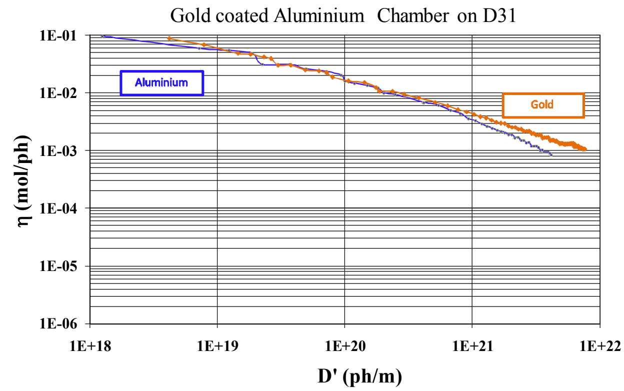

Figure 3: Photodesorption yield of a bare aluminium chamber and the same chamber with a gold coating

Wall Pumping

The Wall Pumping effect was reported by Herbeaux et al. [12] during photodesorption measurements a LURE.

After exposure to radiation, adsorption sites become available at the irradiated surface due to photodesorption. When irradiation is stopped, the surface will then have a small pumping capacity. When the beam is restarted, some of the outgassing will be retained in these sites and the calculated photodesorption yield will be lower than expected.

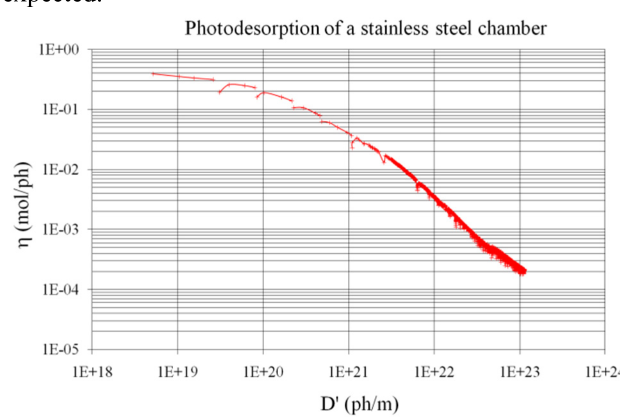

Figure 4: Wall pumping effect on a stainless steel chamber. The breaks show the effect of improved pumping after beam is restarted.

Memory Effect

When continually exposed to synchrotron radiation the yield of a surface decreases with accumulated dose. This decrease is in part due to the progressive cleaning of the adsorbed surface layers. In Figure 5 it can be observed that after exposure of a thoroughly irradiated chamber to air its yield, although increasing, remains at a lower than the initial value. Even at the second consecutive venting it can still be observed a small improvement. As such the chamber retains some "memory" of the previous condition.

At ESRF the memory effect is of great use to precondition chambers in a dedicated sector before final installation.

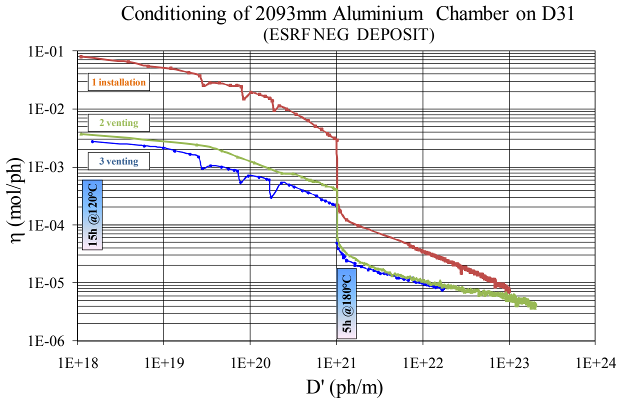

Figure 5: Repeated activation test. After each test the chamber was vented. The initial yield was progressively lower. The step behaviour is due to NEG activation.

CONCLUSION

The field of photodesorption measurements has considerably matured over the years. Theory and models have been developed to explain the induced desorption. Nevertheless the prediction of photodesorption behaviour remains a challenging issue. An installation like D31 allows vacuum chambers to be tested in real conditions without compromising the operation of the machine.

Chambers from different sizes and geometries have been tested. The emphasis is now on materials and coatings. Low secondary electron yield (SEY) coatings like the TiZrV NEG coating are very useful in the production of ID undulator chambers as they have shown equally low photodesorption yield (when activated). Low SEY coatings are also useful in the mitigation of electron cloud effects in positive particles accelerators. As such we plan to continue in this direction, by producing and testing chambers with coatings of gold, TiN and graphite.

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