Development of Solid-State Dye-Sensitized Solar Cells

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Solar energy

Integratable energy technologies

Photovoltaic (PV) technology is key to sustainably harvesting solar energy at sufficient scale and low cost to meet energy demands in response to increasing levels of climate change.

Currently, PV sales are dominated with rigid, heavy and difficult to integrate Si. In order for the UK to compete, there needs to be a shift towards roll-to-roll (R2R) processing with technology being printable onto flexible substrates.

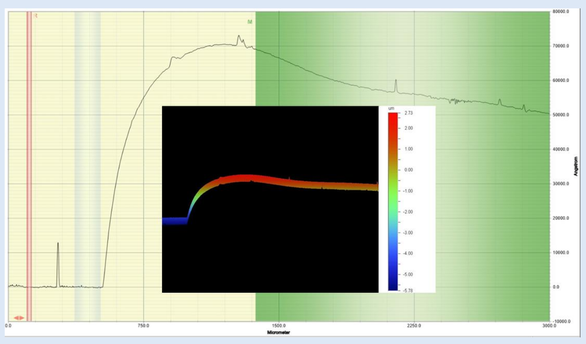
Solid-state dye-sensitized solar cells (ssDSCs)

Liquid DSCs can suffer from durability problems, caused by the liquid electrolyte component corroding electrodes and leaking from devices. In order to improve device stability, this liquid component can be replaced with a solid-state hole conductor[1]. Currently, the highest report for ssDSCs is $\eta = 11\%$[2].

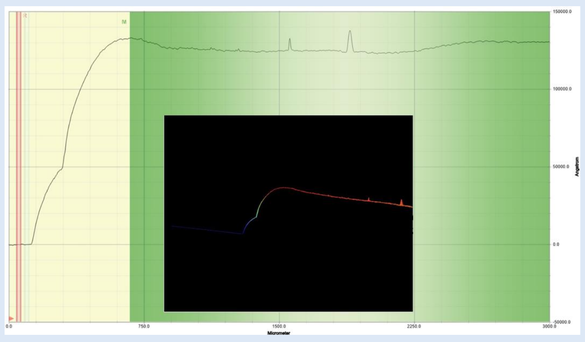
The project will investigate efficiency and stability of ssDSCs, focusing on the improvement of light harvesting and charge extraction by testing combinations of dyes and hole transport materials. One method of improving ssDSCs is that of co-sensitization using different coloured dyes[3,4].

Dyes (left) for sensitisation and a ssDSC (right)

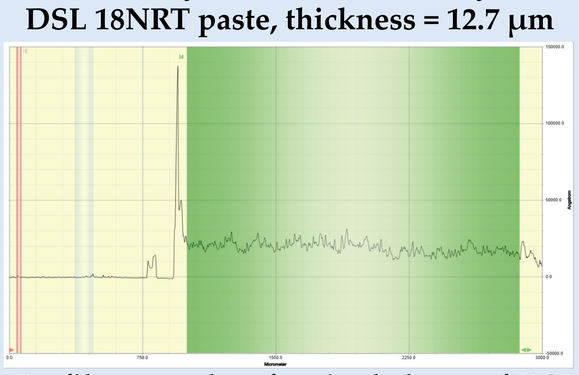
Initial tests have been carried out on TiO_2 layer thickness (profilometry data right) to investigate surface properties of devices. Further work will try to understand how to control surface organisation and sensitization processes, for a cost-effective and scaleable manufacturing process.



Profilometry data for single layer of DSL 18NRT paste, thickness = 5.8 µm



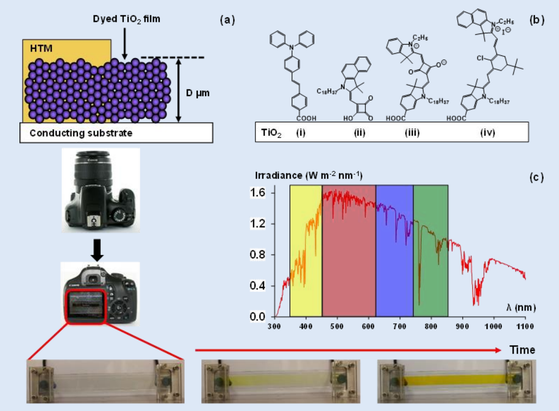
Profilometry data for a double layer of DSL 18NRT paste, thickness = 12.7 µm



Profilometry data for single layer of DSL 18NRT paste and a single layer of AO paste, both thinned down 50:50 with ethanol, thickness = 2 µm

Metrology of sensitization

Dye uptake can be monitored with a camera taking images at regular intervals before analysis to monitor colour changes. This can be used to monitor the stability of DSC devices after light soaking to reveal the degradation mechanism[5].



(a) *In situ* digital image analysis of ssDSC devices, (b) ssDSC energy levels, (c) yellow, red, blue and green dyes and their typical light harvesting ranges on the AM1.5 spectrum

Before fast dye

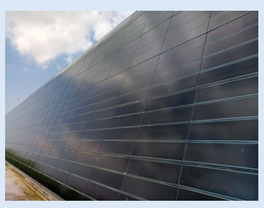
After fast dye with Rhodamine B

UV-Imaging

Cameras with UV capabilities can reveal more can be seen with the naked eye. We are currently investigating UV imaging of DSC devices.

Rose – Standard Image

Rose – UV Photograph



PV technology

Conclusions

- Shift towards R2R processing, with PV technology being printable onto flexible substrates.
- ssDSCs have potential to outperform liquid electrolyte devices but investigative work needed to extend lifetimes and efficiency. This includes controlling crucial dye-TiO_2 and dye-HTM interfaces.
- In-line metrology may provide continuous data in a real-time feedback loop, allowing greater control during processing.

Acknowledgments

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