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Energy

Improving the efficiency of PV devices, via luminescent down-shifting of the incident light

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Introduction

Most photovoltaic (PV) technologies respond with different efficiencies to different wavelengths of the sunlight, exhibiting significantly lower efficiencies for blue and ultra-violet photons. The energy content of such photons can be harnessed more efficiently if they are absorbed by a luminescent species before reaching the semiconducting component of a PV device and then re-emitted at longer more favourable wavelengths. Where encapsulation within a polymer is used for sealing PV modules (>85% of the global market), it is possible to dissolve the luminescent species in the pre-existing encapsulation layer. Thus, the luminescent down-shifting (LDS) can be applied introducing no modification to the established manufacturing process. As a side effect of LDS, the modules are coloured, due to emission losses from their top and side planes, which can be useful in the developing area of building integrated PV (BIPV).

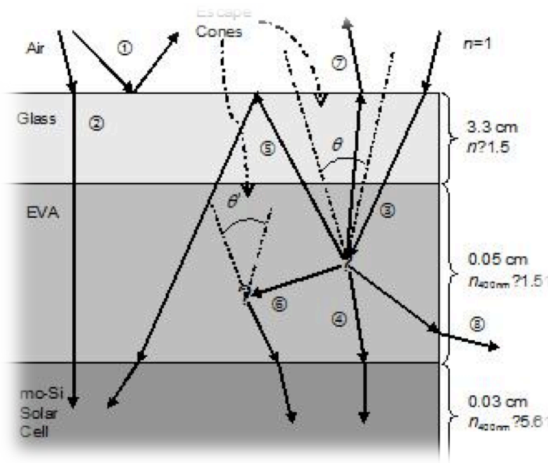

Fig 1. Cross-section of the front half of a mc-Si module encapsulated in doped EVA, with the possible optical events for the incident photons highlighted

Objectives

- Review previous relative applications in the literature
- Establish through simulation which technologies can benefit and estimate the possible improvement.
- Identify suitability of available luminescent and host materials.
- Achieve improvement experimentally for multi-crystalline silicon (mc-Si) devices using the pre-existing poly-ethylene vinyl acetate (EVA) encapsulation layer as host matrix.
- Investigate other PV technologies and encapsulants.

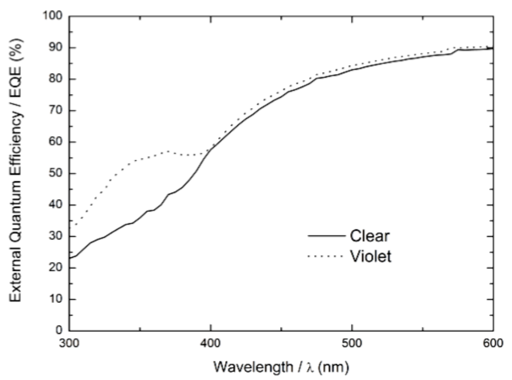

Fig 3. A standard grey and a more efficient violet coloured mc-Si mini-modules.

Progress

- Complete review of previous relative applications [1].
- Ray-tracing simulations predicting positive result for mc-Si and CIS-based technologies.
- 10-18% absolute increase in external quantum efficiency (EQE) in the range 300-400nm, resulting in 1.2% relative improvement (0.18% absolute) in module efficiency achieved for mc-Si using Lumogen violet dye in EVA [2].

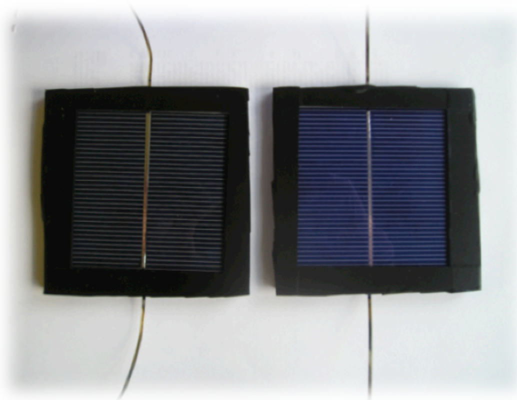

Fig 2. EQE comparison between clear and violet-doped EVA mc-Si modules

References

1. Klampaftis E, Ross D, McIntosh KR, Richards BS. Enhancing the performance of solar cells via luminescent down-shifting of the incident spectrum: A review. *Solar Energy Materials & Solar Cells* 2009; **93**: 1182 – 1194.
2. Klampaftis E, Richards BS. Improvement in multi-crystalline silicon solar cell efficiency via addition of luminescent material to EVA encapsulation layer. *Progress in Photovoltaics: Research and Applications ;* Submitted.

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