Combining In-situ Photoluminescence and Ellipsometry: A New Approach to Analyse and Optimize ALD Materials for Photovoltaic Applications

Navid MOUHAMAD [1], Nao HARADA [1], Maxime LEVILLAYER [1], DELAMARRE Amaury [3], COLLIN Stéphane [3], Alexandra LEVTCHENKO [1], Jean-François GUILLEMOLES [2], Daniel SUCHET [2], Géraud DELPORT [2], Nathanaelle SCHNEIDER [2]

1 - IPVF, Institut Photovoltaïque d'Ile-de-France, 18 Boulevard Thomas Gobert, 91120 Palaiseau, France

2 - IPVF, UMR 9006, CNRS, IPVF SAS, Ecole Polytechnique, PSL Université, 18 Boulevard Thomas Gobert, 91120 Palaiseau, France

3 - C2N, Centre de Nanosciences et de Nanotechnologies, 10 Boulevard Thomas Gobert, 91120 Palaiseau, France

Contact: navid.mouhamad@ipvf.fr

Abstract: For the last decades, Atomic Layer Deposition (ALD) has undoubtedly become a key technique to deposit thin films in various research fields. As the deposition is sequential and self-limited, a high control over the films' thickness can be reached together with a high conformality. Moreover, the deposition can be done at low temperatures (below 100 °C) and allows the growth of a large panel of materials on different substrates. In the field of PV, ALD films are already used at an industrial scale (for instance in PERC solar cells) but their use also extends to buffer layers for CIGS cells, transparent conductive oxides (TCO), encapsulation, passivation or charge transport layers (ETL & HTL) for perovskite solar cells … [1]

An innovative in-situ instrumentation set-up is being developed at IPVF: it combines Spectroscopic Ellipsometry (SE) with photoluminescence (PL). These techniques were considered relevant for correlating the film's growth properties and its functions. Indeed, by acquiring SE data, the film's thickness and optical properties are addressed during the growth [2], while its function is determined by analysing PL spectra or PL decays (by Time Resolved Photoluminescence TRPL) [3]. In-situ SE is commonly used during ALD growth, only one example of in-situ PL has been developed and none combines the two techniques [4], making our approach original. In-situ characterizations would also be very useful for pre-industrialization, by reducing the number of samples required to totally take advantages of ALD specificities and generate highly-performant devices. This presentation will introduce our experimental set-up in more details, as well as some first analysis results on the growth of ALD-Al_2O_3 thin film as passivated layer for GaAs, by combining SE and PL measurements.

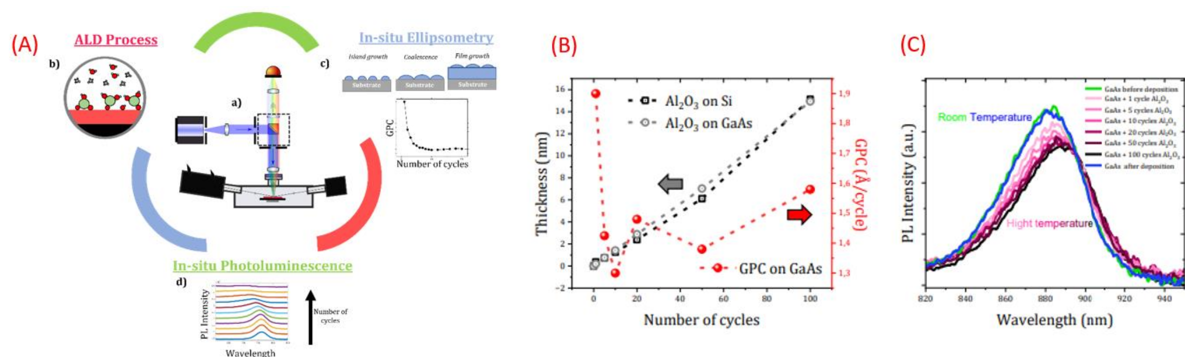

Figure 1 – (A) - a) Experimental set-up with in-situ PL and ellipsometry in an ALD reactor, b) ALD growth c) In situ ellipsometry, d) In situ PL. (B) - Growth tracking of ALD-Al_2O_3 via ellipsometry on native Si and GaAs etched. (C) – PL tracking during the growth.

1. "Atomic Layer Deposition (ALD). Principes Généraux, matériaux et applications" *Ouvrage spécial des Techniques de l'Ingénieur : Principes et applications de la technique ALD (Atomic Layer Deposition)*
2. Langereis, E. *et al.* *J. Phys. Appl. Phys.* **42**, 073001 (2009).
3. Unold, T. & Gütay, L. in *Advanced Characterization Techniques for Thin Film Solar Cells* -275–297.
4. Kuhs, J. *et al. ACS Appl. Mater. Interfaces* **11**, 26277–26287 (2019).