Coating machine concepts for precision optics

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Abstract: The performance of a tandem plasma source solution for large box coaters is investigated for layer performance and achievable growth rates. A new fully automated sputter coating system for producing complex interference filters is presented.

OCIS Codes: (310.1860) Deposition and fabrication (310.6860) Thin films, optical properties

1. Introduction

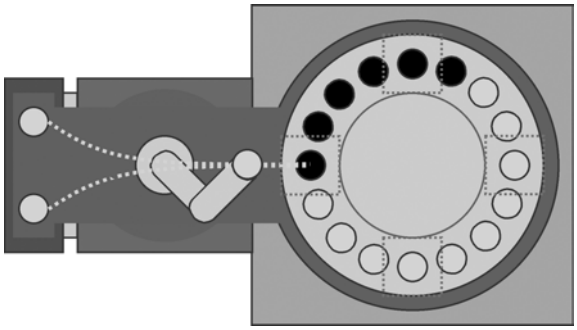
Coating equipment for precision optics in general has to deal with a great variety of substrates in different shapes and dimensions. Complex processes have do be realized to create demanding interference filter designs. Box coaters still are the most flexible coating system that fulfils the needs of the industry. Coating costs decrease with increasing dimension of the coating equipment. Therefore large chamber dimensions are of special interest in high volume manufacturing of interference filters. To ensure that in large chambers the amount of ion bombardment that is necessary to create dense, shift-free coatings is available, we investigated a tandem plasma source solution in a SYRUSpro 1500 Box coater.

Whereas in semiconductor industry fully automated solutions are standard, there is a lack of similar high standard equipment for production of complex layer systems with the special demands in precision optics. We developed a fully automated sputter coating system, which is flexible, fast and can create in very short production cycles challenging interference filter designs.

2. Tandem plasma source solution for large coating areas

Since many years plasma ion assisted deposition (PIAD) with the Advanced Plasma Source (APS) provides a maximum regarding performance and productivity in optical thin film coatings [1]. Various types of application examples have been presented in the past [2],[3],[4]. These applications include AR-coatings, edge filters, dielectric mirrors, narrow band pass filters. Transparent, electrically conductive oxide coatings and abrasion resistant coatings can been deposited in low temperatures processes on different plastic substrates. The application range exists from the UV to the IR spectral region. The new high power APSpro allows for significantly higher rates with the same layer properties as achieved with the former version. To further increase the productivity, we investigated a tandem plasma source approach in a SYRUSpro 1500. Both sources are mounted on the base plate of the coater, with source-to-substrate distance of about 1300mm (fig.1). The control software permits running both sources simultaneously and choosing the source parameter independently. The superposition of the plasma bombardment results in improved uniformity across the substrate holder, hence, smaller refractive index variations are observed. Running only one source, we measured wavelength shift due to moister absorption of less then 0.1% with rates for silica coatings of 0.25nm/s. By using both plasma sources, we could reach rates of up to 1nm/s with the same wavelength shifts after 100h storage under ambient conditions. With niobia as high index material we were able to produce absorption free cold light mirror coatings without any post treatment. These cold light mirror reflector coatings for the ultra-high lumen segment of digital projection showed excellent temperature and humidity resistance.

Fig. 1 Tandem plasma source solution: Two Advanced Plasma Sources running in a SYRUSpro



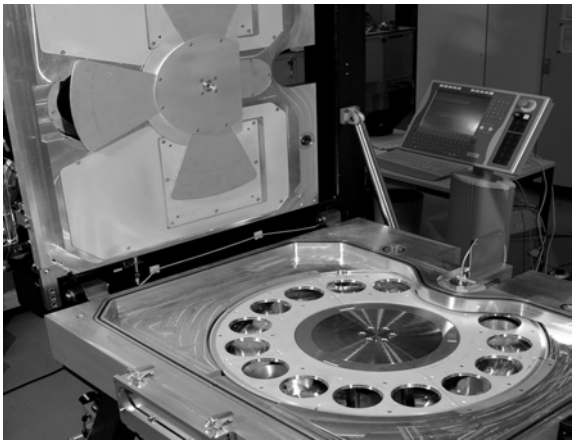


Fig. 2 HELIOS sputtering system: Substrate handling and turntable

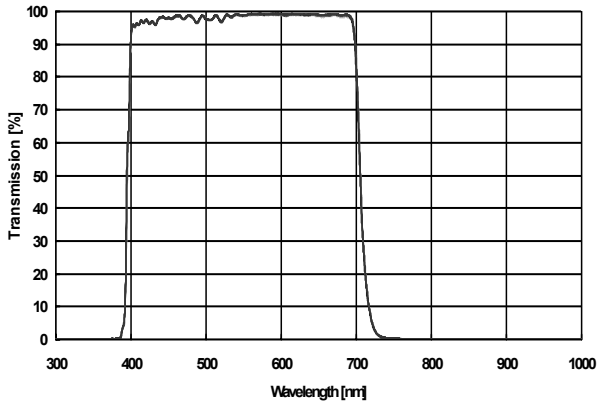


Fig. 3 Performance of a dichroic UV-IR cut filter deposited with the HELIOS sputter system. The design consist of 52 non quarter wave layers, all layers are time controlled

3. Automated sputter system for precision optics

The Helios sputtering system is a flexible platform for fast, precise and fully automated thin film coating. The coating chamber is equipped with two mid frequency powered dual magnetron sputtering sources. An additional high frequency powered plasma source is assisting the deposition process. This technique allows a high rate process with excellent layer performance. By a so called lambda-probe technique the reactive sputtering process is monitored and stabilized. This method guarantees a long term stable deposition rate together with uniform layer properties. For further accuracy a direct on-substrate monitoring system can measure the transmittance of the growing layer stack. A cassette substrate handling system allows for an easy integration to a clean room production. The substrates are loaded from the cassette load lock via a transfer chamber into the deposition chamber (fig. 2). Without venting the process chamber continuous operation of one week ore longer is possible. The substrates are coated in a dynamic deposition process simultaneously. By the high speed rotation of the turntable even thin layers can be coated with high thickness accuracy and the substrate to substrate uniformity is excellent. The lateral uniformity achieved so far is typically better than ± 0.4% over a 4 inch wafer. The direct optical monitoring is performed at an arbitrary selected substrate position on the rotating turntable. The high reproducibility of the layer properties together with the sophisticated monitoring technique allows for rapid prototyping of even demanding interference filters (fig. 3).

4. Summary

The integration of two Advanced Plasma Sources in large coating chambers permits significant higher deposition rates together with improved plasma uniformity. The Helios sputtering system allows for a full automatic production of demanding interference filters with very short production cycles. Its clean-room compatibility and low maintenance requirements opens a new way to cost-effective production in precision optics.

5. References

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