Technological Laboratory of the TUM

P. Maier-Komor, M. K. Nacke, and W. Heimkes

The UHV Box Coater for VUV Reflective Coating of the HADES-RICH Mirror

in cooperation with A. Bergmaier, G. Dollinger, J. Friese, S. Karsch, and K. Zeitelhack

As explained in [1,2] the HADES RICH detector needs large mirrors with excellent reflectivity in the vacuum ultra violet (VUV) range down to 140 nm. For this an UHV box coater with electron beam evaporators for Al and MgF_2 was designed. For the Poly-C substrate the diffusion rate especially for water vapor was not well known, that is why a thin Ti layer as diffusion barrier was planned. In case of defect reflectivity properties the Al and MgF_2 layers can be easily washed away with acid, this is not the case for a Ti layer which can be removed only by mechanical polishing. It was planned that the Finnish company who does the polishing of the Poly-C substrates should remove the Ti layer in case of defect mirror quality. Unfortunately the actual design of the polishing machine can only be used for circular substrates but no longer after cutting to the final shape, which must occur before deposition of the reflectivity layers. That is why the idea with the diffusion barrier was given up. ERDA measurements of Al films on flat Poly-C substrates, which were outgassed by irradiation heating prior to Al-deposition, show negligible amount of H impurities at the interface between Poly-C and Al. It is hoped, that a clean Al layer can be prepared without the Ti diffusion barrier on the actual concave Poly-C substrates.

It was planned to evaporate Al, MgF_2, and if necessary Ti from a multi hearth electron gun. Unfortunately we experienced cross contamination problems from the close hearth positions to the materials. Especially some parts of the MgF_2 layer on the walls of the electron gun could be evaporated again during the high power Al evaporation. That is why two electron guns were installed with shields between them to overcome the cross contamination problem. The power supply for the MgF_2 source has 4 kW at 5 kV and the electron beam can be wobbled to ensure a uniform evaporation without shading problems for the subliming MgF_2. The Al source should be powered by the 10 kW power supply, used before for the pilot plant. We discovered at power levels above 6 - 7 kW a complete shut down of the power supply with nearly every spark and consequently a destruction of the quality of the Al layer. The producer of the power supply could not improve the situation. That is why we ordered a new power supply with 14 kW power.

For the test depositions in the pilot plant hydrocarbon impurities could be detected in the Al layer as demonstrated in fig. 6 of [2] even though the main pump of this plant is a refrigerator cryopump. The reason for this impurity was oil backstreaming from the roughing pump due to the use of a two-stage sliding vane pump. The roughing cycle was applied only down to a vacuum of about 10 Pa, where the backstreaming should be neglidible, nevertheless due to the base metal properties of Al gettering of hydrocarbons could not be prevented. Even low carbon impurities could negatively influence the VUV reflectivity of Al. There is a second source of hydrocarbon impurities which comes from the outgassing of the walls of the vacuum vessel and which will be defeated by heating the walls to about 470 K prior to deposition. The only solution, however, against oil backstreaming is the use of dry vacuum pumps.

Most dry vacuum pumps for the rough and medium vacuum range are expensive. For minor demands, however, scroll pumps and diaphragm pumps can be utilized. Scroll pumps have sufficient pumping speed (≈ 10 l/s) and reach an ultimate vacuum of < 1 Pa. Such a pump is suitable for roughing of the large boxcoater with its volume of $\approx 1.5\,m^3$, but cannot be used for the continuous pumping of the differential volume between the two viton O-rings of the front gate. Frequent replacements of the scroll tip seals would be necessary. In order to pump the differential volume a cheap long lasting diaphragm pump with a pumping speed of ≈ 1 l/s is sufficient, but its high ultimate total pressure of 200 Pa must be tolerated. There are, however, hybrid turbomolecular pumps on the market which reach with a backing vacuum of 200 Pa an ultimate vacuum of $< 10^{-6}$ Pa. For this setup such a pump with a pumping speed of 200 l/s on its DN 100 CF flange is used via a bellows sealed gate valve directly on the deposition chamber.

The complete setup of the vacuum pump system is schematically shown in fig. 1. The UHV box coater (1) is connected to the DN 500 ISO refrigerator cryopump (4) via a DN 500 ISO bellows sealed gate valve (3). These flanged couplings are the only ones which could not be made by CF flanges and were sealed instead by gold wire rings with a 1 mm cord diameter. The other two bellows sealed gate valves (6 and 10) are flanged to the deposition chamber via CF flanges. All three gate valves are electro-pneumatically driven. The five bellows sealed right-angle valves are manually operated, because they are not used in every pumping cycle. Thus with the vent valve (13) the flow can be dosed, but venting cannot be started before the gate valve (10) is opened.

Starting the vacuum system means first the regeneration of the cryopump. In this mode all valves are closed with the exception of the valves (5) and (11). The scroll pump (14) is evacuating the cryopump (4) to a vacuum of ≈ 5 Pa which is measured by a convection vacuum gauge (18). In the meantime the diaphragm vacuum pump (8) and the turbomolecular pump (7) are started. When in addition the thermocouple vacuum gauge (17) shows a vacuum of ≤ 5 Pa the valve (11) is closed and the scroll pump is switched off. Instead valve (9) is opened and the cryopump (4) is further pumped down by means of the turbomolecular pump (7) to a vacuum of 5×10^{-2} Pa which can be controlled by the ionization vacuum gauge II (16) after the vacuum gauges (17) and (18) have reached their limits. At this vacuum valves (5) and (9) are closed and the cryopump (4) is started.

