Shining a Light on New Solar Cell Materials

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The Goal

In theory, sufficient energy reaches the earth's surface from the sun to meet all of our foreseeable energy needs in a sustainable manner. In practice, for photovoltaic power to make a significant contribution to total energy demands we need technology that can be manufactured using processes that are:

- Continous (large scale)
- Environmentally friendly
- Low cost
- Energy efficient (i.e. low temperature)

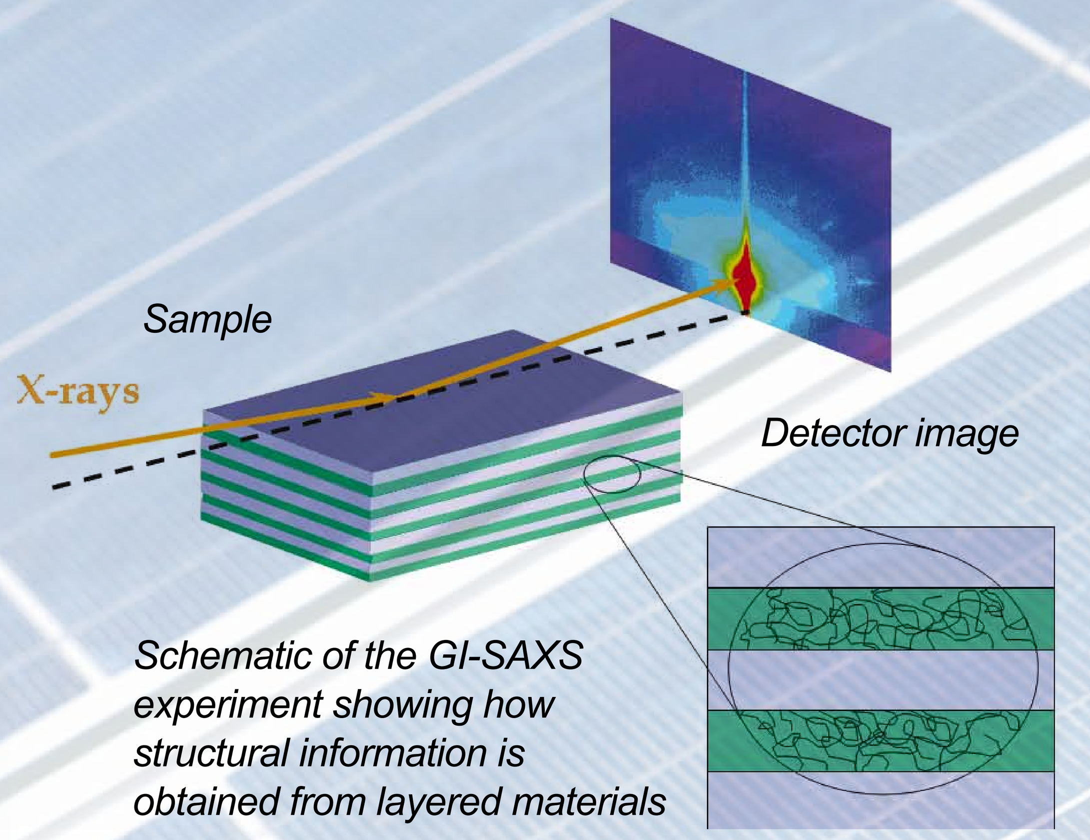
An organic photovoltaic solar cell

The Challenge

One new class of photovoltaics is based on blends of semi-conducting polymers. As the polymers are coated onto the flexible substrates, the molecules self-assemble to form a complex composite material. The performance of the polymer photovoltaic films is very sensitive to their nanoscale morphology. Understanding the influence of different processing conditions on the nanoscale structure of these polymer films is key to the design and optimisation of the next generation of efficient and environmentally friendly solar technology.

The Approach

Grazing incidence small angle X-ray scattering (GI-SAXS) probes the nanoscale structure of thin films and is ideally suited to the investigation of changes in the film morphology during processing. We are developing the GI-SAXS technique for use on beamline I22 at the Diamond Light Source. Diamond is the UK's new synchrotron radiation source; the largest new scientific facility built in the UK for over 40 years. The high brilliance of I22 allows reliable access to millisecond and shorter timescales to allow in situ real time examination of the nanoscale structure of materials under the relevant environmental conditions.



