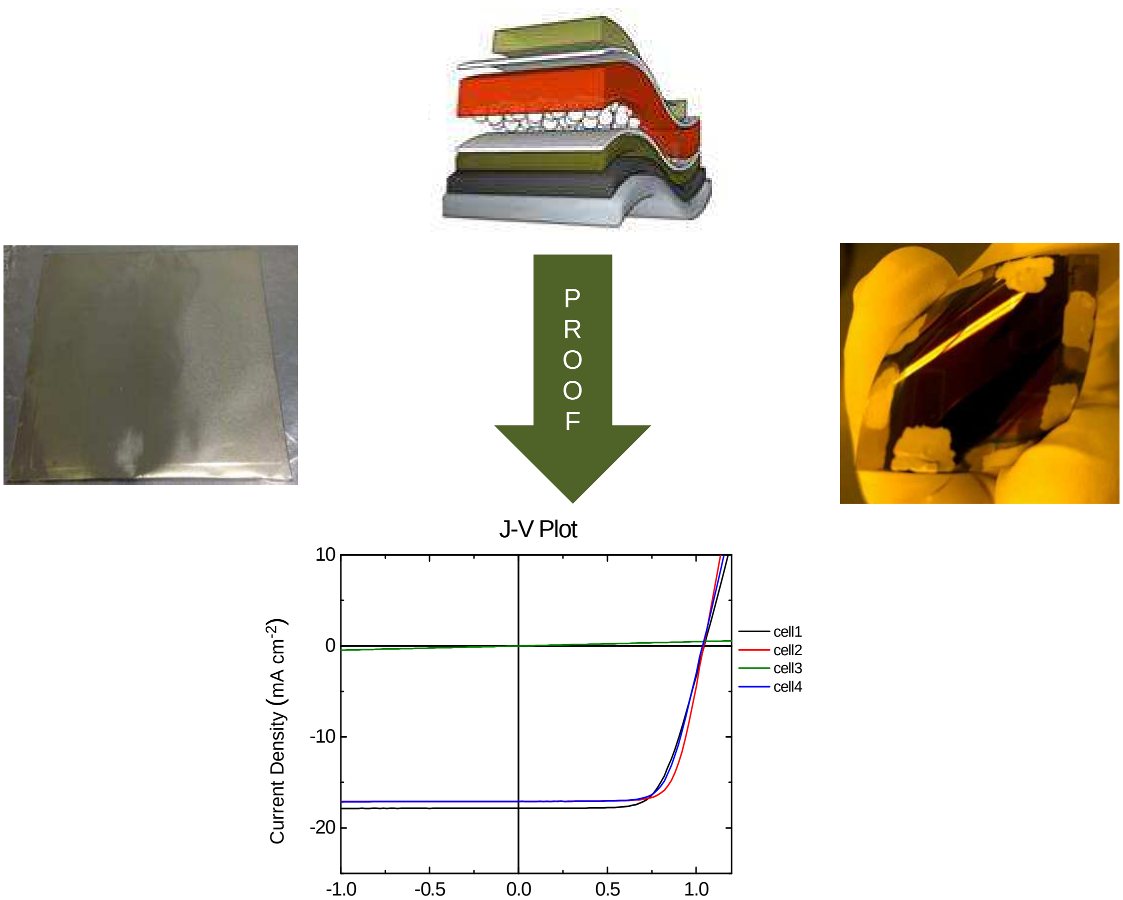
Public summary of final report

PROOF

Prove Roll-to-roll process-ability of perOvskite mOdules by application of an innovative Foil substrate



Contents

1 Data project

1.1 Projectnumber
TEID115099

1.2 Project title
PROOF
Prove Roll-to-roll process-ability of perOvskite mOdules by application of an innovative Foil substrate 1.3

Applicant and co-applicant

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1.4 Project period
October 1st, 2015 until September 30st, 2016.

2. Executive Summary

2.1 Objectives & Results

Roll-to-roll processing allows to fully exploit the benefits of perovskite solar modules to obtain very low cost, flexible modules. A critical step towards roll-to-roll processing is to transfer the current high efficiency reference device from a rigid (glass) substrate to a flexible substrate while maintaining the high power conversion efficiency. This requires compatibility of the flexible substrate with established process conditions for high quality materials. The best candidate is a metal foil coated with an isolating layer. The electrical barrier layer separates the metallic substrate from the perovskite device stack. This enables, in a next step of development to introduce a monolithic interconnection.
With the overall aim to develop a suitable substrate for flexible and thus roll-to-roll processable perovskite solar modules, PROOF has the following main project objectives:

