PLASMA DEPOSITED W/SICH NANOCOMPOSITE AS HIGH TEMPERATURE AIR-STABLE SOLAR SELECTIVE ABSORBER COATINGS FOR CONCENTRATED SOLAR POWER RECEIVERS

Aïssatou DIOP,[1] Danielle NGOUE,[1,2] Amine MAHAMMOU[1,2], Babacar Diallo[3], Alex CARLING-PLAZA[1], Hervé GLENAT[1], Sébastien QUOIZOLA[1,2] Angélique BOUSQUET[4], Antoine GOULLET[5], Thierry SAUVAGE[3], Audrey SOUM-GLAUDE[1], Eric TOMASELLA[4], Laurent THOMAS[1,2]

[1]PROMES-CNRS (Laboratory of PROcess, Materials, Solar Energy)-Perpignan/Font-Romeu- Odeillo-Via, France

[2]Université de Perpignan, Perpignan, France

[3]CEMHTI (Conditions Extrêmes et Matériaux), Orléans, France

[4]ICCF (Institut de Chimie de Clermont-Ferrand), Aubière, France

[5] IMN (Institut des Matériaux Jean Rouxel), Nantes, France

e-mail address: aissatou.diop@promes.cnrs.fr , webpage of the project : nanoplast-project.cnrs.fr

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Summary: Improving the performance of concentrated solar power technologies (CSP) requires the development of optically efficient innovative materials. One objective is to develop, by plasma deposition techniques, composite coatings with spectral selectivity, that is to say high absorption in the solar spectrum range (UV, visible and near infrared) and low emissivity in the infrared range to limit radiative thermal losses. These materials should also have other characteristics: resistance to high temperatures in air under concentrated solar conditions, and high resistance to the high amplitude cyclic thermomechanical stresses inherent to such applications.

High-performance solutions have been developed in PROMES laboratory such as, on one hand, dielectric-metal multilayer interference stacks, and on the other hand, ceramic-metal composites (cermets). Compared to multilayers, nanocomposites are known to be more resistant to oxidation, corrosion and thermomechanical stress. Indeed, their microstructure limits the diffusion of ambient oxygen into the coating by eliminating grain boundaries and improving mechanical properties (blocking of cracks propagation, resistance to deformation, etc.). As a matter of fact, previous optical simulations showed that cermet composites present higher heliothermal efficiencies compared to classical multilayers.

Composites were thus produced using two different plasma ways. The first one is by annealing multilayers to provoke interlayer diffusion. The latter are stacks associating a refractory metal (W) deposited by RF magnetron PVD and a ceramic (SiC:H) deposited by µwave-PACVD, allowing to improve solar absorptance (~ 89%) as well as thermal stability. The second way is by direct deposition of a SiC:H matrix with inclusions of W, by reactive magnetron sputtering, with or without assistance of ECR microwave sources. To highlight the high performance of these two types of materials, plasma process diagnostics (OES, laser diffusion) were coupled with material characterizations (SEM, EDS, XPS, RBS, Ellipsometry, UV-Vis-IR Reflectometry) of the monolayers and their association in high-performance stacks.

On one hand, for multilayers, coupling of SEM/EDS, RBS profiles and reflectometry measurements on annealed multilayers (500°C in air during 96 h) show W diffusion at W/SiC:H interfaces and Silicon oxidation at the top surface of the stacks (O~16%at.)(Fig. 1). Formation of a self-protective silicon based oxide top layer, with a low refractive index, and creation of complex SiC:H-W interlayers could explain the observed improvement of solar performance of the multilayers after thermal treatment in air. On the other hand, multimode AFM show that assisting reactive magnetron sputtering with microwave ECR excitation give rise to composites where W metal nanoparticles are homogeneously embedded in SiC:H matrix. (Fig. 2)

Those nanocomposites are proposed to be stacked in multilayers. Those two solutions present thermomechanical compatibilities with CSP applications.

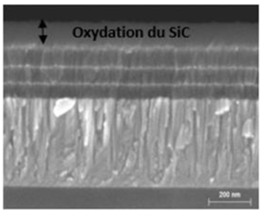

Fig. 1 MEB image of multilayers W/SiCH

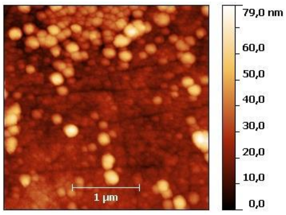

Fig. 2 AFM image of W-SiCH nanocomposite