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

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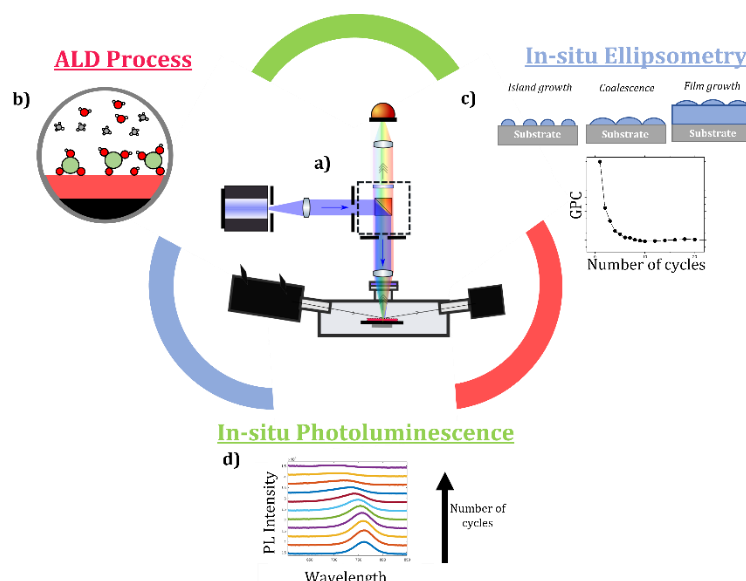
**Abstract:** For the last decades, Atomic Layer Deposition (ALD) has undoubtedly become a key technique to deposit thin films in various research fields. As the deposition is sequential and self-limited, a high control over the films' thickness can be reached together with a high conformality. Moreover, 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), passivation or charge transport layers (ETL & HTL) for perovskite solar cells … [1]

In-situ ellipsometry together with photoluminescence (PL) were considered as relevant techniques to correlate film's growth properties and its functionalization. Indeed, by acquiring Spectroscopic Ellipsometry (SE) data, the film's thickness and optical constants are addressed during the growth [2], while its function is determined by analysing PL spectra or PL decays (by Time Resolved Photoluminescence TRPL) [3]. While 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 thin films on solar cells correlating SE and PL measurements.




*a) Experimental set-up with in-situ PL and ellipsometry in an ALD reactor b) ALD growth c) In situ ellipsometry - Thickness, optical constants and growth mechanisms d) In situ PL – Functionalization properties (passivation, carrier behaviour)*

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).