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ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

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Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

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All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Dielectric-semiconductor interface structure for n-type polymer transistors	**Experiment number**: 28-01-712
Beamline: BM28	**Date of experiment**: from: 28 Sept 2005 to: 4 Oct 2005	**Date of report**: 23 Nov 2006
Shifts: 18	**Local contact(s)**: Dr. Danny MANNIX	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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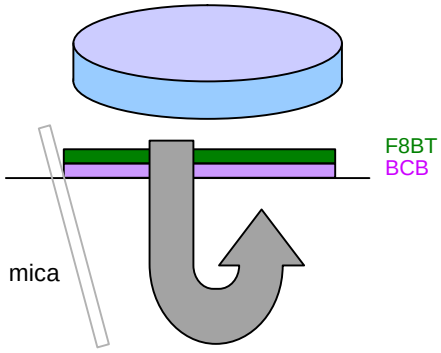
Report:

One of the major obstacles in conjugated polymer electronics over the last decade or so has been the difficulty of obtaining n-type conduction in field-effect transistor (FET) structures, n-type behaviour being limited to a small number of materials. It has been widely accepted that electron mobilities are typically a factor of 10-100 lower than the corresponding hole mobilities. Sirringhaus' group has demonstrated that this widely observed pattern is *not* intrinsic to the conjugated polymers, but is rather the result of trapping of electrons at the semiconductor–dielectric interface by hydroxyl groups, present in the form of silanols in the commonly used SiO_2 dielectric [1]. The authors demonstrate n-type behaviour in a wide range of conjugated polymer FET structures using a hydroxyl-free divinyltetramethylsiloxane-bis(benzocyclobutene) derivative (BCB) gate dielectric. The central aim of this experiment was to investigate the structure at the interface between the BCB gate dielectric and the semiconducting polymer channel poly(9,9-di- n-octylfluorene- alt-benzothiadiazole) (F8BT).

As-prepared samples are not suitable for the grazing-incidence diffraction experiments as the BCB dielectric is deposited onto silicon and is cross-linked by rapid thermal annealing at 290°C for 15 seconds prior to spin-coating of the semiconducting polymer. However, the electron density of the upper semiconductor layer is larger than that of the BCB, thus precluding depth-dependent studies of the buried interface. This was solved by preparing the BCB/F8BT structure on a mica substrate and then gently translating the mica downwards, at a shallow angle, through the surface of clean deionised water to float the polymer layers onto



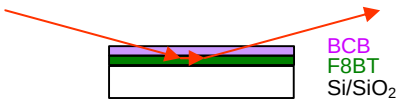


Fig. 1 (a) Depositing the bilayer onto silicon by flotation from a mica substrate (b) Diffraction from the interface for α_c (BCB) < α_c (F8BT)

the water surface. These were then transferred onto a Si/SiO_2 substrate by bringing the substrate vertically downward onto the floating film giving a Si / SiO_2 / 50nm F8BT / 30nm BCB structure (fig. 1).

Depth-resolved diffraction was performed by taking area detector images for a range of incident angles α covering the three critical angles for BCB, F8BT and SiO_2. Fig. 2 shows the diffraction pattern from a sample annealed at 300°C followed by a slow cool to 200°C and sections through the images for a range of critical angles. The F8BT peaks can be seen to develop with increasing α. Sharp peaks from mica are also observed from the surface, whose integrated intensity is significantly weaker than for the F8BT. The sharpness of these mica peaks indicate that there are very small localised traces of mica on the BCB surface arising from the flotation process, which could not be seen visually and that were not detected in AFM scans. The F8BT peaks do not correspond to the only reported unit cell parameters for crystalline F8BT (monoclinic cell with a = 14.65 Å, b = 5.3 Å, c = 16.7 Å, c-axis at 98° to the a-b plane [2]). Our peaks indicate a c-axis which is a factor of 2 greater than this published value and a different crystalline arrangement in our samples. Refraction from the buried F8BT-BCB interface could not be clearly observed, indicating a rather diffuse interface. Reflectivity scans to probe the diffuseness of the interface were inconclusive, fitting being complicated by the mica traces on the top surface. As a result it was difficult to draw definitive conclusions regarding the gate dielectric-semiconductor interface from this challenging experiment.

