Ambient processing for high-efficiency R2R scalable perovskite solar cell technology

Publieke samenvatting / Public summary

Aanleiding

Upscaling perovskite solar cell production is essential for commercialization. For the realization of highly efficient architectures, a suitable perovskite formulation and scalable quenching method for solvent extraction should be developed. Ambient processable perovskite formulations have been shown in scalable R2R-SD environment by TNO, however, a complete R2R process is missing. In the usual practice, R2R perovskite is processed without a rapid quenching step, and solar cells are post processed via sheet-to-sheet (S2S) process, due lack of R2R process development on the remaining layers. For that, improved perovskite quenching, development of solution processable charge transport layers (CTLs) via R2R-SD process, and development of buffer layers via R2R-sALD process is required. Development of such a technology will be an enabler for highly efficient flexible perovskite PV suitable for R2R processing.

Doelstelling

This project AMBIENT aims to develop ambient-processable perovskite formulations and CTLs, scalable quenching tools for rapid solvent extraction and reliable layer conversion during R2R-SD process, and develop buffer layers via R2R-sALD process, required for stability and improved current collection. The development, led by TNO will open up the path towards fully R2R processed perovskite solar cells, enabling a critical commercialization step for Kalpana Systems on R2R-sALD equipment manufacturing, and Perovion Technologies on

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commercialization of the flexible Perovskite PV as a product. The development contributes to the “Herniewbare elektriciteitsopwekking op land en in the gebouwde omgeving” thema. The project focuses on improving the technology for the production of light-absorbing layer and contact layers of perovskite solar cells and it is technically and economically feasible to create a product within five years after the start of the project. The partners are at the forefront of the technology development, increasing the chances of success.

Korte omschrijving

• Benchmark TNO perovskite formulations and translate them into scalable solvent systems relevant for ambient R2R-SD processing. • Develop a R2R compatible quenching process that will extract the solvent of perovskite ink efficiently, enabling conformal, uniform, and defect-free perovskite films at continuous processing speeds. • Optimize the R2R-SD ETL deposition process by means of materials and process parameters, enable the growth of R2R-sALD processed buffer layers. • Develop functional barriers with combined charge collection and protection properties using R2R-sALD process. Integration of existing sALD layers into developed stack at S2S level as benchmark and development of R2R sALD compatible process for SnOx-based functional barrier layers. • Validate device efficiency and stability via electrical characterization, apply state-of-the-art encapsulation, report on reliability and performance. • Evaluation of commercial viability, definition of process specifications for R2R-sALD for functional layer deposition in perovskite solar cells, for R2R-SD coating of perovskite stack and the industrial scale production process covering economic and permitting requirements.

Resultaat

The AMBIENT project aims to deliver key process innovations enabling industrial roll-to-roll (R2R) perovskite PV manufacturing. This includes: • Ambient-processable perovskite ink formulations translated into scalable solvent systems compatible with R2-SD coating; • A validated R2R-compatible

quenching process enabling controlled crystallization and formation of uniform, defect-free perovskite films under continuous processing; • Optimized R2R deposition routes for ETLs ensuring full process integration; • R2R-sALD processes for SnOx-based functional buffer layers providing combined charge extraction and protection; • Integrated flexible perovskite devices demonstrating >15% power conversion efficiency and >1000 hours stability under ISOS conditions; • A comprehensive set of process specifications and techno-economic assessments supporting industrial scale-up to TRL6, including cost, and manufacturing integration. These results address key bottlenecks in scaling perovskite PV from lab-scale to high-throughput manufacturing.

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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