Novel rear structure design for an effective optical enhancement in ultrathin Cu(In,Ga)Se_2 solar cells

A. J. N. Oliveira[1]

J. De Wild[2,3,4], K. Oliveira[1], B. A. Valença[1], J. P. Teixeira[1], J. R. L. Guerreiro[1], S. Abalde-Cela[1], M. Prado[1], T. S. Lopes[1,2,3,4], R. M. Ribeiro[1,5], J. M. V. Cunha[1,6,7], M. A. Curado[1,8], M. Monteiro[1,9], A. Violas[1,5], A. G. Silva[9,10], P. A. Fernandes[1,6,11], B. Vermang[2,3,4], P. M. P. Salomé[1,7]

[1]INL – International Iberian Nanotechnology Laboratory, Avenida Mestre José Veiga, 4715-330 Braga, Portugal
[2]Imec division IMOMEC (partner in Solliance), Wetenschapspark 1, 3590 Diepenbeek, Belgium
[3]Institute for Material Research (IMO), Hasselt University (partner in Solliance), Agoralaangebouw H, Diepenbeek, 3590, Belgium
[4]EnergyVille 2, Thor Park 8320, 3600 Genk, Belgium
[5]Departamento de Ciência dos Materiais, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Campus de Caparica, 2829-516 Caparica, Portugal
[6]I3N, Departamento de Física da Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
[7]Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
[8]CFisUC, Departamento de Física, Universidade de Coimbra, 3004-516 Coimbra, Portugal
[9]Departamento de Física, Faculdade de Ciências e Tecnologia Universidade Nova de Lisboa Campus de Caparica, 2829-516 Caparica, Portugal
[10]CEFITEC, Departamento de Física, Faculdade de Ciências e Tecnologia Universidade Nova de Lisboa Campus de Caparica, 2829-516 Caparica, Portugal
[11]CIETI, Departamento de Física, Instituto Superior de Engenharia do Porto, Instituto Politécnico do Porto, Porto 4200-072, Portugal
antonio.oliveira@inl.int

Amongst all the thin film solar cells technologies, Cu(In,Ga)Se_2 solar cells stand out, due to presenting the foremost power conversion efficiency value (23.35 %), and for satisfying the requirement for new application possibilities imposed by the photovoltaic industry [1]. Nonetheless, sub-μm ultrathin solar cell absorbers have been gaining relevance, as they allow to meet economic and technological targets through cost-reduction objectives [2]. However, the thickness reduction comes with drawbacks, such as, a decreased light absorption and increased interface recombination. To tackle the imposed downsides, light management as well as interfacial passivation strategies need to be employed. In this work, a novel light management architecture is used to enhance the optical path in the absorber. Gold nanoparticles (NPs) aggregates were integrated at the solar cell rear contact and encapsulated with a dielectric matrix commonly used as a passivation layer in solar cells. The rear substrate fabrication procedure is represented in **Figure 1**. This way, an encapsulation strategy shielding the fabricated nanostructures from the high temperatures and harsh processing conditions of the remaining device is coupled with a passivation approach to reduce rear interface recombination. An X-ray photoelectron spectroscopy analysis was conducted demonstrating the effective encapsulation of the Au nanostructures. With the novel rear architecture, a broadband external quantum efficiency increase was obtained, leading to a 17.4 % increase of the short circuit current density value over a reference device.

REFERENCES

[1] C. Heske, D. Lincot, M. Powalla, P. M. P. Salomé, R. Schlatmann, and A. N. Tiwari. CIGS White Paper **2019** – CIGS Thin-Film Photovoltaics. url: https://cigs-pv.net/cigs-white-paper-2019-now-available/.
[2] Stamford, A. Azapagic, *Sci. Total Environ*., 688 (2020), 1092.
[3] A. J. N. Oliveira, et al., *Solar RRL* (2020), DOI: 10.1002/solr.202000310.

FIGURES

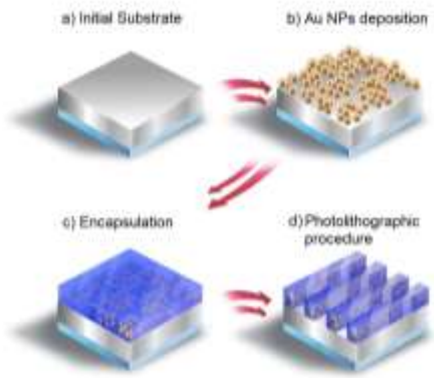

Figure 1: Schematic illustration rear structure fabrication. a) Initial substrate. b) Au NPs deposition. c) Au NPs encapsulation with a 25 nm Al_2O_3 layer. d) Photolithographic procedure allowing for an electrical contact. Taken from [3].