In situ monitoring of multilayer deposition for organic solar cells

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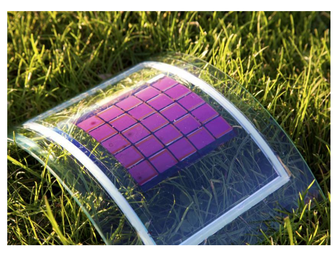
WAFT Deliverable 1.1.1

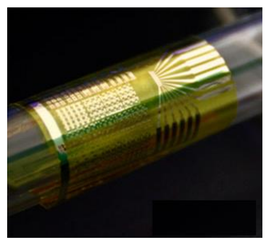
The primary objective of WP1 Strand 1.1 is developing a metrology solution to monitor the growth of functional layers during fabrication. We report here successful ***in situ*** **monitoring** of multilayer stack of more than three such layers vacuum-deposited on top of each other using **spectroscopic ellipsometry** (**SE**) during fabrication of a high efficiency organic solar cell, which fulfils **Deliverable 1.1.1**.[1]

Powering Wearable Electronics



Organic solar cell [2]

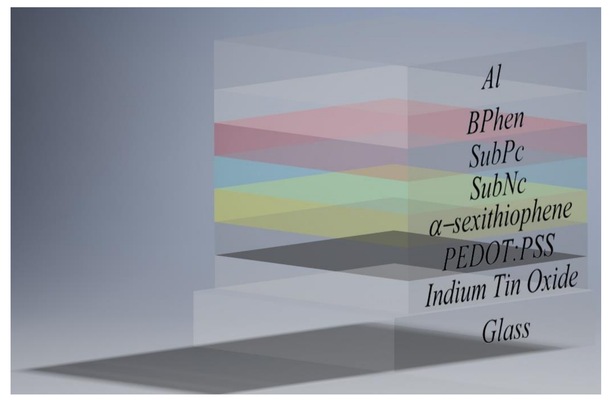
Sensors [4]



Displays [3]

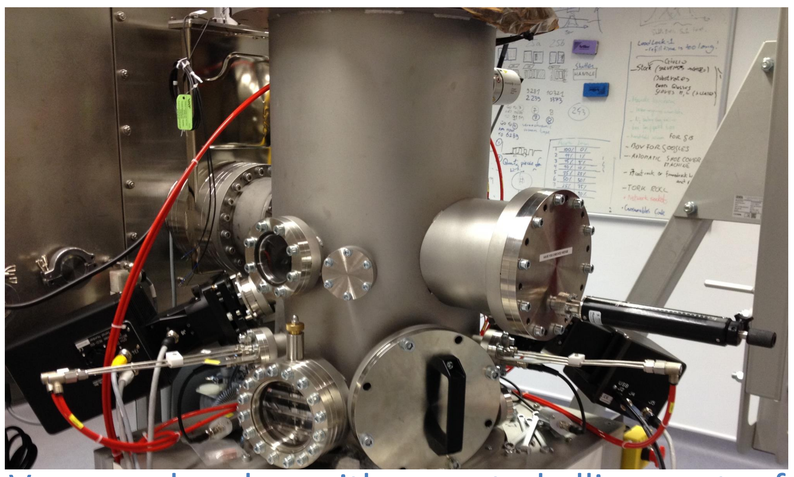
(Phase change materials)

Multilayer Organic Solar Cell



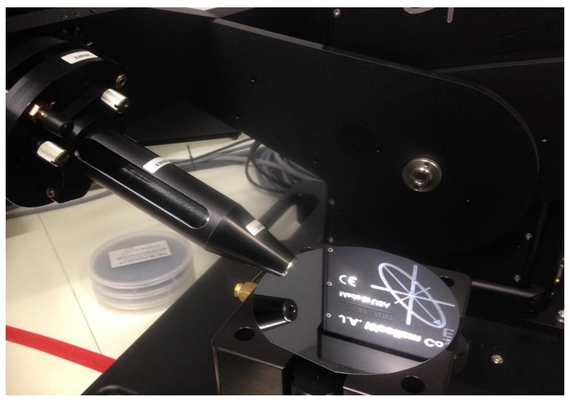
Cascade Structure [5]

