Morphology of fullerene-free bulk heterojunction blends for photovoltaic applications

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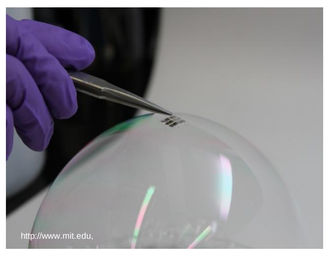
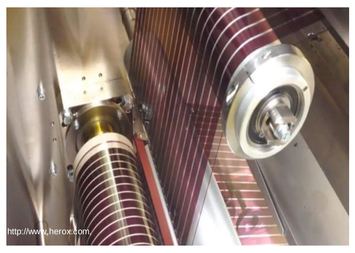
1. Motivation

Advantages of organic solar cells

- flexibility
- transparency
- cost-efficiency
- versatility
- light weight

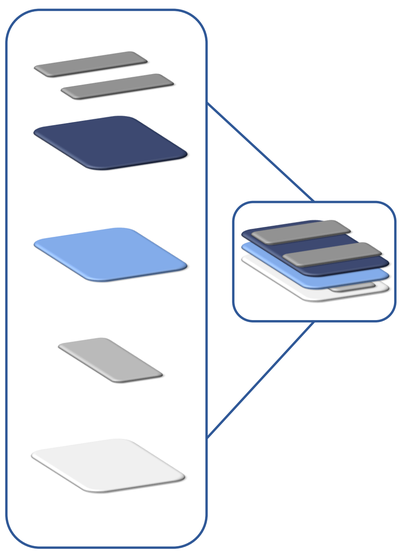




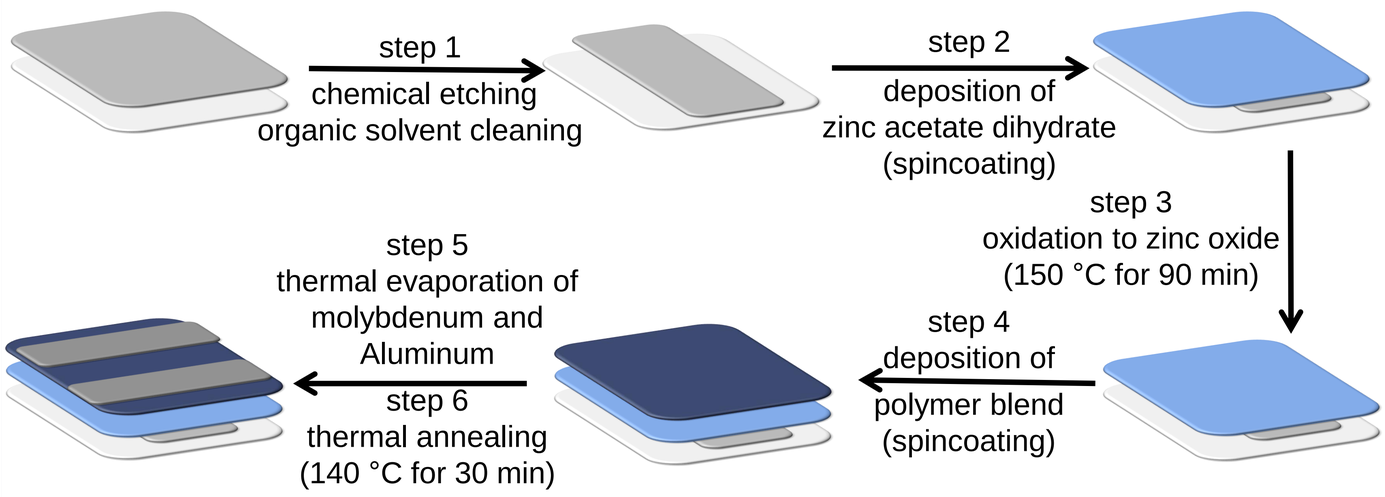
2. Introduction

Schematic structure of a organic solar cell

- back electrodes:
  molybdenum oxide and aluminium
- active layer: bulk hetero junction
  PBDB-T (poly[(2,6-(4,8-bis(5-(2-ethylhexyl)thiophen-2-yl)-benzo[1,2-b:4,5-b']dithiophene))-alt-(5,5-(1',3'-di-2-thienyl-5',7'-bis(2-ethylhexyl)benzo[1',2'-c:4',5'-c']dithiophene-4,8-dione)])
