# PhotoVoltaic modules based on a P-i-n stack

## Publieke samenvatting / Public summary

### Aanleiding

A decade ago 'perovskite' solar cells did not exist, but they have now realized power conversion efficiencies (PCEs) up to 23%, close to record PCEs for commercial PV technologies. Advances in the scientific literature and within the Solliance network including Greatcell Solar Limited (GSL) have shown that specific perovskite solar cell stacks, referred to as inverted or p-i-n, can pass critical stability tests. Recently, GSL and Solliance have improved PCE of roll-to-roll (R2R) processed perovskite solar cells (PSCs) from 13.5% to 16% (three R2R layers), which is a world record. Solliance has also developed a scalable process route for PSCs reaching 17% with stable performance under accelerated lifetime testing. The motivation to develop PSCs is based on opportunity to turn abundant and inexpensive materials, processed at low temperature and in high volumes at low cost, into high quality semiconductor films, suitable for solar modules. However, several challenges need to be addressed including, environmental profile, long term outdoor performance, up-scaling processing, integration and validation of new products, and the PV PRESS will address the up-scaling challenges.

### Doelstelling

PV PRESS connects Dutch industry (Maan & VDL) via Solliance with a world-leader Greatcell Solar Ltd (GSL) in perovskite solar cells (PSCs). GSL & Solliance previously developed process flows to scale up flexible perovskite modules. However, the currently applied stack on roll-to-roll (R2R) shows limited thermal stability with high material costs. The aim of PV PRESS is to transfer a PSC stack with

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good efficiency, stability and low material cost from sheet-to-sheet (S2S) (on glass) to R2R (on PET). This is challenging since thermal budget of PET foil is significantly lower than glass, limiting processing to form a high quality charge transport layer (CTL). Secondly, as R2R substrate and process equipment differs from S2S, the perovskite needs further optimization. To facilitate development of CTL on the PET substrate and perovskite, detailed surface analysis measurements are planned. The complete process flow can be executed on existing equipment except for one step: atomic layer deposition (ALD) of protective layers on R2R at atmospheric pressure. PV PRESS delivers key design aspects for a R2R spatial ALD tool capable of depositing CTLs on perovskite stacks at high speed.

**Korte omschrijving**

Maan, IMEC & TNO will develop a safe and low temperature process to deposit a charge transport layer (CTL) on PET foil with an electrode. Together with TUE the properties of the transport layer will be investigated. Next IMEC and TNO together with GSL will develop a suitable ink formulation and drying/annealing processes for the R2R deposition of the perovskite. TUE will investigate the perovskite layer and in particular the CTL/perovskite interface after completion of the full PSC devices.

**Resultaat**

PV PRESS: 1) Enables the development of a safe and scalable deposition process for p-type CTLs in perovskite solar modules on PET foil on the R2R scale. 2) Delivers R2R processed (four layer) perovskite solar modules (6 inch) with a PCE of 15%. The modules will be stable towards high temperature (85oC, 1000 hrs) and continuous light soaking (one sun, 1000 hrs) 3) Delivers the functional design specification of a future perovskite PV module manufacturing facility. 4) Provides fundamental insights in the role of interfaces in perovskite PV devices. The project represents a great opportunity for Dutch equipment manufacturers to position themselves within this new market in collaboration with a world leading end-user in GSL. The project connects with the

strengths of Solliance to transfer lab-scale processes from the lab to fab to support commercialization of the PSC technology. As such, this project fits the ambition of TKI UE to support the Dutch economy and, concomitantly support the development and scale up of new thin PV technologies.

De data in deze applicatie is afkomstig van de Rijksdienst voor Ondernemend Nederland (RVO) en wordt in samenwerking met de Topsector Energie ontsloten.
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