Press Release

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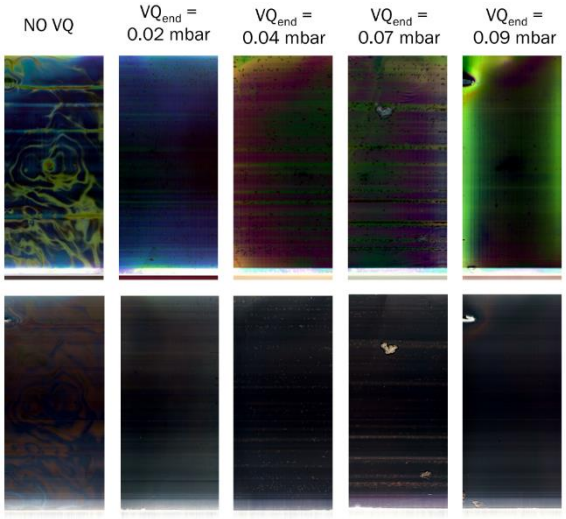
New Multimodal Real-time Methods for In-line Nanomaterial Characterization Developed

Project NanoQI Successfully Finalized

Eight partners worked together to **develop industry-ready, real-time, in-line technology for the characterization of nanomaterials**. NanoQI optimized and combined X-ray diffraction analysis (XRD) and X-ray reflectometry (XRR) with novel **hyperspectral imaging (HSI)** technology to provide industry access **to real-time assessment of nano-dimensions, structure and morphology of thin film nanomaterials**, as well as correlative imaging of their homogeneity and defects.

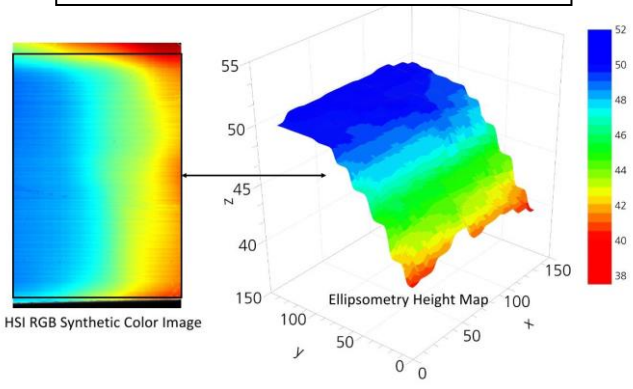
After just over three years, the NanoQI methodology has been demonstrated on three research pilot lines for perovskite solar cells, thin optical layer stacks, and gas barrier films.

At TNO, the analytical tool, including an in-situ double camera HSI setup and the customized XRD Proto-T unit, has been demonstrated for application in **perovskite solar cell manufacturing**. Films with variations in characteristic properties, such as **thickness, roughness and phase composition**, were fabricated and analyzed with the HSI and XRD tools to develop prediction models for quality control purposes. The result was a validation tool for coating properties prediction with the potential to become a routine characterization setup in sheet-to-sheet and roll-to-roll production lines.



TNO: SWIR (top) and VNIR (bottom) HSI images of perovskite coatings

FhG-IAP: 3D thickness plot of the 150 mm x 150 mm deposition of TiO2 on silicon



At-line investigation of **layers of different oxides** deposited by **Atomic Layer Deposition (ALD)** was achieved after the installation of the HSI measuring system close to the ALD chamber in the glovebox of **the Fraunhofer IAP pilot line for processing of organic electronic devices.** It was proven that HSI can sensitively monitor the

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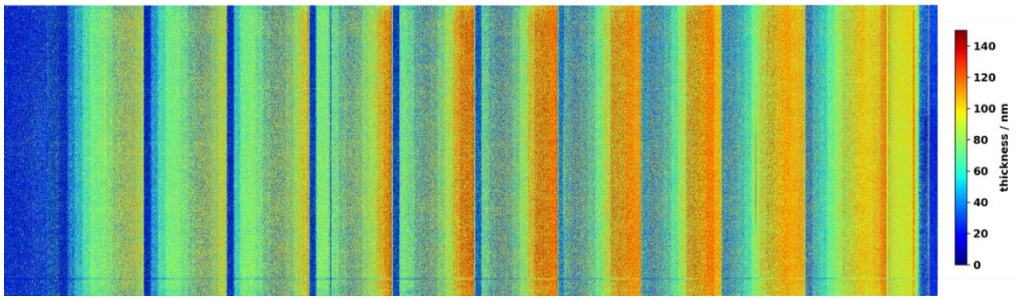
thickness and prove layer homogeneity, making the NanoQI methodology a promising tool for the characterization of active layers in OE devices.

At **Fraunhofer FEP**, the NanoQI system was tested on the **coFlex600 vacuum web coating plant** for coating flexible materials with optical, electrical, and decorative functional layers and barrier layers. The NanoQI solution, which combines monitoring hardware with powerful AI-aided software, proved to be capable of characterizing the thickness and homogeneity of several single-layer and double-layer systems on polymer film.



FhG-FEP: Predicted ITO layer thickness on a 100m sample

The NanoQI project was the first initiative to combine 3 characterization tools (XRR, XRD and HSI) to provide industry access to real-time evaluation of **nano-material geometry, structure and morphology and correlative imaging of deviations** of these properties. **After a successful conclusion of the project, the project partners are open to discussing other potential applications and propositions for further collaboration.**

Contact Us	
Email	info@nanoqi.eu
Web	https://nanoqi.eu/

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