Protective coatings for front surface silver mirrors with some characterization by Spectroscopic Ellipsometry and GD-OES

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Abstract

Silver is an ideal metal for the front surface mirrors for optics in both visible and infrared wavelength ranges. In this range, silver possesses the highest reflectivity, the lowest emissivity, and lowest polarization splitting of all known metals. Silver, however, can be oxidized very easily and requires reliable protection to be stable even in the mildly aggressive operating environment. The problem of protection of silver layers is a very important one for a number of practical applications, such as telescope (ground and space-born) mirrors, reflective IR imaging optics, photovoltaic concentrator mirrors, III-V laser back-reflectors, etc.. The space environment especially results in severe damage arising from the exposure to the highly oxidizing atmosphere on Low Earth Orbit (LEO).
The atomic layer deposition (ALD) technique provides an efficient way to form a coating, protecting the sensitive surface of silver from a corrosive and oxidizing environment. Moreover, ALD layer provides extremely high conformality (even when deposited over high aspect ratio features) and has high integrity, efficiently blocking foreign species diffusion to the silver-overcoat interface.
We have developed optimized RF magnetron sputtering procedure for silver mirrors in order to withstand the ALD deposition process, which has a potential to degrade the reflectivity of mirrors due to sensitivity of silver coatings to temperature and atmosphere of the process.

We tested the efficiency of the protection of silver mirrors against oxygen plasma exposure (in high-density, low ion energy oxygen plasma system) by the ALD-deposited Al2O3 layers by combining spectroscopic ellipsometry measurements, specular reflection measurements, and pulsed Glow-Discharge Optical Emission Spectroscopy (GD-OES) profiling [1]. We have found that for optimal protection of the silver against oxidation, the thickness of the ALD deposited layer should exceed at least 15 nm (about 150 ALD cycles at 150 oC). We have also demonstrated that the deposition of 15 nm of a protective ALD-deposited Al2O3 layer does not significantly affect the absolute reflectivity of a silver mirror in a spectral range 320 -2500 nm.

References

[1] P. Bulkin, S. Gaiaschi, P. Chapon, D. Daineka, and N. Kundikova, Optics Express, 11 (2020) 15753.