In situ Spectroscopic Ellipsometry



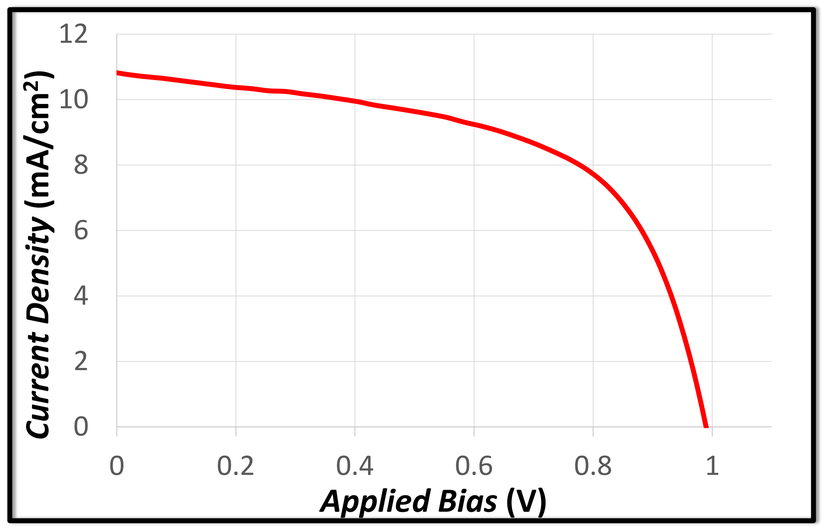
Vacuum chamber with mounted ellipsometer for ***in situ*** monitoring

Ex situ characterization



Combined with extensive ***ex situ*** characterization

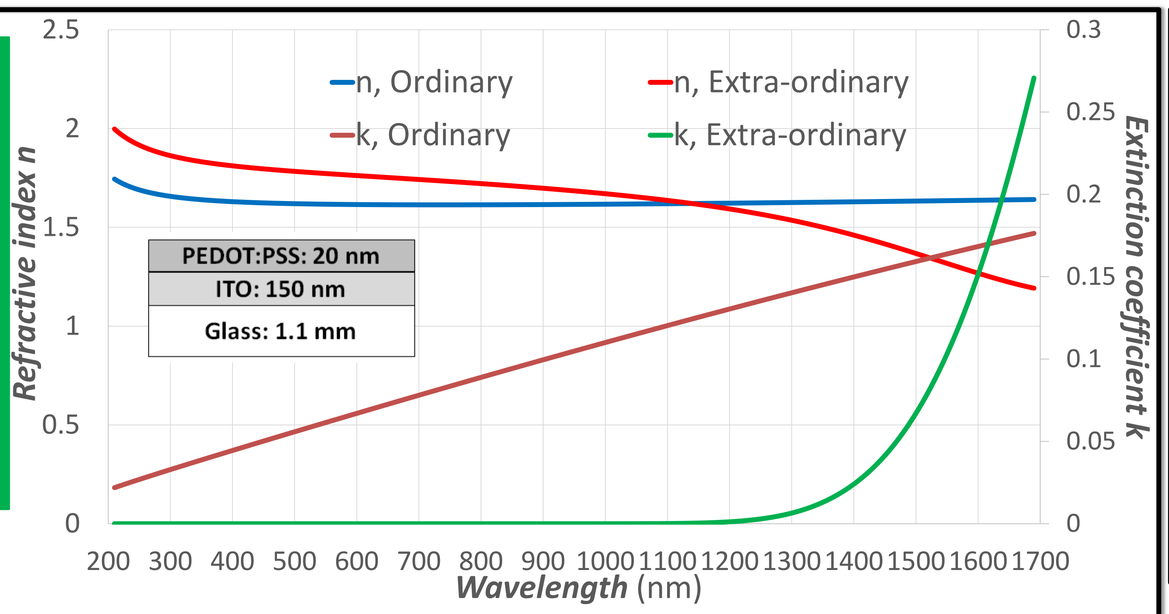
Device Characteristics



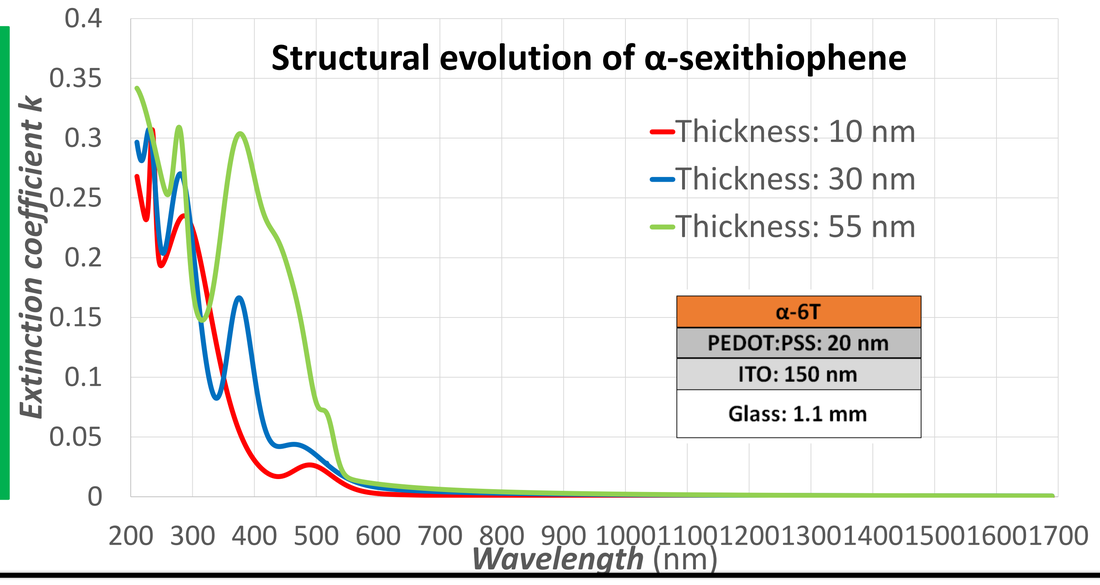
Power conversion efficiency, η: **6.2 %**

