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Durability tests of solution-chemically derived spectrally selective absorbers

Tobias K. Boström[a,*], Ewa Wäckelgård[a], Gunnar Westin[b]

[a]*Division of Solid State Physics, Department of Engineering Sciences, Uppsala University, P.O. Box 534, SE-751 21 Uppsala, Sweden*
[b]*Division of Inorganic Chemistry, Department of Materials Chemistry, Uppsala University, P.O. Box 538, SE-751 21 Uppsala, Sweden*

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Abstract

A promising novel solution-chemical method to fabricate spectrally selective solar absorber coatings has been developed. The objective was to create highly efficient, flexible, inexpensive and durable selective absorbers for solar thermal applications using simple techniques. The selectively absorbing film consists of a composite with nickel nano-particles embedded in a dielectric matrix of alumina.

The anti-reflection (AR) material should have the following properties: the proper refractive index, low thermal emittance, dense, flexible and long-term stable. The AR materials tested were silica, alumina and mixtures of silica–titania. The refractive indexes of the above-mentioned materials range from 1.4 (silica) to about 2.1 (50/50 molar ratio silica/titania mixture). Besides increasing the normal solar absorptance, α_{sol}, it is equally important that the AR layer is long-term stable in order to create a successful solar selective coating. The anti-reflection coatings were synthesized using different solution-chemical methods and deposited on the absorbing layer by spin coating. Prepared samples were subjected to an accelerated lifetime test. In the test procedure the temperature of the environment was set to 40 °C and the relative humidity to 95%. Samples made with alumina as anti-reflection coatings failed the aging test. All other materials, silica and silica–titania mixtures proved to be very resilient. Samples that were coated with these anti-reflection materials showed no visible degradation of the sample surface even after 600 h of testing.

*Corresponding author. Tel.: +46 18 471 3783; fax: +46 18 500 131.
E-mail addresses: tobias.bostrom@angstrom.uu.se (T.K. Boström), ewa.wackelgard@angstrom.uu.se (E. Wäckelgård), gunnar.westin@mkem.uu.se (G. Westin).

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Nomenclature

α_{sol}	normal solar absorptance
ε_{therm}	normal thermal emittance
I_{sol}	direct normal solar irradiance
I_p	Planck black body distribution
T_s	final heat treatment temperature (°C)
PC	performance criterion
A	alumina
S	silica
HS	hybrid silica
ST73	silica/titania (70/30 mol%)

Single-layer absorbers without an AR layer typically attain a normal solar absorptance of 0.80 and a normal thermal emittance of 0.03. Of the samples made with durable films a 70/30 silica/titania mixture showed the greatest increase of the α_{sol} value, 0.91, while the thermal emittance remained unaltered.

Keywords: Durable; Anti-reflection; Absorber; Selective and solar

1. Introduction

The most efficient thermal solar collectors for hot water production use a spectrally selective surface that absorbs and converts solar radiation into heat. High performing selective surfaces already exists on the market but there are a few difficulties with some of them, such as the long-term durability, moisture resistance, adhesion, scratch resistance, cost and complicated production techniques. In order to make thermal solar collectors more accepted and widespread, the price per unit has to decrease. The most costly component of a thermal solar collector is the spectrally selective surface.

This work is a continuation of a preceding study where spectrally selective absorbers were produced using a novel solution–chemical technique [1]. Advantages of this technique are: it is simple and easy to control, the coating can be manufactured under ambient pressure conditions, the chemicals involved are environmentally friendly and it is low in material consumption. Furthermore there exist several methods like spin-, flow-, spray- and dip-coating to coat a surface with a liquid medium. The method seems promising and could hopefully reduce production costs for spectrally selective absorbers and hence make them less expensive and more available. The focus in this part of the thesis has been set on the durability properties of spectrally selective absorbers treated with an anti-reflection (AR) layer. The optical characteristics of produced samples before and after the accelerated aging testing were investigated.