The roughing of the deposition chamber can be started now. For this the vent valve (13) is opened, after completion of the venting the gate valve (10) is opened the vent valve (13) is closed again and the scroll pump (14) is started. Opening valve (11) starts the roughing cycle. After a few seconds valve (12) can be opened to pump in addition the differential volume (2). When the convection vacuum gauge (18) shows a vacuum of < 5 Pa valve (10) can be closed and valve (6) can be opened for further pumping down by means of the turbomolecular pump (7). The scroll pump (14) can be switched off again. When the ionization vacuum gauge I (15) shows a vacuum of $< 10^{-2}$ Pa the halide lamps can be switched on for outgassing, if new equipment was installed which might be a source of hydrocarbons. In this case the cryopump is not loaded with the hydrocarbons and the gas load is generally lower compared to a roughing vacuum of only 5 Pa. Before the cryopump (4) can produce the UHV the gate valve (6) must be closed. Now the gate valve (3) can be opened. The gate valves (3), (6) and (10) are protected by an interlock system. Next valve (9) can be opened again. The turbomolecular pump (7) keeps now all vacuum tubings under high vacuum conditions. In this way the differential volume (2) has only a very little diffusion leakage through the viton O-ring into the UHV chamber and also the viton O-ring gate seals of valves (5), (6) and (10) which see the UHV present in this way negligible diffusion leakage. The power consumptions of the diaphragm vacuum pump (8) and the turbomolecular pump (7) are quite small in comparison to the cryopump and it can be tolerated therefore that they run in addition, whereas the scroll pump (14) is only used for the short roughing cycles.

References

[1] P. Maier-Komor *et al.*, Jahresbericht 1996, p. 94

[2] P. Maier-Komor *et al.*, Nucl. Instr. and Meth. **A397** (1997) 194

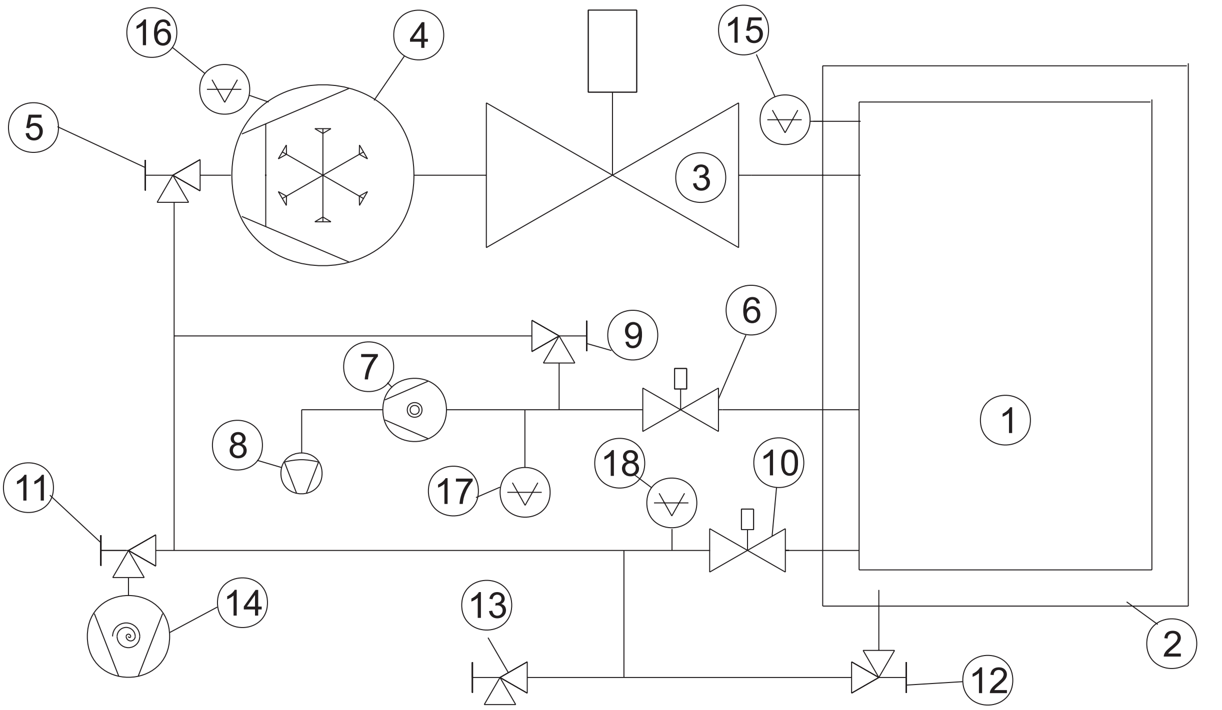

Fig. 1: Outline of the UHV pump system: (1) deposition chamber, (2) differential pumping volume for the front gate, (3) bellows sealed gate valve with 50 cm diameter free opening, (4) cryopump, (5) regeneration valve of cryopump, (6) bellows sealed gate valve with 10 cm diameter free opening, (7) turbomolecular pump, (8) diaphragm vacuum pump, (9) differential high vacuum valve, (10) bellows sealed gate valve with 7 cm diameter free opening for roughing of the UHV chamber, (11) right angle valve for isolation of the scroll pump, (12) right angle valve for isolation of the differential volume, (13) vent valve, (14) scroll pump, (15) ionization vacuum gauge I, (16) ionization vacuum gauge II, (17) thermocouple vacuum gauge, (18) convection vacuum gauge.