Schematic of the GI-SAXS experiment showing how structural information is obtained from layered materials

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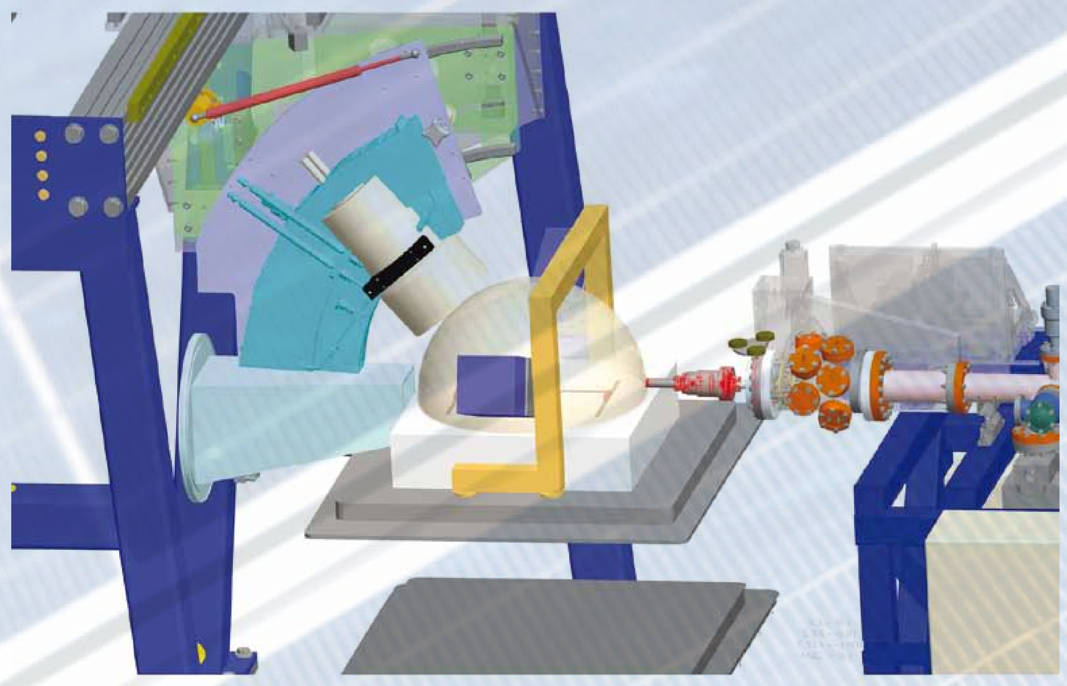
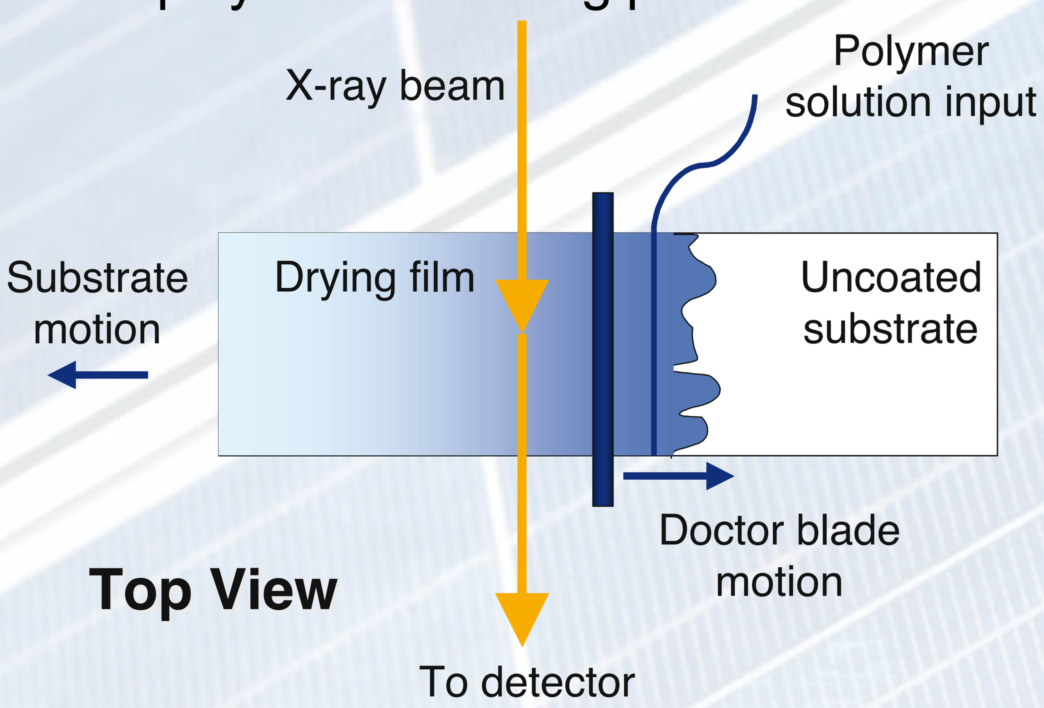
Side view of experiment



