VUV Optics for the HADES Project

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Manufacturing and testing of optical components for the HADES-RICH (ring imaging cherenkov) detector, a 5mm thick, 1.4m diameter CaF_2 window and a 1.5m diameter, R=87cm spherical mirror with an Al/MgF_2 reflective layer on a 2mm thick polished polycarbon substrate, has been continued [1]. The mirror is used to image the Cherenkov light onto a position sensitive detector and the window separates the radiator gas from the detector gas. Due to the wavelength dependence of the sensitivity of the CsI cathode of the photon detector and the transmission of the radiator (C_4F_{10}) and the detector gases (CH_4), the system operates between 145 and 200nm and an optimum optical quality is needed for both the mirror and the window in this wavelength region.

The CaF_2 window will be composed of crystals which are hexagonal in shape with 200mm diameter of the circumference, each. The crystals will be glued together using epoxy glue. In 1998 a first batch of 18 crystals was delivered by the manufacturer and the transmission was measured. Unfortunately this particular batch showed strong variations in optical quality, as shown in fig.1. By performing various polishing procedures it could be deduced that the variations at the long wavelength side (150 to 190nm) were due to polishing problems and the low transmission values below 150nm due to absorption by a yet unidentified impurity in the CaF_2 material used for growing the crystals. All crystals were returned to the manufacturer. Some will be used for building the window after repolishing. Crystals showing the absorptions will be replaced. All further crystals will be grown using higher purity material.

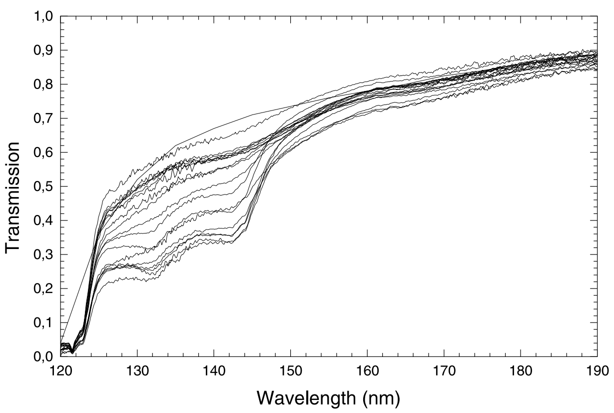

Fig. 1: Transmission curves of 18 CaF_2 crystals. The large variations in transmission will be reduced by a better polishing process and avoiding the absorption which appears on the short wavelength side of the transimission spectra.

Various reflectivity measurements of mirror samples, aluminized in the evaporization plant in the technology laboratory of the Technische Universität [2], have been performed as a continuation of the work described in ref [1]. Optimum reflectivity, obtained so far, is in the range of 80%. A slight decrease of reflectivity in the wavelength range between 160 and 180nm, still visible, can be attributed to an absorbing layer of water of about 1μg/cm^2. The specular reflectance R_s of a surface is a function of the wavelength-dependent reflection coefficient R(λ), as well as of the surface roughness σ and possible absorping layers with absorption coefficient α and thickness l on the surface:

$$R_s = R_\lambda \times exp(-(4\pi(\sigma/\lambda)^2)) \times exp(-\alpha l) \qquad (1)$$

To disentangle the effects of decreasing reflectivity with decreasing wavelength, originating from either surface roughness or reflection index, an experiment has been set up to measure the surface roughness independently. It is based on the wavelength and angular dependence of the intensity of scattered light $I_s(\alpha,\lambda)$ for smooth surfaces [3],

$$I_s(\alpha,\lambda) = I_0 R(\lambda)(\sigma/\lambda)^2(a/\lambda)^2\theta exp[-(\pi sin\theta a/\lambda)^2] \qquad (2)$$

with the autocovariance length a (in small angle approximation). The intensity of a periodically chopped 632nm HeNe-laser beam is sent onto the mirror surface and the scattered light intensity is measured versus the angle of incidence using a Si-PIN photodiode and a lock-in amplifier. Data for a polished and aluminized piece of the original HADES polycarbon mirror are shown in fig.2 together with a fitting curve according to eq.2. A surface roughness of 1.6nm results from these measurements, well within the specification of 2nm.

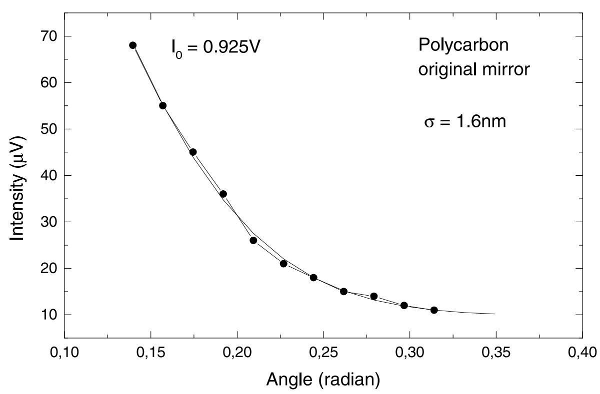

Fig. 2: Straylight scattered from the surface of a polished and aluminized polycarbon substrate is shown versus angle of incidence together with a theoretical curve according to eq.2. A surface roughness of 1.6nm results from this fit.

Optimization of the reflective layer is in progress.

References

[1] W. Czech *et al.*, Jahresbericht 1997, p. 95
[2] P.Maier-Komor *et al.*, Jahresbericht 1997, p. 81
[3] H.E.Bennett, J.O.Porteus, J. Opt. Soc. Am **51** (1960) 123