Processing of nanoparticle polymer mixtures for organic photovoltaic films:

Introduction

Organic- and hybrid solar cells

Cost efficient: Low energy consumption for raw materials
Roll to roll production
Low thickness
Flexible, lightweight, good utilization of diffuse light
Design: Transparency, color, form
Solvent based deposition, roll to roll process

Motivation

Processing strongly influences morphology and device performance
State of the art: power conversion efficiency:
Lab scale: ~7% (Organic solar cells)
Pilot scale: ~2% (Organic solar cells)
Lab scale spin coating does not allow independent process control
Investigation of the processing of functional films

Processing

Development of coating tools

- Roll to roll compatible coating tools for organic electronic are necessary
- Slot die coating and gravure printing show highest potential
- Material prices are still high thus reduction hold up is essential
- Lab scale slot die coater with holdup of ~2 ml for wet film thicknesses >5 µm

Drying of organic electronic films

- Drying determines cell efficiency
- Experimental setup enables controlled drying with in-situ film thickness measurement
- In-situ GIXRD is possible
- Local transfer coefficients and drier optimization are investigated (separate poster)
- Independent variation of drying conditions

Characterization

Morphology characterization

- Microscopic characterization of Baydots® (5nm diameter) / P3HT films.
- (A) TEM low particle concentration: shows the agglomeration of individual nanoparticles at low particle concentration.
- (B) TEM high particle concentration: displays the particle distribution in a film with realistic Baydots®-concentration.
- (C) AFM high particle concentration: shows no pinholes, AFM pictures are related to domain size.
- (D) Light microscope reveals thickness variations in the mm range at realistic particle concentration.

Electro-optical characterization

- Absorption increases with decreased drying speed and annealing time and temperature. This is caused by further crystallization of the polymer.
- Voltage-current plots show the behavior of the solar cell. Short current density and Efficiency are a function of the drying conditions.
- Hybrid solar cells have been produced with a roll to roll compatible method yielding efficiencies of up to 1.18%.
- No difference between spin coating and doctor blading

Summary

- A slot die coater for organic electronic films has been developed and successfully tested
- Experimental setup allows independent variation process parameters.
- A coating and drying plant enables investigation on pilot scale
- Drying kinetics determines film morphology, film properties and cell efficiency
- Hybrid solar cells have been produced with roll to roll compatible method yielding 1.2% efficiency

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