High Performance Coatings with Large RF Plasma Source

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Abstract: The performance of a PIAD process with RF-plasma source in a large box coater is investigated in respect to high performance coatings. UV-IR cut and BP-filters with low losses are presented.

1. Introduction

Plasma or ion sources are key components in nowadays box coaters for precision optic application. Various designs have been presented in the past, but only few are in use in large numbers, like the Mark II or advanced plasma source (APS) source.

The advantage of RF-powered sources in terms of stability, especial in case of coatings with dielectrical materials, is well known. Gridded ion sources for the application of ion assisted deposition have been reported up to a diameter of 38 cm [1]. However, the maintenance, alignment and replacement of grids larger approx. 20 cm are a challenging, costly business. Moreover, running the sources with ion energies in the range of 500 – 1000 eV and using practical grid spacing of more than 1mm, the total beam current will be limited by the space charge saturation as derived from the Child's law to range of 1- 4 mA/cm^2 [2].

Usage of single grid designs allows for much easier maintenance, alignment and replacement of the grids at lower costs. Commonly, single grids are only used with low beam voltages, to reduce the sputtering of the grid.

2. RF-Plasma Source

A new RF-powered plasma source for large box coaters was introduced [3]. The source is designed for PIAD processes in large box coaters. It uses a special shaped single grid and the design allows a quasi neutral bombardment of the growing films, requiring no additional neutralizer.

A water cooled body has a 300 mm diameter single grid. It uses the ECWR Principle [4] and operates with an inductive coupled radio frequency of 13.56 MHz. The matching network, mounted beneath the source, controls the ion energy by capacitive coupling a portion of the used RF-power into the plasma. By this means, the ion energy can be controlled in broad range. The source and the auto matching network are designed for high RF-power loads of more than 4kW. The source is designed for easy maintenance, allows the operation with various gases, like oxygen, argon, nitrogen or mixtures of them. Source control is fully integrated into the control software of the coating plant and allows the operation in automatic mode. Measurements of the ion current density near the grid orifice showed values of up to 3mA/cm^2, which is consistent with a potential of a total ion current of more then 2 amps. The mean energy can be varied in the range of 90-900eV by changing the working parameters of the source. Results of single layer coatings were already presented [3].

3. UV-IR cut filters

For the production of UV-IR Cut filters we used the above described 300mm-RF-source, type Lion 300, in a Syruspro 1510 coating chamber. To achieve average transmittance values in the passband of more than 98% it is necessary to avoid any absorption and scattering losses. We were able to produce such filters with excellent performance over the large dome shaped substrate holder (Ø 1450mm). The specification is shown in table 1. The design consists of 36 alternating layers of TiO_2 and SiO_2. The total thickness is app. 5µm. The deposition rates were set to 0,6nm/s for TiO_2 and 0,4 nm/s for the SiO_2. Direct optical monitoring with OMS 5000 was used for layer thickness control [5].

Specification	Wavelength
UV-Cut $T_{50\%}$	415 +-5nm
IR-Cut $T_{50\%}$	680 +-8nm
UV blocking range	< 400nm
IR blocking range	700nm – 1200nm

Table 1: UV-IR Cut filter specification

The achieved performance in the range 350nm – 1200nm with backside AR is shown in figure 3. Figure 4 shows the distribution over the dome up to 1400mm out of centre. The $T_{50\%}$ IR cut edge varies from 673nm to 677,5nm, which is less than 0,7%.

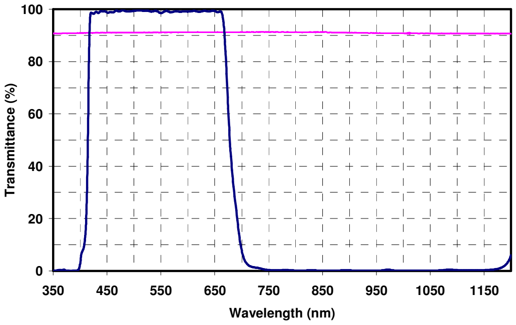


Fig. 3: UV-IR cut filter with backside AR

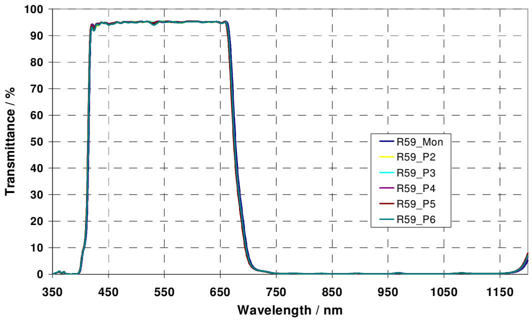
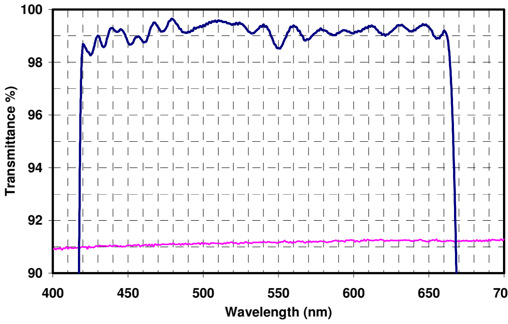


Fig. 4: Distribution over 1400mm dome

The high transmittance in the passband is clear to see in figure 5. Figure 6 shows the result of a reflectance measurement. If we consider both measurements, we can assume absorption and scattering losses less than the measurement accuracy.



