Precision glass processing and PARMS for the efficient manufacturing of advanced and miniaturized optical components

Stefan T. Ochsenbein, Simon Stahel

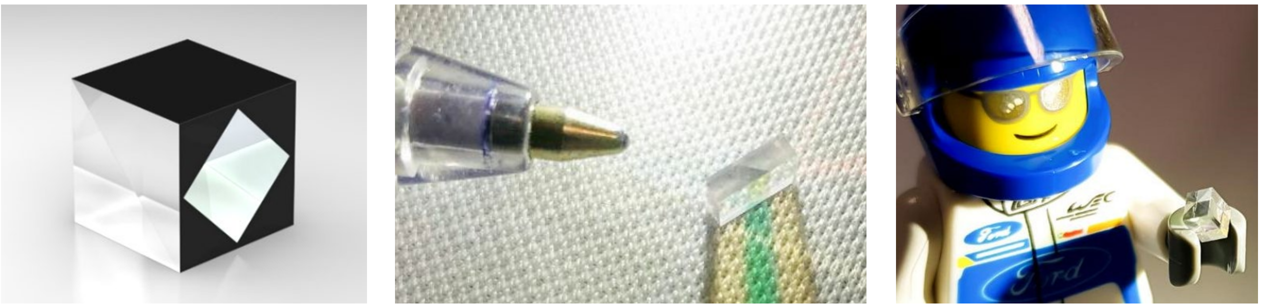
Materion Balzers Optics, Neugrüt 35, LI-9496 Balzers, Liechtenstein

INTRODUCTION

Plasma-assisted reactive magnetron sputtering (PARMS) in combination with a sophisticated optical broadband monitoring (BBM) allows the deposition of dense layers of dielectric materials with very high process stability and layer thickness accuracy, yielding hard dielectric coatings with excellent spectral, mechanical, and chemical stability and durability.

Various glass processing and assembly processes are used for turning the PARMS coated plates into assembled products like polarizing beamsplitters for medicinal imaging applications or RGB-combiners for augmented reality components (some examples in Fig. 1). Parts of these types typically have coatings on different external as well as internal surfaces. Coatings are often required to extend to the edges of a component and features like apertures or color markings have to be applied.

Fig. 1: Examples of beam splitter and combiner cubes



METHODS

A PARMS-coater at Materion Balzers Optics is shown schematically in Fig. 2. From the two dual magnetrons a high-index (Material 1) and a low-index material (Material 2) are sputtered-up in an Argon-plasma towards a turntable holding the substrates. The turntable is rotating at 150 – 250 rpm. After passing the magnetrons, the substrates pass the rf-icp plasma source, where the coated layers are fully oxidized in an O_2-plasma to Nb_2O_5 and SiO_2, respectively. The BBM measures the layer thickness on a test glass after each rotation of the turntable. In this manner, alternating stacks of high-index (Nb_2O_5) and low-index (SiO_2) layers are deposited. The coater is equipped with a load-lock and test glass changer, keeping the process chamber under vacuum for weeks at a time.

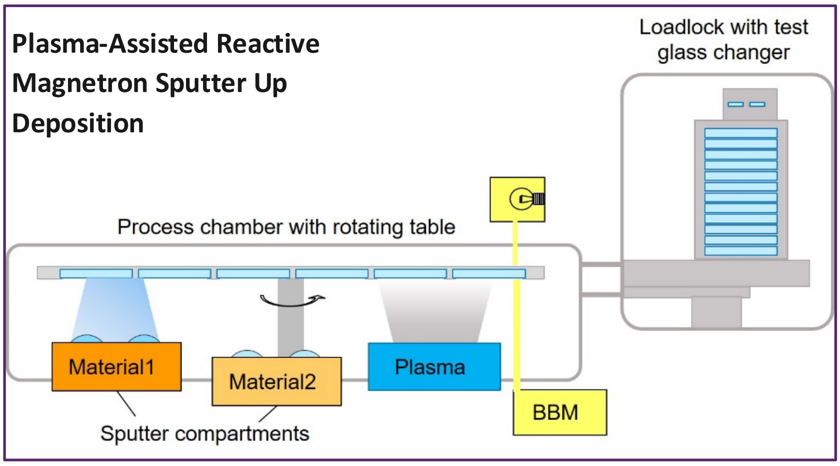


Fig. 2: Schematic of PARMS-coater at Materion Balzers Optics

In many cases, the final components have small dimensions (cube side length < 5 mm, down to 2 mm), which makes them difficult to be handled, coated, and assembled as single parts or as prism bars. A way to overcome this is to work on whole wafers or plates instead of single parts. Plates can be ground and polished on double sided machines in batches of multiple plates. With these processes, parallelism and flatness of component sides can be of much higher quality than what is usually achieved on single parts. A final geometry can be generated by accurately bonding plates to larger arrays and cutting them again to a desired size. For this process, multi-wire saws are used in combination with precise opto-mechanical alignment devices.

RESULTS

With the PARMS-coater described in the Methods section we deposit a wide variety of dielectric filters, ranging from antireflection coatings to complex bandpass-filters with high optical density (OD ≤8), high passband-transmittance (>90%) and very steep edges (90% to OD5 in ≤4 nm). Often this coater is also used to make coatings for our advanced precision glass processing, where reliability of the coating is paramount for efficient, high-yield production of miniaturized optical components. One such coating, a polarizing beamsplitter, is shown in Fig. 3.

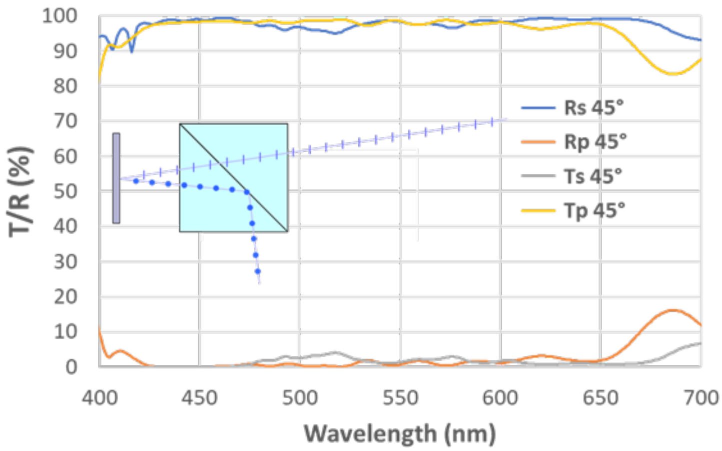


Fig. 3: Performance of a polarizing beamsplitter cube, optimized for high transmittance in p-polarization and high reflectance in s-polarization. Inset: schematic of the beamsplitter cube and transmittance/reflectance of polarized light.

With the described glass processing methods, cubes can be manufactured within dimensional tolerances of ± 10 µm and angle tolerances of ± 0.05°, also for internal (hypotenuse) angles. The positioning accuracy of the hypotenuse can be within ± 50 µm.

DISCUSSION & CONCLUSIONS

The combination of PARMS and precision glass processing at Materion Balzers Optics allows for the efficient, reliable mass production of advanced, miniaturized optical components.

REFERENCES

Broßmann, J., Lappschies, M., Jakobs, S., Kirschner, V., "Low scattering filter coatings made by plasma-assisted reactive magnetron sputtering," Proc. SPIE 9627, Optical Systems Design 2015: Advances in Optical Thin Films V, 962710 (23 September 2015).