Optical characterization of reflective coatings for astronomical telescope mirrors

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Aluminium evaporation is still the standard solution for reflective coatings of large astronomical mirrors. Silver and gold are also used in specific cases depending on the targeted wavelength. This study characterized different metallic coatings - including unusual ones like sputtered iridium - to identify the most suitable mirror coating for the spectral range from ultraviolet to infrared wavelengths.

1 Introduction

Large optical telescopes on ground and in space are quite common in astronomy. In many cases, such telescopes employ three mirrors. An example is shown in figure 1. The primary and secondary mirror are placed at a normal incidence, while the tertiary mirror, also called folding mirror, is working at 45° angle of incidence (AOI).

Fig. 1 *Ø1.3m telescope at the Skalnaté Pleso observatory in Slovakia as an example [1]*

Classical coating materials for astronomical mirrors are aluminum, protected silver [2], and sometimes gold [3]. These state-of-the-art coatings have a limited usability for broadband applications, as they have some unwanted absorption features in the mid IR spectral range. Therefore, there is potential room for the development of new coatings. In this study, we characterized different metallic mirror coatings, including quite unusual sputtered iridium, to identify a coating that is most suitable to cover the spectral range from ultraviolet to infrared. Additional requirements are a long-term stability against harsh environmental conditions, avoidance of a protective layer, and a good removability of the coating from the substrate. The presented work was part of a recent Bachelor´s Thesis at Aschaffenburg University.

2 Methodology

In order to compare the different coatings (see figure 2), polarization sensitive measurements of reflectivity for different angles have been conducted at Wrexham Glyndwr University (see figures 3 & 4). In addition to these measurements, we did simulations of reflectivity based on the Fresnel equations and the complex refractive index data given in literature.

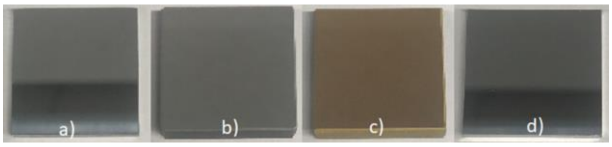

Fig. 2 *Pictures of four characterised mirror coatings a) Al b) protected Ag c) protected Au d) Ir*

Using the Cary 7000 spectrophotometer from the company Agilent, measurement of transmission, reflection, and absorption can be performed from UV to NIR across a large range of angles. Thereby the usable wavelength range is 175 nm to 3300 nm.

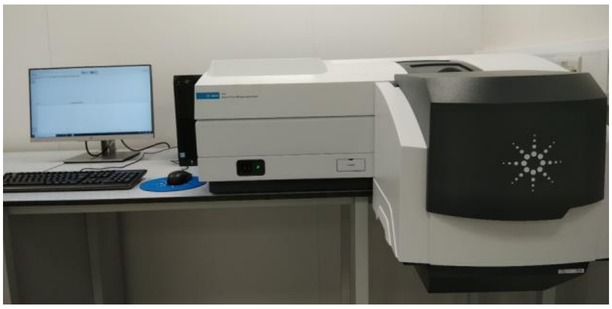

Fig. 3 *Set-up at Wrexham Glyndwr University*

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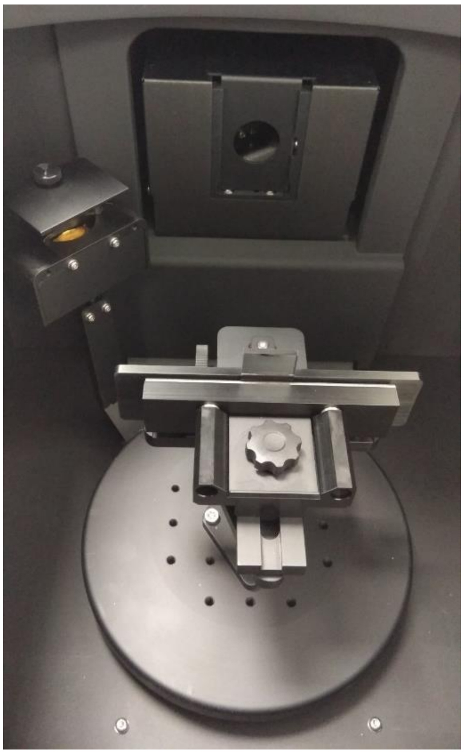

Fig. 4 *Interior of the Cary 7000 spectrophotometer*

3 Measurement results

The measured reflectivity for all four coatings at incidence angles of 6° is provided in figure 5. The data fit quite well to the simulations using the complex Fresnel equations for metallic coatings.