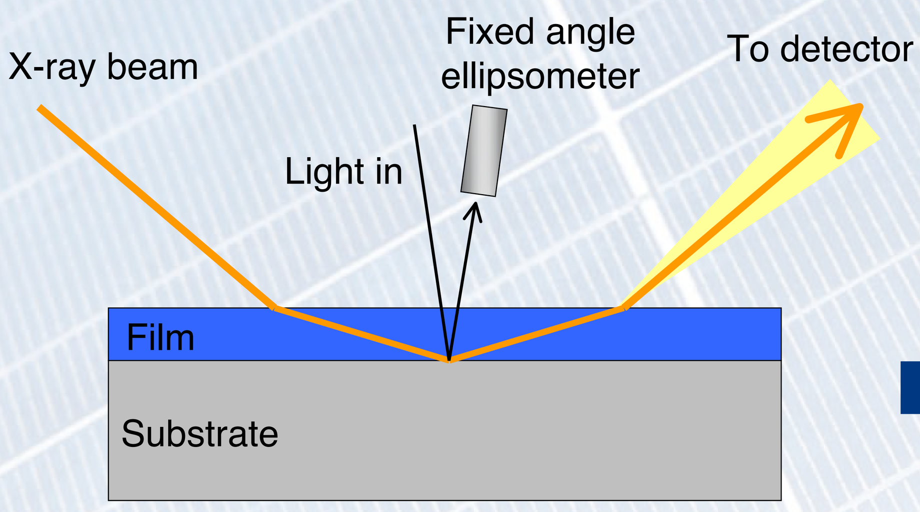
New infrastructure has been developed to allow simultaneous recording of both small and wide angle X-ray scattering under the grazing incidence geometry (GI-SAXS and GI-WAXS) in combination allowing us to probe length scales ranging from a few Angstroms to up to one micron with high resolution.

The Results

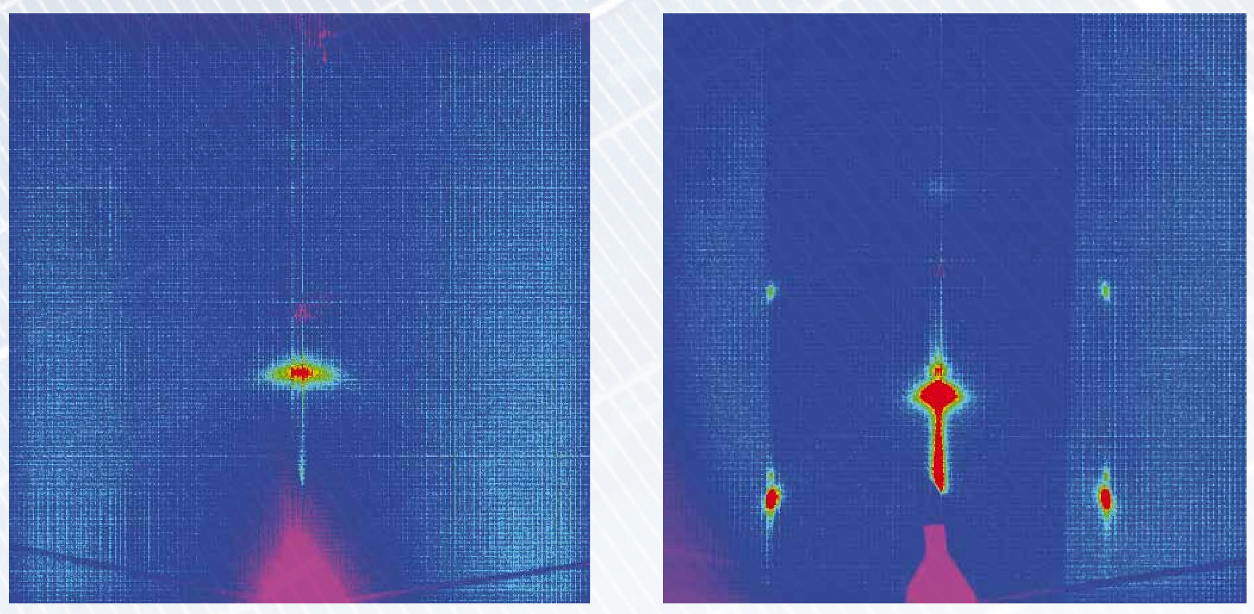
During the experiment, the substrate is evenly coated with the polymer solution and allowed to dry. We use X-ray detector images (right) to monitor the in situ growth and self-assembly processes in real time. Detailed analysis of the images helps us characterise the complex changes in the morphology of the polymer film during process.



Top View



Side View



The images shown above were obtained during the process of coating an organic photovoltaic polymer film onto a silicon substrate using the GI-SAXS technique on I22. This first GI-SAXS experiment on I22 took place in February 2010; the results have not yet been fully analysed.

Acknowledgements

Thanks are due to all involved in the UKOPV collaboration which is supported by a grant from EPRSC.

- University of Sheffield: Prof. D. Lidzey, Prof. R. Jones, Prof. A. Ryan, Dr. A. Dunbar, Dr. P. Staniec, Dr. T. Wang, Dr. R. France, A. Pearson and S. Butler
- University of Cambridge: Prof. A. Donald, P. Hopkinson
- Cardiff University: Dr J.E. Macdonald, S. Lilliu
- Diamond: A. Marshall, A. Day and L. Davidson

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