Contribution of ion beam analysis in multilayer $Si_{1-x}C_x$:H/W solar selective absorber materials characterization

Babacar DIALLO[1], Aïssatou DIOP[2,3,4], Danielle NGOUE[2,3], Aurélien BELLAMY[1], Olivier WENDLING[1], Paul SIGOT[1], Antoine GOULLET[5], Audrey SOUM-GLAUDE[2], Eric TOMASELLA[4], Laurent THOMAS[2,3], Thierry SAUVAGE[1]

[1]CEMHTI (Conditions Extrêmes et Matériaux), Orléans, France
[2]PROMES-CNRS (Laboratory of PROcess, Materials, Solar Energy) -Perpignan/Font-Romeu- Odeillo-Via, France
[3]Université de Perpignan, Perpignan, France
[4]ICCF (Institut de Chimie de Clermont-Ferrand), Aubière, France
[5]IMN (Institut des Matériaux Jean Rouxel), Nantes, France

Hydrogenated amorphous silicon–carbon alloy $Si_{1-x}C_x$:H is an attractive material for receiver absorber in CSP due to its high strength, high thermal conductivity, low thermal expansion, chemical inertness at high temperatures and high solar absorptance [1]. $Si_{1-x}C_x$:H thin films have a refractive index (n > 2.5 at 630 nm) adapted for the design of $Si_{1-x}C_x$:H/W multilayers selective absorber materials. $Si_{1-x}C_x$:H can also act as diffusion barrier for metals to stabilize selective stacks optical properties, for which metal diffusion is a major source of degradation [2].

However, all the properties listed above are intrinsically linked to the $Si_{1-x}C_x$:H material stoichiometry and connectivity of the silicon carbide network. It is known that the chemical bonding and band structure of $Si_{1-x}C_x$:H thin films depend primarily on the value of carbon content x [3]. Likewise, the optical properties such as refractive index and optical band gap also depend on the degree of microcrystallinity and hydrogen content in the films. Therefore, the control of the carbon and hydrogen contents incorporated into the films during the synthesis is essential to optimize the properties of the selective absorber materials.

In this context, the current presentation will concern the contribution of ion beam analyzes through RBS, ERDA and NRA techniques in the exploration and optimization of the deposition parameters in PVD magnetron sputtering for W layers and microwave PECVD for $Si_{1-x}C_x$:H layers. The objective is to produce multilayers films endowed with excellent optical properties and chemical inertness at high temperatures to design multilayer selective absorber materials for CSP. Ion beam analyzes before and after annealing at 500°C are complemented by electron microscopy, XPS and infrared spectroscopy, allowing in-depth analysis of the material network, which can be linked to the materials optical properties measured by ellipsometry and spectrophotometry.

[1] C.K Ho et al., Solar Energy, 152, pp.38-56, (2017).
[2] A. Soum-Glaude et al., for the book: Nanotechnology for Energy Sustainability, Wiley-Blackwell, pp.231-248, (2017)
[3] I. Solomon et al., Applied Surface Science, 184 pp.3-7, (2001)