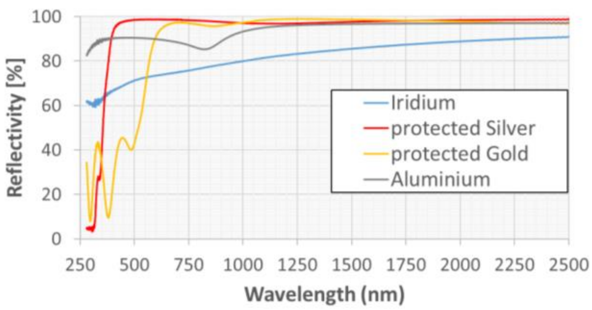

Fig. 5 *Measured reflectivity of different coatings at 6° AOI*

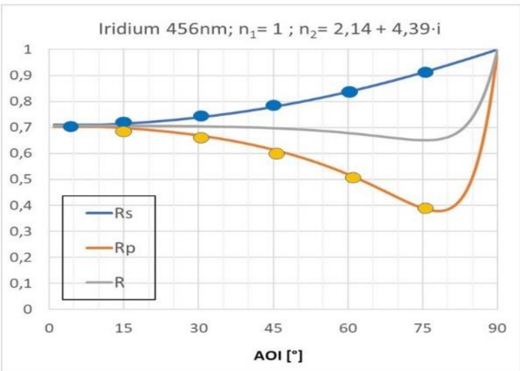

Fig. 6 *Measured s- and p-reflectivity of iridium for different incidence angles at λ=456nm, compared with simulations based on the* complex *Fresnel equations.*

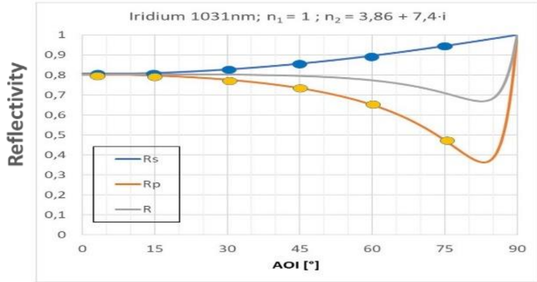

Fig. 7 *Measured s- and p-reflectivity of iridium for different incidence angles at λ=1031nm, compared with simulations based on the* complex *Fresnel equations.*

The results showed that the reflectivity of iridium increases gradually with increasing wavelength. Iridium seems very suitable for the infrared and especially for the mid infrared range. It also has good reflection properties in the infrared range and a high resistance to heat and solvents.

4 Summary

We did a comparison of four mirror coatings: aluminium, protected silver, protected gold, and iridium. The reflectivity of these four different mirror materials was measured from UV to NIR. When it comes to the strengths of each coating, aluminium provides good reflectivity for wavelengths of visible light at a low cost. Gold has a high reflectivity in red and infrared range. Silver has a high reflectivity over a large light spectrum except in UV, while iridium showed good results in the infrared range. However, all coatings also come with their weaknesses. Aluminium is a soft material and silver needs a protective coating to prevent degrading oxidation. The reflectivity for gold is low below 600 nm wavelengths and for iridium low in the visible range. Furthermore, iridium is expensive and needs to be applied by a sputtering process.

However, the reflectivity of iridium increases gradually with wavelength and this coating material seems to be suitable for the near infrared and the mid infrared range. The measured reflectivity for polarized light fits to corresponding simulations (figures 6 and 7). We conclude that iridium is an interesting coating material, especially due to its high resistance to heat and chemical solvents, even without protective coatings. Iridium has potential to serve as a mirror coating material for some special cases in astronomy.

5 References

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