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1. VUV Reflective Coating of the HADES-RICH Mirror

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For the HADES RICH detector large mirrors with excellent reflectivity in the vacuum ultra violet (VUV) range down to 140 nm are needed. As far as we know, none of the European companies providing acceptable mirror reflectivities down to wavelengths of 140 nm has the equipment to coat large substrates of the size necessary for the HADES RICH detector. So far, only A. Braem [1] from CERN has the equipment and the experience to provide the quality needed for our mirrors. Unfortunately the preparation of our 20 mirror segments will require about half a year working time not including the setting period. This is definitely too long for a non CERN project.

That is why we had decided to build our own evaporation-condensation system for these mirror coatings, because all our physical vapor deposition systems which were designed for target preparation are too small (450 mm ∅, 450 mm height) for these mirror coatings. Nevertheless we can use them as pilot plants for investigating process parameters before deciding the equipment and conditions necessary for the preparation of the quite expensive mirror segments.

For theoretical reasons, which will be explained later, we believe that a process vacuum in the ultrahigh vacuum range should result in better VUV reflectivity coatings. In order to prove this, we modified two of our evaporation-condensation systems. One was chosen, because it is equipped with a diffusion pump, capable to obtain a base vacuum in the 10^{-5} Pa range, and with simple tungsten boats as resistively heated evaporation sources. This system is similar to the one of A. Braem [1] and it should be possible to reproduce his good results. In order to improve the reproducibility and may be also the quality of the coatings a second more modern evaporation-condensation system was modified. It is equipped with a cryopump of 2500 l/s pumping speed and reaches with clean conditions a base vacuum of 5×10^{-7} Pa, which is similar to the aimed 10^{-8} Pa range for the UHV box coater. In this system a 10 kW electron beam turret source with three positions was installed. Its O-ring sealed rotation shaft had to be modified to install a partition vacuum to reduce the O-ring leak rate by 5 orders of magnitude. Otherwise this relatively good vacuum in the system could not have been attained. For the UHV box coater a similar electron gun but with a bellows sealed three position sliding crucible is planned. Both types of electron guns are driven by the same 10 kW power supply, which means that control parameters can be transferred directly from one system to the other one.

With both systems Al layers of $20\mu g/cm^2$ followed by $10\,\mu g/cm^2$ MgF_2 protection layers on silicon substrates were prepared. Of all these layers hydrogen depth profiles were measured by ERD in the Q3D spectrograph in order to determine the influence of the partial pressure of water on the impurity content as well of the MgF_2- as of the Al-layer. In case of the samples prepared with the diffusion pump system a hydrogen content of ≈ 6 at-% was detected through the whole MgF_2 layer which only monotonically decreased in the next 8 - 10 mug/cm^2 of Al. The quality of the MgF_2-layer and the Al top layer are responsible for a good VUV reflectivity. Nevertheless samples prepared by A. Braem by the same procedure show reflectivities of nearly the theoretical value of an ideal surface with 3 nm surface roughness. In case of the samples, prepared in the cryopump system with the better vacuum, we found only a surface layer of $0.33\,\mu g/cm^2$ hydrogen which comes from a $\approx 3\,\mu g/cm^2$ water layer. As well in the MgF_2- as in the Al layer practically no hydrogen could be detected.

So far we could not measure reflectivities with good accuracy. But we now have good indications that the lower impurity content should result in a superior reflectivity. The high surface layer of $3\,\mu g/cm^2$ water, which seems to be also on the samples prepared with the poorer vacuum, but could not be resolved due to the high hydrogen level in the whole sample, needed attention. Therefore we deposited for both vacuum conditions the MgF_2-Al layers directly on a quartz thickness monitor and measured the adsorption and desorption amounts of water, when repeatedly venting and pumping to high vacuum takes place. For both types of layers we found several $\mu g/cm^2$ water when vented, which completely disappeared under high vacuum conditions. The water adsorption was after several cycles still completely reversible with an uncertainty of $< 0.2\,\mu g/cm^2$. The reason for detecting much more water on the ERD targets seems to be the irradiation damage caused by the heavy ion beam which might have activated the beam spot area and created a hydrophil surface. Due to the poor vacuum of 10^{-3} Pa in the scattering chamber the impingement rate of water is $\approx 0.1\,\mu g\,cm^{-2}s^{-1}$, which means for full sticking: the $3\,\mu g/cm^2$ water were built up in 30 s.

MgF_2 is the state of the art of protection layer for Al in the UV range, the reason for this is not clearly found in the literature. Probably it was chosen, because it can be easily evaporated from a standard Mo or W boat. It has, however, some disadvantages. Even for a thin protection layer of $10\,\mu g/cm^2$ halides show a surface roughness of 10 nm [2]. That is why the MgF_2 should contribute to the diffused reflection especially in the VUV region. In addition there might be some chemical bond exchange of the fluorine to the Al, which also could negatively influence the VUV reflectivity. The average crystal size of $10\,\mu g/cm^2$ halide layers should be > 30 nm, which means the nanocrystals have about the same width as height and thus the layer is not completely closed. Higher diffusion rates for oxygen and especially water vapor should cause a