NEG-COATED VACUUM CHAMBERS AT THE ESRF: PRESENT STATUS AND FUTURE PLANS

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Abstract

The problem of reducing the amount of bremsstrahlung radiation generated by the interaction of the 6 GeV electron beam passing inside the 5 metre-long narrow gap vacuum chambers of the ESRF has been solved by applying thin-films of Non-Evaporable Getter (NEG) materials. A status report on such chambers presently installed at the ESRF is given, together with details of the R&D program being pursued. A new NEG-coating facility under completion is described, and future plans discussed.

1 STRAIGHT SECTIONS AND BEAMLINES

Figure 1 shows the status of all straight sections and beamlines of the ESRF, as of Run 02-2 ending on 22 May 2002. “CV” stands for “chambre á vide”. “CV5000-15” identifies a 15 mm chamber (external vertical dimension), approximately 5000 mm long. “INVAC” stands for “in-vacuum undulator”. The straight sections of cell 4, 5, 7, 23 and 25 are taken by RF cavities or machine diagnostics. “BM#” identifies the experimental beamlines making use of the synchrotron radiation (SR) generated inside the dipole magnets (critical energy 20.5 keV), while “ID#” those utilizing undulator and/or wigglers. Few ID beamlines are splitted into several sub-stations. Additional details about the ESRF vacuum system can be found in ref.[1].

2 NEG-COATED VACUUM CHAMBERS

2.2 Location and Inventory

Table 1 gives some details concerning the NEG-coated vacuum chambers which are installed in the storage ring Table 1: List of NEG-coated vacuum chambers. Material 1 is extruded-aluminium, 6060 T6. Material 2 is 316 LN stainless steel, with 50 µm of electro-deposited copper.

<table>
<thead>
<tr>
<th>Material</th>
<th>Section (HxV) mm²</th>
<th>Length (mm)</th>
<th>Installation Time/Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>74x11</td>
<td>5073</td>
<td>May 2000/ID8</td>
</tr>
<tr>
<td>1</td>
<td>74x11</td>
<td>5073</td>
<td>Aug 2000/ID13</td>
</tr>
<tr>
<td>1</td>
<td>74x11</td>
<td>5073</td>
<td>March 2002/ID2</td>
</tr>
<tr>
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<td>74x11</td>
<td>2093</td>
<td>Aug 2001/ID22</td>
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<td>Jan 2002/ID29</td>
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<td>2</td>
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<td>Oct 2001/ID31 (a)</td>
</tr>
<tr>
<td>1</td>
<td>57x8</td>
<td>5073</td>
<td>May 2002/ID6 (b)</td>
</tr>
</tbody>
</table>

(a) ID31 used to be the test section for Machine/Safety/Vacuum studies, now moved to ID6;
(b) This chamber is NOT NEG-coated yet, will be used as reference for future studies.

2.2 Description of the Chambers

The three different cross-sections listed in tab.1 are shown below, in fig.2a, 2b and 2c. For all coated chambers, the NEG material has been chosen to be the ternary alloy Ti-Zr-V, as it has been found to be the one with the lowest activation temperature [5]. All coatings have been performed at CERN by EST-SM staff.

The NEG-coatings have been activated during bake-out. The bake-out temperatures are 180 degrees C for those made out of aluminium, and between 200 and 250 C for the stainless steel ones. The aluminium chambers have elliptical beam apertures, while the stainless steel ones

Figure 1: Narrow-gap vacuum chambers, type and location, and beamlines.

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The stainless steel chambers make extensive use of electron-beam (EB) welding. There are 6 EB welds running along the 5 m long chamber profile, 3 on the upper face and 3 on the bottom face. For all chambers, a total power of approximately 550 W at 200 mA is dissipated along the external wall.

Figure 2a: 10 mm, extruded-aluminium vacuum chamber.

Figure 2b: 15 mm, extruded-aluminium vacuum chamber.

Figure 2c: 10 mm, stainless steel vacuum chamber. Two versions exist, with 50 and 57 mm horizontal apertures, respectively.

Figure 2d: Close-range view of the “10 mm”, extruded-aluminium CV5073 installed on ID6 (right).

3 MACHINE PHYSICS AND VACUUM ISSUES

Remarks of general interest are the following:

- The prototype “15 mm” extruded aluminium chamber (tested between Oct 1999 and Oct 2000 on ID31), had been activated 6 times and vented 5 times, without noticeable degradation of its performances [2,3].

- Two “15 mm”, extruded-aluminium chambers (installed on ID8 and ID13 since May/Aug 2000) have never been in need of a re-activation of the NEG coating. The dynamic pressures measured on the chambers immediately before and after these two chambers have reached the 1.0E-12 mbar/mA range after one machine run (tipically around 150 A·hour), and have since remained at that level [3,6].

- No occurrences of peeling-off, or release of dusts from the NEG-coated chambers have ever been recorded in the form of sudden beam losses.

- No adverse effect on the impedance of the machine caused by the electric conductivity of the NEG coatings has been noticed [4]. One of our colleagues, --E. Plouviez of the Diagnostic Group, Machine Division-- has measured the surface resistance of sample kapton foils which had been coated by us (thicknesses measured: 0.6 and 2 µm). At the chosen frequency of 14 GHz a resistivity of 5.0E-6 Ω/m has been measured. This means that the skin-depth at 14 GHz is greater than the NEG-coating thickness [7].

4 NEG-COATING FACILITY

The longest chambers installed on the ESRF storage ring measure approximately 5.2 m. With the aim of performing the NEG-coating by ourselves, a new building allowing the set-up of chambers of that size in a vertical position has been built close to our laboratory. Fig.3a shows a cross-sectional view of the facility, scheduled to become operational in June 2002. A 5 metre-long chamber and the solenoid have been sketched for reference.
An air-cooled solenoid, 1 metre long, with an internal diameter of 320 mm --generating a magnetic field of approximately 500 G at a circulating current of around 100 A-- has been fabricated. It will be fixed to a motorized device which will move it up and down along the chamber to be coated so as to allow sputtering the NEG-materials under the more favorable "magnetron configuration" [5]. Fig.3b shows the solenoid under test in our lab. As it can be derived from fig. 3a, should the solenoid not be used ("diode configuration" for the NEG-sputtering), then longer chambers could be coated.

5 FUTURE PLANS

The main points of action for us in the near future are:
• Commissioning of the new NEG-coating facility.
• Coating of a 10 mm, extruded-aluminium, (57x8) mm² CV5073.
• Coating of a crotch-absorber.
• Coating of a "generic" achr omat-profile chamber [1].

6 CONCLUSIONS

Narrow-gap vacuum chambers coated with a thin-film of NEG materials have proved to be a good solution for the reduction of bremsstrahlung radiation deposited in the experimental hutch of the ESRF. No limiting machine issues have been observed so far. The resistive-wall impedance seems to be very marginally affected by the NEG-coated chambers, and no generation of dust or peeling-off has been observed. The current program of R&D aims at coating 5 metre-long, 8 mm chambers (internal vertical dimension), made out of extruded aluminium. Coating of crotch-absorbers and achromat-type chambers could to be an interesting development.

7 ACKNOWLEDGMENTS

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8 REFERENCES