  ITIC (3,9-bis(2-methylene-(3-(1,1-dicyanomethylene)-indanone))-5,5,11,11-tetrakis(4-hexylphenyl)-dithieno[2,3-d:2',3'-d']-s-indaceno[1,2-b:5,6-b']dithiophene)
- electron blocking layer:
  zinc oxide
- bottom electrode:
  indium tin oxide (ITO) layer
- glass substrate



3. Sample preparation

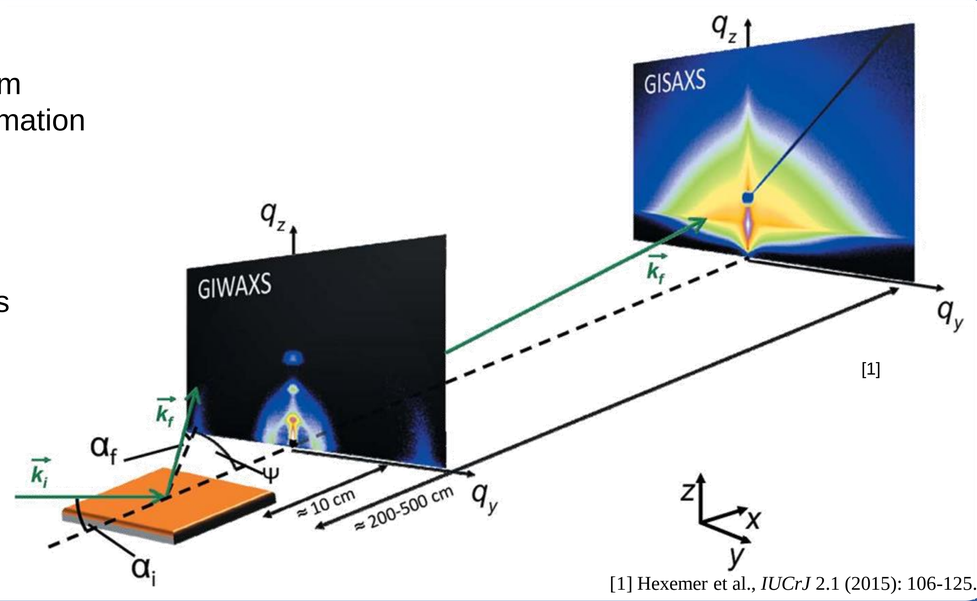


4. Grazing Incidence X-ray Scattering

GIWAXS
- length scales 0.1-1 nm
- crystallographic information (phase, orientation)

GISAXS
- length scales < 1 µm
- (crystal) domain sizes

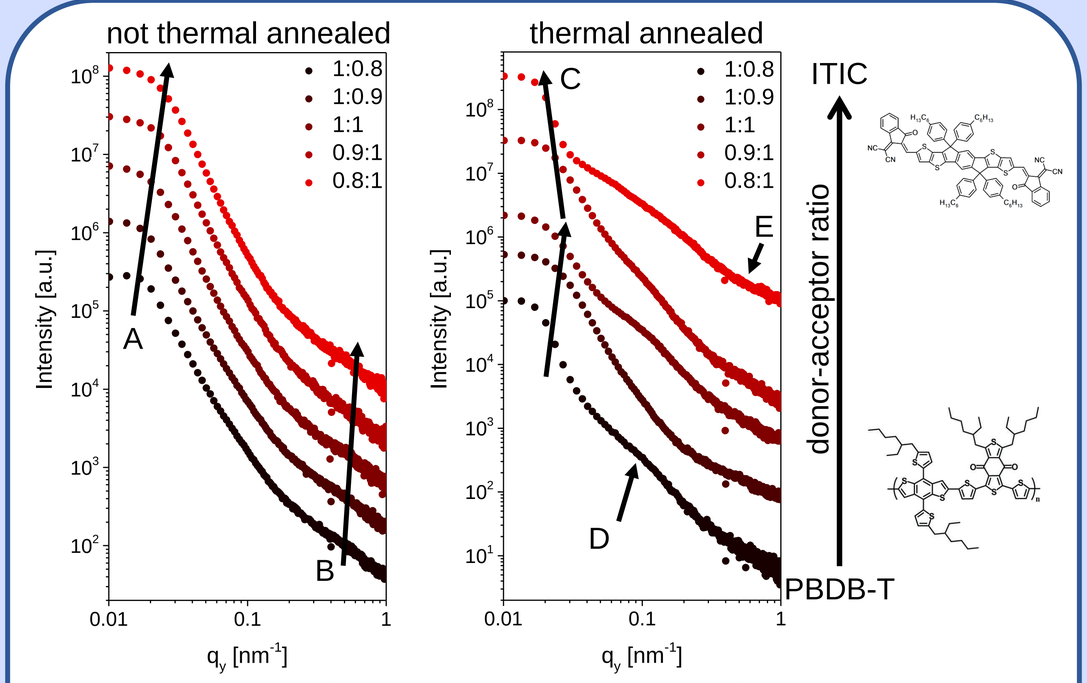
Advantages
- non-destructive
- large sample volume
- good statistics