Ex situ and *In situ* Measurements, Development of Dielectric Function Models, *In situ* Monitoring

Substrate



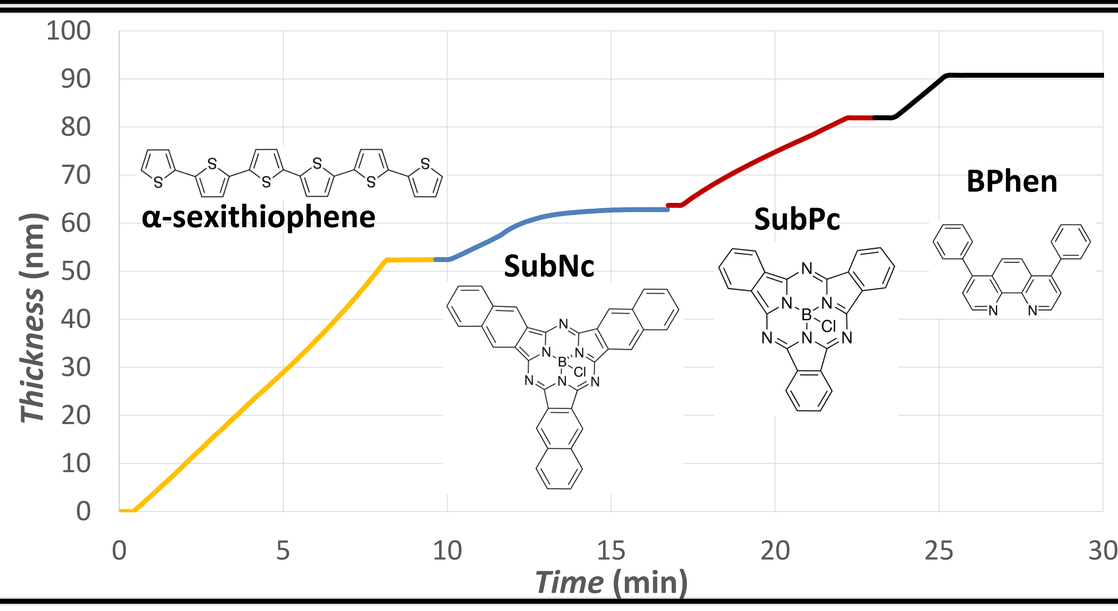
Functional Layer



Dielectric Models

- ❑ Total number of parameters defining the dielectric functions of all the six layers on glass in the spectral range **210 nm – 1700 nm ~ 170**
- ❑ Number of Oscillators defining dielectric functions of
  - α-sexithiophene: **13** Gaussian
  - SubNc: **6** Gaussian, **2** Lorentz, **3** Tauc-Lorentz
  - SubPc: **3** Gaussian, **3** Lorentz, **2** Tauc-Lorentz
- ❑ Dielectric function of BPhen was modelled using Cauchy function
- ❑ Thus, considering the complexity of the stack, ***in situ*** **monitoring** was carried out by analysing real-time data in the transparent region (**700 nm – 1700 nm**) using a maximum of **5** parameters for fitting

In situ monitoring



Future Objectives

- *In situ* monitoring on a flexible substrate
- Deliverable 1.1.2: measurements of atleast 6 organic layers deposited on top of each other
- Extend the methodology to also monitor the quality of the films in real-time through refractive index determination in the absorbing region
- Replace PEDOT:PSS with a vacuum-deposited material for the hole transport layer

Other Materials

Other materials characterized using SE

- Metal oxides
- Perovskite single crystals
- Polymer thin films

References

1. Report on Asana
2. *www.phys.org*
3. Hosseini *et al*., *Nature* 2014, 511, 206-211
4. Wang *et al., Nano Letters* 2012, 12(3), 1527-1533
5. Cnops *et al., Nature Communications* 2014, 5:3406

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