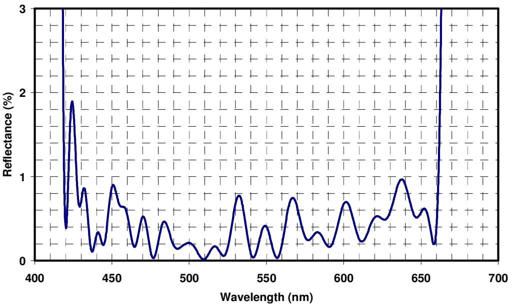


Fig. 5: Passband of the UV-IR cut filter

Fig. 6: Reflectance in the passband

4. Bandpass Filter

A multicavity bandpass filter with broad blocking range was produced in a Syruspro 1510 chamber with Lion 300 plasma source. Layer thicknesses were controlled with direct optical monitoring [5].

The centre wavelength 828nm is specified for an f/2.4 cone angle aperture. Out of band blocking OD3 is required between 350nm and 1050nm. The specified bandwidths of FWHM<15nm and 90% bandwidth >9nm lead to a 6 cavity design with TiO2 and SiO2 coating materials. Figure 7 shows the measured performance in the range 815nm to 840nm. The filter shape and the peak transmittance are very close to theory. Figure 8 shows the transmittance of the same filter in the range from 350nm to 1050nm. The high transmittance peaks in the lower wavelength range indicate low scattering and absorption losses. The short edge at 400nm is given by the absorption edge of TiO2.

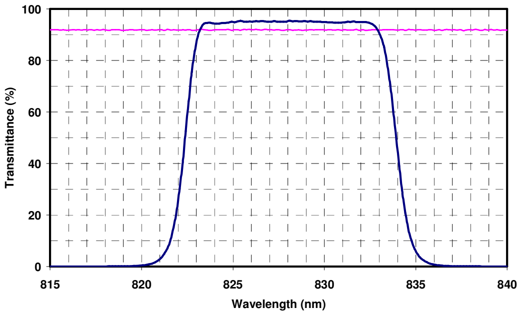


Fig. 7: 6-cavity filter with TiO2/SiO2

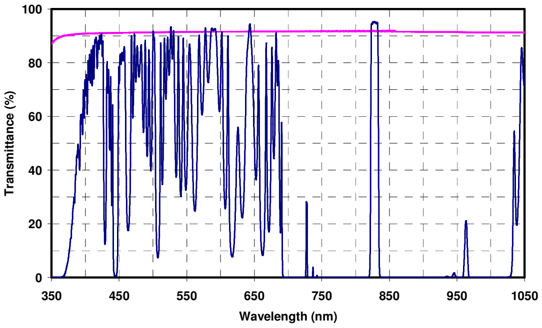


Fig. 8: 6-cavity filter with TiO2/SiO2

Figure 9 shows the transmittance measurement with broadband blocking. The specified blocking, OD3 from 350nm to 1050nm, was made with an all dielectric backside coating. The total layer thickness of front and backside was app. 19µm consisting of 150 layers. The high transmittance of nearly 98% in the passband is remarkable. Figure 10 shows the shift of centre wavelength (CWL) vs. AOI. The CWL shifts 5nm with 14° AOI only. The relatively short angle shift was achieved by using a special bandpass design.

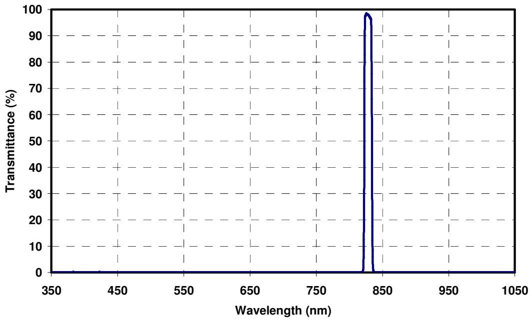


Fig. 9: 6-cavity filter with all dielectric backside blocking

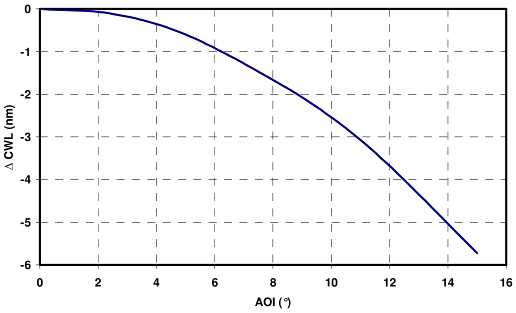


Fig. 10: 6-cavity filter CWL shift with AOI

5. Conclusions

Using a new single gridded RF-Plasma source, type Lion 300 in a 1500mm chamber we produced a 6 cavity bandpass filter with broad blocking with excellent performance and low losses. The results of the UV-IR Cut filters demonstrate the ability of high performance coatings on large substrate areas.

6. References

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