REFLECTIVE MULTILAYER COATINGS WITH DIELECTRIC BARRIERS FOR HIGH CONCENTRATION PHOTOVOLTAICS BY MID FREQUENCY DUAL MAGNETRON SPUTTERING

Introduction

First-surface mirrors based on reflective multilayer coatings on polycarbonate substrate have been developed and tested for use as primary optics in high concentration photovoltaic (HCPV) systems. These coatings must provide high reflectance properties over a wavelength range between 300 and 1800 nm, where multijunction cells are significantly active for PV generation [1]. Additionally, a good ageing resistance to UV radiation and high humidity/temperature conditions must be achieved [2].

Experimental details

Coating development

- Silver, aluminium and Ticusil® (titanium, copper and silver alloy) films were developed on polycarbonate substrate and protected with either SiO$_2$ or Si$_3$N$_4$ layers.
- Effect of substrate roughness and multilayer mirrors were previously designed using CODE software.[3].
- Reflective and protective films were grown by sequential sputtering deposition DC and by reactive mid frequency dual magnetron sputtering, respectively.

Characterization

- Refractive index of SiO$_2$ and Si$_3$N$_4$ was obtained from spectroscopic ellipsometry over a 200-1000 nm range. Fitted using Cauchy dispersion equation.
- Total and diffuse reflectance spectra were obtained from UV-Vis-NIR spectrophotometer with a 150 mm integrating sphere. Specular reflectance spectra result from calculation.

Accelerated ageing

- Durability of the developed mirrors was evaluated through damp heat and UV exposure tests following the IEC 62108 standard.
- Damp heat test: 1000h exposure at 85°C and 85% RH.
- UV test: 1270h exposure to 340nm lamps at 60°C.

Results

Dielectric layers growth by reactive MF-DMS

- Transition of process from metallic to poisoned mode. Transition occurs very rapidly requiring the use of feedback control to hold the process in the transition state.

Specular reflectance

- Specular reflectance is, by design, the most relevant magnitude for a concentrating PV system.
- Initial samples show very low values of diffuse reflectance.
- Specular R values higher than 89% were found for Al/SiO$_2$.
- Ag/SiO$_2$ and Ag/Si$_3$N$_4$ showed specular reflectance values up to 96% as deposited.
- Ticusil®/Si$_3$N$_4$ R values considerably lower.

Simulation of Reflectance: Effect of substrate roughness

- The effect of substrate roughness, extracted from profilometer measurements, on Specular R values was simulated using CODE software.

Conclusions

- First-surface mirrors for HCPV applications were designed and deposited on polycarbonate substrate by PVD.
- Silver, aluminium and Ticusil® reflective layers were grown by DC magnetron sputtering and protected with dielectric SiO$_2$ or Si$_3$N$_4$ films grown by reactive Mid Frequency- Dual magnetron sputtering.
- Highest initial specular reflectance values up to 95% and 89% were obtained for Ag-based coatings before and after testing. In the case of Al, only a slight decrease less than 1% was observed from initial 88% after accelerated ageing tests.
- Further research needed to meet the demanding durability requirements of HCPV application with high reflectance values.

References


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