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REFLECTIVE MULTILAYER COATINGS WITH DIELECTRIC BARRIERS FOR HIGH CONCENTRATION PHOTOVOLTAICS

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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. The use of polycarbonate allows high throughput manufacturing by injection processes, leading to lightweight and easy-to-handle mirrors. The coatings must provide high reflectance properties over a wavelength range between 300 and 1800 nm, where multijunction cells are significantly active for PV generation [1,2]. Additionally, a good ageing resistance to UV radiation and high humidity/temperature conditions must be achieved [3,4] .

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_3N_4 layers
- The multilayer mirrors were designed using CODE software [5] .
- Reflective and protective films were grown by sequential sputtering deposition DC and by reactive RF sputtering, respectively.

Characterization

- Refractive index data obtained from spectroscopic ellipsometry over a 200-1000 nm range. Fitted using Cauchy dispersion equation.
- Total and diffuse reflectance spectra from UV-Vis-NIR spectrophotometer with a 150 mm integrating sphere. Specular reflectance spectra result from calculation.

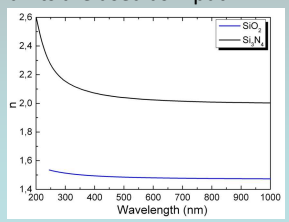
Accelerated ageing

- 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.

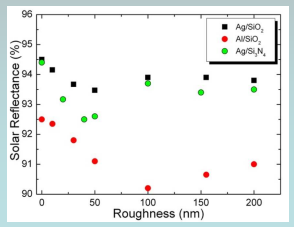
Results

Simulation of optical properties

- The effect of substrate roughness, metallic reflector and protective films on total spectral reflectivity was studied with CODE software.
- Refractive index measurements and fits are used as input.
- Lower R values for increasing roughness up to approx. 80 nm.
- Ag layers show higher R than Al, together with lower dependence with substrate roughness.



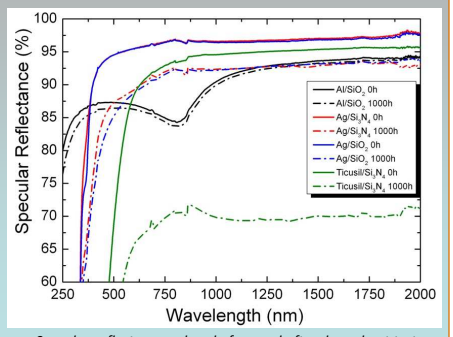
Spectral refractive index



Total reflectance as a function of substrate roughness

Specular reflectance

- Specular reflectance is, by design, the most relevant magnitude for a concentrating PV system.
- Before testing, the samples show very low values of diffuse R.
- Integrated R values higher than 89% were found for Al/SiO_2.
- Ag/SiO_2 and Ag/Si_3N_4 showed values up to 96% before durability testing.
- Ticusil®/Si_3N_4 R values considerably lower.

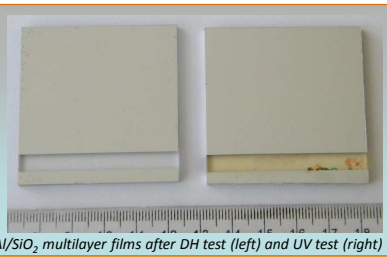


Specular reflectance values before and after damp heat test

Accelerated ageing tests

- Best overall results for Al/SiO_2. Samples undamaged after damp heat and UV test. Total and specular reflectance remained almost constant.
- Ag and Ticusil® coatings showed delamination and shallow cracking. Appreciable decrease in specular reflectance, specially for Ticusil ®.

Multilayer	0h		1000h	
	Total	Specular	Total	Specular
Al/SiO_2	89.4	88.2	89.2	87.5
Ag/SiO_2	95.6	94.6	93.7	88.1
Ag/Si_3N_4	96.0	94.8	93.2	88.9
Ticusil®/Si_3N_4	82.2	--	80.0	61.2



Al/SiO_2 multilayer films after DH test (left) and UV test (right)

Conclusions

- ✓ First-surface mirrors for HCPV applications were designed and selected multilayers were deposited on polycarbonate substrate by PVD.
- ✓ Silver, aluminium and Ticusil® reflective layers were protected with dielectric SiO_2 or Si_3N_4 films and their durability was tested.
- ✓ 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 of less than 1% was observed from initial 88%.
- ✓ Further research needed to meet the demanding durability requirements of HCPV application.

References

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