

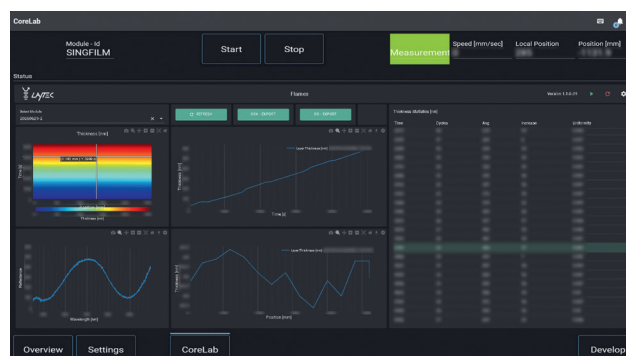
In-line monitoring of perovskite film thickness during Singfilm's proprietary evaporation deposition process

LayTec's Flames in-line metrology system has been chosen by Singfilm, a leading manufacturer of next-generation perovskite solar cells and modules, for monitoring its industrial evaporation process with respect to perovskite film thickness. In this note, key features and benefits of the system are summarized.

As perovskite solar cells are approaching mass production as the next generation of photovoltaic devices, numerous industrial players are currently ramping up production volume. Singfilm Solar Pte. Ltd. is one of the pioneers of this technology, which originally emerged from the National University of Singapore, with a track record of several efficiency world records. Whilst for record devices, the one single device is crucial, a constant high level of device quality and high throughput is key for the manufacturing ramp-up. Optical in-line metrology is perfectly suited for monitoring film properties without any delay or disruption to the process. Therefore, Singfilm chose LayTec's Flames system for in-line monitoring of the perovskite film thickness by means of optical reflectance spectroscopy. The Flames system was integrated at an optical viewport and monitors film thickness on the moving sample as the substrate passes the measurement head. The model-based analysis is carried out in real-time, and the deduced film thickness is displayed in the graphical user interface (GUI) of LayTec's Insight software. Furthermore, the evolution of film thickness along the substrate is displayed as well as the sample uniformity. Additional information such as the latest spectra and thickness values can also be shown in the customizable GUI. In Singfilm's process, the sample is measured several times during the deposition process, such that film growth can be monitored continuously in order to meet the thickness targets with optimum precision.

The system has been commissioned in early 2026 and is now constantly supporting Singfilm's production. Similarly, the Flames system can be customized to other dry or wet-chemical deposition steps for all functional layers in the layer stack of perovskite-based solar cells or similar thin film devices. Optionally, the system can also be combined with LayTec's in-line spectral (PearL) or time-resolved (t-PearL) photoluminescence metrology systems to also monitor the band gap and composition or charge carrier lifetime, respectively. Thus, a complete monitoring scheme for controlling all relevant perovskite properties can be implemented to ensure efficient production at the highest level of quality. Similarly, Flames can also be applied for monitoring subsequent processes, such as vacuum drying, annealing, and ETL/HTL or TC deposition.

- Available for VIS (400-1100nm) or NIR (900-1600nm)
- 1-7 heads per control unit
- Sampling frequency of 10-100 Hz
- Optional feed-forward to and from related process preceding and subsequent process steps
- Can be combined with LayTec's photoluminescence systems PearL and t-PearL for additional composition control
- Customizable GUI with different user level views
- Data saved to local network or directly fed into MES (optional)
- The thickness measurement accuracy is typically 1-2 %



Exemplary data from in-line monitoring of Singfilm's perovskite deposition process: Graphical user interface of LayTec's proprietary Insight software displaying the color-coded evolution of the film thickness during the process (upper left). In the upper right, the average substrate thickness is plotted over time. In the lower left, the selected / latest spectrum is displayed. The thickness evolution along the substrate is depicted next to it. On the right side, recent measurement results are tabulated (time, average, thickness, process step/cycle, thickness change, uniformity).

APPLICATION NOTE

What the customer says

"LayTec's Flames delivers real-time thickness data that plays an important role in our production ramp-up. It helps us accelerate learning, maintain high yield, and ensure consistent quality throughout the scale-up phase."

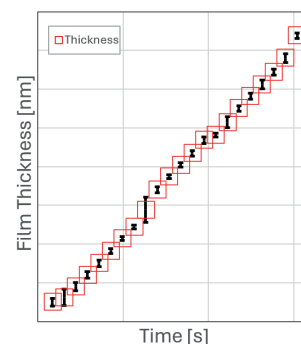
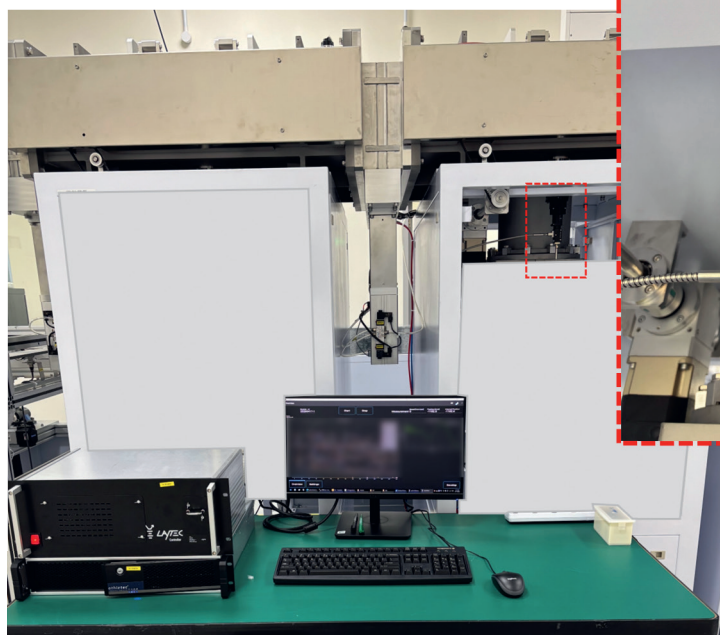


Photo of the LayTec system as integrated into Singfilm's production line. In the front, the controller unit and the measurement PC are depicted. In the back, the optical measurement head mounted to the evaporation tool is shown (red box). In the inset, deduced substrate average film thickness values (center of red boxes) and the substrate uniformity (black error bars) are shown.



About Singfilm Solar Pte. Ltd.:

Singfilm Solar was born in NUS laboratories to reinvent solar power for the AI era. Singfilm holds multiple world records in perovskite solar efficiency across cells, modules, and tandem architectures. These breakthroughs are already translated into manufacturing through a 15 MW production line in Singapore, the largest perovskite PV facility in ASEAN.



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