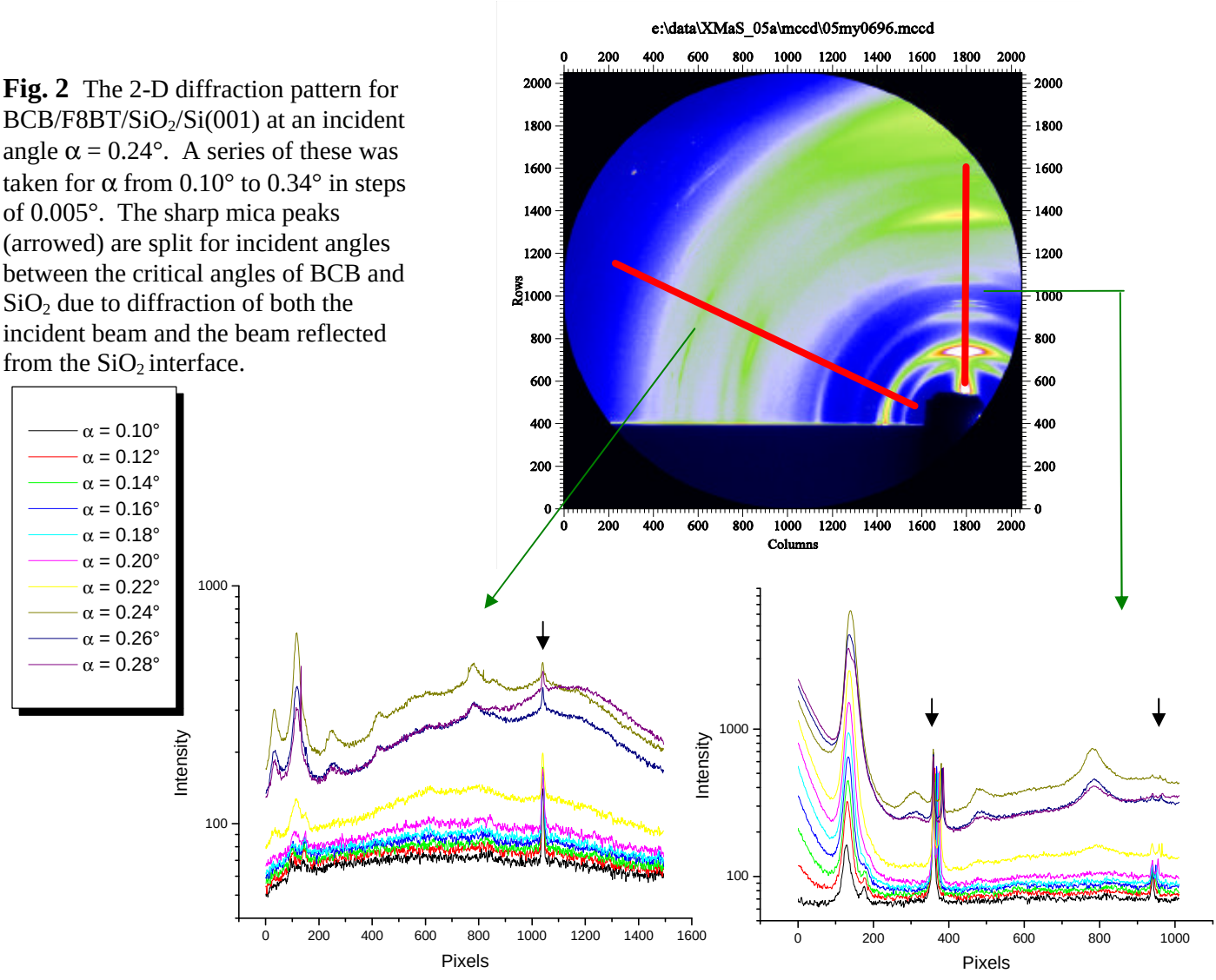


Fig. 2 The 2-D diffraction pattern for BCB/F8BT/SiO_2/Si(001) at an incident angle α = 0.24°. A series of these was taken for α from 0.10° to 0.34° in steps of 0.005°. The sharp mica peaks (arrowed) are split for incident angles between the critical angles of BCB and SiO_2 due to diffraction of both the incident beam and the beam reflected from the SiO_2 interface.

References

[1] L-L Chua, J Zaumseil, J-F Chang, E C-W Ou, P K-H Ho, H Sirringhaus and R H Friend, Nature 434 (2005) 194-199

[2] C.L. Donley et al, J Am Chem Soc 125 (2005) 12890-12899