Main objectives

1. **Identify metal foil for R2R processing of perovskite modules**

2. **Development of a planarization coating (R_a<100 nm) with high breakdown voltage (V_{bd}> 1500V) and wide temperature range (from -40 to 500 ^oC).**

3. **Develop process for metal foil / lacquer / electrode for perovskite modules**

Results

1. **Two metal foil substrates were identified and found suitable: aluminum foil and stainless steel.**

2. **Two coatings were identified with sufficient thermal stability (300 up to 500 degrees C); low cost and good coating properties.**

3. **A process was developed to coat the electrical barrier layer on the metal foil using a scalable method (slot die coating).**

4. **On top of the coating well working devices were prepared (PCE from JV-curve: 12%).**

2.3 Exploitation

During the project execution phase, the required temperature for perovskite solar cells with a meso-porous TiO_2 layer was reduced, decreasing the thermal requirements of the isolating coating. The relaxed requirements allow the application of a less expensive coating. The low temperature process also reduces the embodied energy in perovskite solar modules and eases the processing thereof.

The project results provide C-coatings and Solliance partners Holst Centre and ECN with a good position to further develop thermally stable coatings (C-coatings) and roll-to-roll processable perovskite solar modules (Solliance).

The project resulted in a transparent coating with good film forming properties and a good thermal stability. This coating is suitable for perovskite solar modules, may find application in perovskite solar modules, other solar technologies (including hybrid tandems) and outside the PV market.

2.4 Further information

Figure 1 shows an example of a barrier coating deposited via spin coating on a glass substrate. On top of the electrical barrier layer, titanium electrodes are thermally evaporated followed by an e-beam deposited TiO_2 layer. To prove to the scalability of the developed electrical barrier layer, the barrier was also deposited by slot die coating an a steel substrates. One of the slot die coated samples is presented in the background of Figure 1 Example of a 6 inch stainless steel foil coated with an isolating barrier coating. Also presented is a 3 cm x 3 cm test structure for preparing devices on the foil with coating.

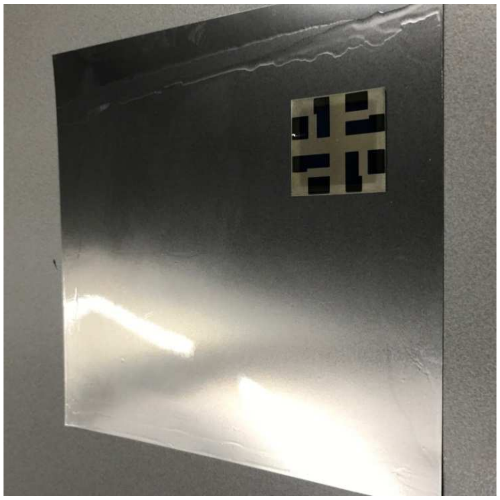

Figure 1 Example of a 6 inch stainless steel foil coated with an isolating barrier coating. Also presented is a 3 cm x 3 cm test structure for preparing devices on the foil with coating.

To prove the compatibility of the developed barrier with the perovskite device architecture, working devices were first developed on glass substrates and subsequently transferred to metal substrates. The cells presented in Figure 2 show over 12% efficiency. This is amongst the highest efficiencies obtained for flexible perovskite solar cells on a metal foil with isolating coating.

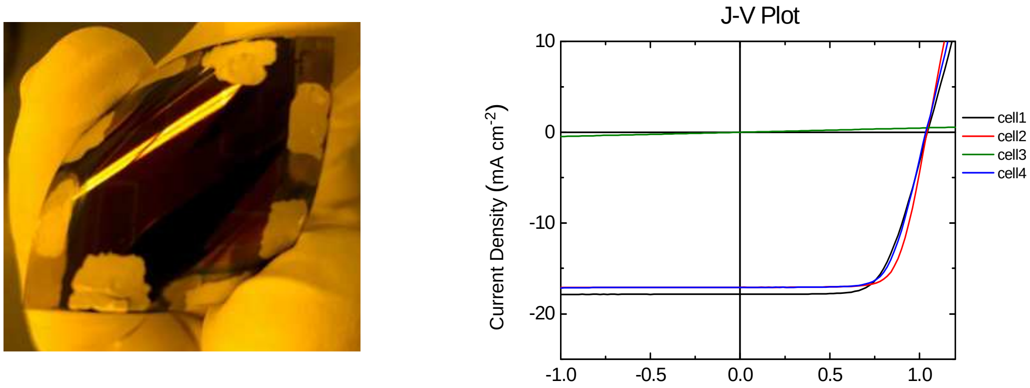

Figure 2 Picture of four flexible perovskite solar cells processed on a steel foil with a MO18 coating (left. The current density – Voltage curves are also presented (right).