[1]

[1] Hexemer et al., *IUCrJ* 2.1 (2015): 106-125.

5. Investigation on PBDB-T:ITIC ratios



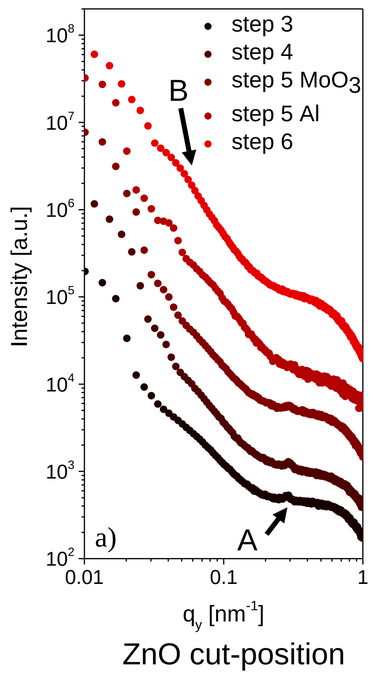
not thermal annealed:
two structures observable

- structure A:
  appearance of large domains
- structure B:
  increasing number of small domains

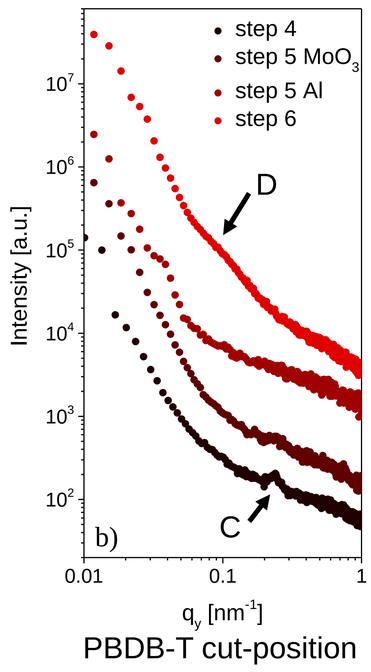
thermal annealed:

- structure C:
  initial formation of large domains
  growth with increasing acceptor content
- structure D:
  constant domain size app. 30 nm
- structure E:
  domain sizes app. 12 nm

6. Investigation on functional solar cell stacking



ZnO cut-position



PBDB-T cut-position

horizontal line cut at
the Yoneda peak position of
zinc oxide (a)) and PBDB-T (b))
for the following stacking

ZnO position:

- structure A:
  decrease number of small domains
- structure B:
  growth of larger domain sizes

PBDB-T position:

- structure C:
  small domain sizes related to ZnO sublayer
- structure D:
  thermal induced domain growth

influnence of the solar cell stacking on the different components observable

7. Outlook

- evaluation of the domain sizes and size distribution
- further investigations on crystallinity with GIWAXS
- investigation on the influence of polymere ratios on photoelectric properties
- investigation of the correlation between inner morphology and photoelectric properties

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