Investigation of Deposition Parameters for VUV Reflective Coatings on the HADES RICH Mirrors ◇

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The HADES RICH detector at GSI is equipped with spherical mirror segments of high reflectivity in the VUV region. So far, two sectors are installed with glassy carbon (SIGRADUR® G) panels and four sectors with 2 mm thick float glass. Meanwhile, the remaining SIGRADUR® G panels have been produced and are presently prepared to replace the glass mirrors. In order to reach the required reflectivities at wavelengths down to 140 nm the substrate surfaces need to be polished to highest quality. It turned out that the surface roughness obtained after machine polishing by the Finish company OPTEON could still be improved by an additional polishing by hand with a paste containing 0.25 μm diamond grains. Besides this we continued to investigate and optimise the deposition technique for the reflective substrate coatings.

The Al reflection layer needs to be protected against corrosion by a MgF_2 film of the optimal thickness for best reflectivity in the wavelength range of 120 nm $\leq \lambda \leq$ 220 nm. Since the optical quality of the film might be spoiled by sticking of residual gases during the vacuum process highest attainable deposition rates were applied and the switching time T_s from the Al to the MgF_2 evaporation was reduced as much as possible. It was not evident if this conception leads to the best results. In order to understand better and to improve the deposition process needed for the further twelve panels and for the second coating of the six ones in use, T_s was enlarged in several steps up to 5 minutes. Lower deposition rates were tried for the MgF_2 evaporation. The substrate temperature was increased up to 570 K. Now the panels can be processed at a starting vacuum of $1 \cdot 10^{-8}$ Pa. VUV reflective coatings with high reflectivity of > 80% at 150 nm can be well reproduced. It was found that annealing of the panels up to 600 K prior deposition does not result in deformation of the panel and does not negatively influence the VUV reflectivity. Substrate temperatures above 370 K decrease the VUV reflectivity. The deposition rate for MgF_2 could be kept low (80 ng cm^{-2} s^{-1}). This might increase the VUV reflectivity and the process security, because the evaporation source for the MgF_2 is not so heavily strained. The length of the switching time between the Al and the MgF_2 evaporation is not critical, from a few seconds up to five minutes no differences in the VUV reflectivity could be noticed. With a Quadrupole mass spectrometer partial pressures in the UHV box coater were measured. One result is noteworthy, it was measured during the evaporations for one VUV mirror. The mass spectrometer was shielded by a large area, 1.5 mm thick copper sheet which was water cooled during evaporation. Nevertheless a ^{24}Mg peak with a partial pressure of about $3 \cdot 10^{-8}$ Pa could be identified. In Fig. 1 a mass spectrum as function of time is recorded. In the period (A to B) the Ti evaporation was performed, after a pause (B to C) the Al evaporation was done in the interval (C to D). Next to a short pause (D to E) the MgF_2 evaporation started and lasted 79 s (E to F).

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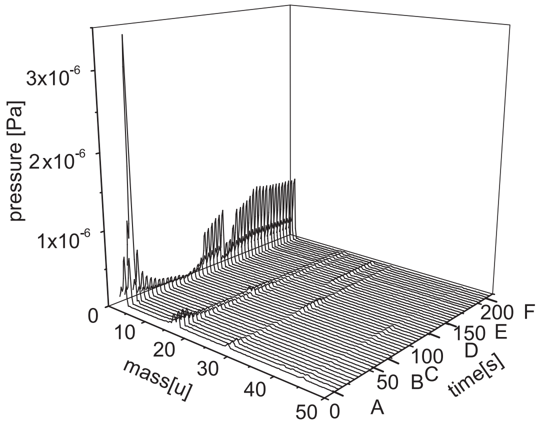

Fig. 1: Changing partial pressure during a full evaporation process. A ^{24}Mg peak appears in the period E to F.

The origin of the Mg peak comes from the dissociation of MgF_2 in the evaporation source. An evaporated MgF_2 molecule is scattered on the hot tantalum walls several times before it leaves the chimney. At each collision it might be dissociated. The free Mg particles obey their vapor pressure at the source working temperature of > 1500 K and this is above the boiling point of Mg (1390 K). Fluorine was not detected in the mass spectrum, this proves that no MgF_2 could have reached the mass spectrometer to be dissociated and ionized. Its low vapor pressure of a few Pascal is evidence for a high sticking coefficient on all walls and does not allow the many reflections necessary to reach the well shielded mass spectrometer. In contrary to the magnesium the fluorine, liberated in the evaporation source, can not reach the mass spectrometer, because it is chemically bound on all copper and aluminum surfaces in the vacuum chamber.

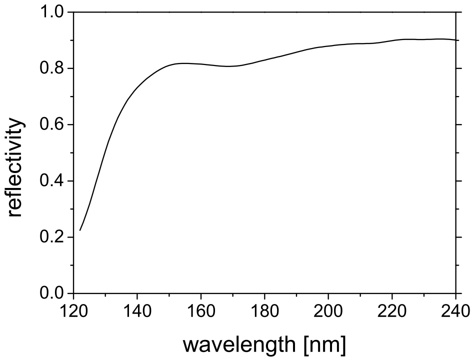

Fig. 2: Reflectivities measured for a hand polished glassy carbon substrate coated with Al/MgF_2.

With these optimised deposition parameters we obtain now routinely relectivities $\geq$ 80% down to λ = 150 nm (see figure 2) and match the requirements of the HADES RICH detector.