11th International Conference
on Advanced Materials

ICAM 2009

Rio de Janeiro Brazil
September 20 - 25

Magnetron Sputtered Ti/SiO_2 Nanostructured Cermets for Selective Solar Absorbers – Optical Properties and AFM Images

M. Martins(1)* and R. A. Simão(1)

(1) PEMM, COPPE/UFRJ, Rio de Janeiro, Brazil, 21941-972. email: moema@metalmat.ufrj.br
* Corresponding author.

Abstract – For efficient photothermal conversion in solar collectors, the absorber material must have selective reflectance: high absorbance of incident solar radiation and minimum emittance of infrared thermal radiation. In this work, sputtered Ti/SiO_2 cermet absorbers where deposited onto glass, silicon and aluminium substrates. Substrates where positioned on a rotating disk and immerged in Ti and SiO_2 plasmas cyclically. Optical properties where analysed on UV/Visible/IR regions and the surface morphology was analysed with Atomic Force Microscopy. Very low reflection on the visible and near-infrared regions was achieved. AFM images show that a nanostructured surface was produced by this method.

Solar radiant energy can be used in electric energy generation using solar collectors. In these systems, light is absorbed, converted to heat and transferred to a working fluid. This fluid will participate in the generation of steam, followed by the generation of electric energy itself. The main component of a solar collector is the absorber on which the photothermal conversion takes place. For efficient use of the solar energy, this absorber must have selective reflectance, having maximum absorbance of the incident solar radiation and low emittance of infrared thermal radiation. Thin films of metal-dielectric nanocomposites (cermets), consisting of metal nanoparticles in a ceramic matrix, are strong absorbers of solar radiation because of small particle resonance and the interband transitions in the metal [1].

In this study, three-layer tandem selective absorbers were deposited by magnetron sputtering, first layer consisting of moderately IR reflective Ti, second a Ti/SiO_2 cermet and third an anti-reflective SiO_2 layer. To produce the cermet layer, substrates where positioned on a rotating disk, adapting a multilayer equipment to operate similarly to a co-deposition one. Substrates were then cyclically immerged in Ti and SiO_2 plasmas, working on DC and RF power supplies, respectively. Substrates used were glass, silicon and aluminium and the rotation applied was one per second. High purity Ti and SiO_2 targets were used and the pressure was kept on 1×10^{-3} mbar in pure argon atmosphere.

Optical properties of several films were analysed on UV/Visible/IR. Figure 1 presents the spectral reflectance of a three-layer absorber produced, as well as glass with only a Ti deposited film and a non-deposited one. The three-layer tandem presents very low reflection on the visible and near-infrared regions – implying in very high solar absorption – and moderate reflection on the mid-infrared region.

Pure cermet films were deposited for Atomic Force Microscopy analysis. Results show that a nanostructured surface was produced by the method described above. Figure 2a shows the topography of the film with having a very flat surface with a peak to valley distance of 2,373 nm. Figure 2b presents the phase contrast image of the same film showing two different phases on the surface. Darker regions correspond to the harder oxide phase, while lighter regions correspond to the softer metallic phase.

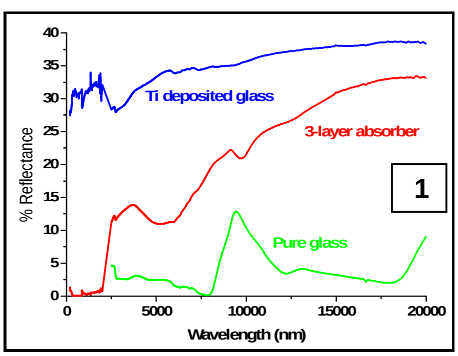

Figure 1: Spectral reflectance of pure, glass, Ti deposited glass and 3-layer absorber film deposited on glass.

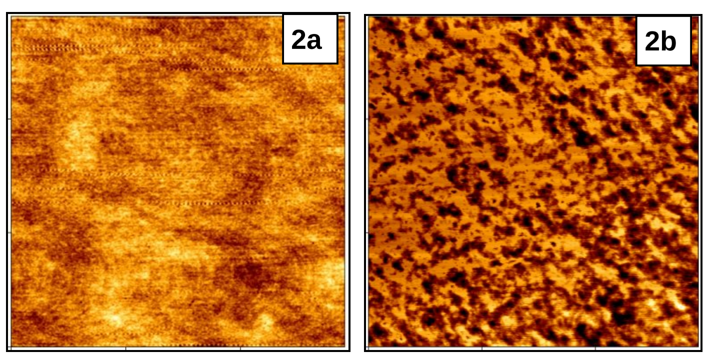

Figure 2: 1,5 μm^2 AFM images showing **(a)** topography and **(b)** phase contrast.

References

[1] C. E. Kennedy. Review of Mid- to High-Temperature Solar Selective Absorber Materials, NREL (2002) page 6.