MEng project CHESS-10: Slot-Die Coating – Film Morphology Formation versus Coating Speed

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Future use of organic electronics and self-assembled nanostructures relies on the development of suitable coating techniques. Essential for the performance of devices such as organic transistors, solar cells or light-emitting devices are the *morphology, texture, and grain boundaries* which determine the charge transport in organic thin film. In this project we would like to explore, how morphology, texture, and grain boundaries are related to the specific coating conditions such as coating speed, gap, and temperature as well as solute concentration.

We have recently developed a miniature knife coater, in order to study deposition and drying processes for organic transistor materials in-situ and in real time [1]. We have observed a strong dependence of the film morphology on the coating speed and gap. Now we would like to compare the morphologies obtained in slot-die coating to those in knife coating. Slot-die coating is considered the most advanced method for the deposition of functional nanomaterials. In slot-die coating a premetered amount of solution of the functional material is deposited on a “web” which can be a polymer foil or a glass slide. The difference between slot-die coating and the simpler knife coating technique is that the amount of material deposited per area is exactly known – an important consideration for industry, when working with designer molecules at a typical cost of $1,000 per gram.

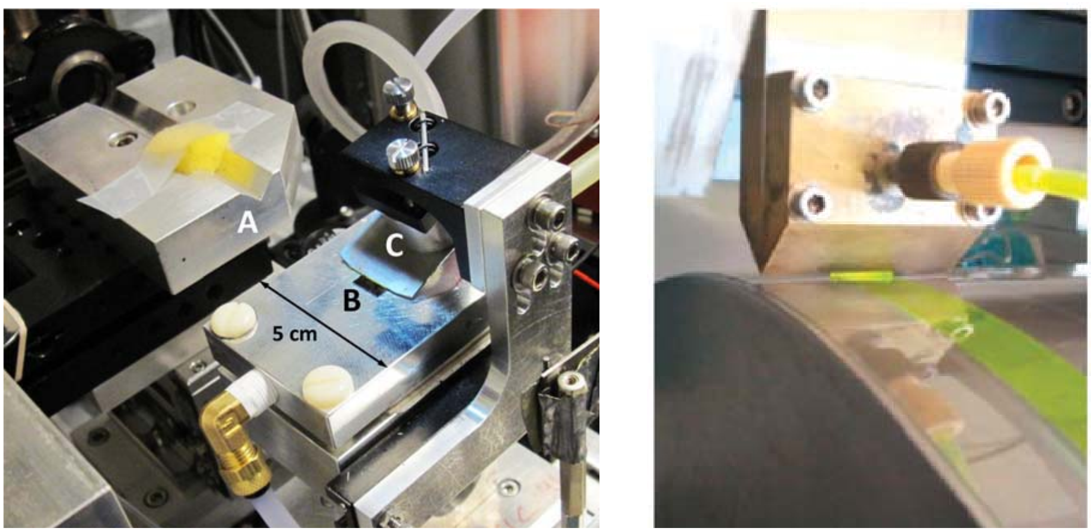

Figure 1. Left: CHESS in-situ knife coating set-up (A microbeam optics, B substrate, C coating knife). Right: slot-die coater in operation [2] – a similar head is used in the new CHESS slot-die coater.

In this exploratory project we will start by working with affordable model molecules such as anthracene or perylene. The glass substrates need to be functionalized with phenyl groups, in order to ensure an even coverage of the molecular film and to avoid dewetting. Basic chemistry skills are required for making and handling of solutions and functionalization. Some familiarity with microfluidics equipment such as syringe pumps and tubing will be useful. Initial experiments will be performed in the Sample Environment Lab at CHESS. Goal is to establish good coating parameters and obtaining optical microscopy images similar to those shown below.

Depending on the CHESS Run Schedule the candidate will also be invited to participate in in-situ x-ray scattering experiments.

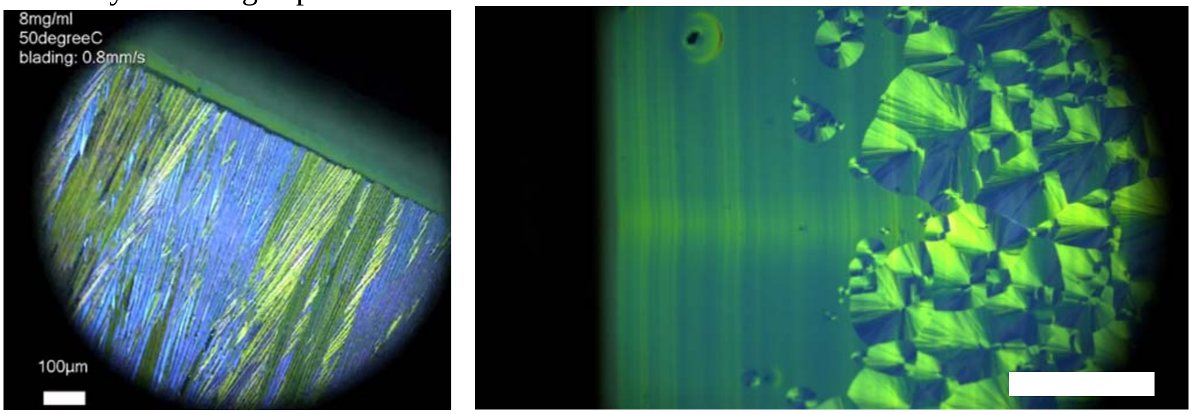

Figure 2. Left: Ribbon-like crystallites growing at low coating speed (<1mm/s), as seen in high-speed optical microscopy; right: spherulite formation at high coating speed – also see the movies in the supplement of reference [3].

Design Project: 3 or 6 credits for a duration of 1 or 2 semesters
Sponsored by
Dr. Detlef Smilgies CHESS Staff Scientist and Adjunct Associate Professor of Chemical Engineering
Dr. Ruipeng Li, CHESS Postdoctoral Fellow

Suggested reading
[1] Detlef-M. Smilgies et al.: "Look fast: Crystallization of conjugated molecules during solution shearing probed in-situ and in real time by X-ray scattering", Phys. Status Solidi - Rapid Research Letter 2013, 7, 177-179.
[2] Andreas Sandström et al.: " Ambient fabrication of flexible and large-area organic light-emitting devices using slot-die coating”, Nature Comm. 2012, 3, 1002.
[3] Gaurav Giri et al., "One-dimensional self-confinement promotes polymorph selection in large-area organic semiconductor thin films", Nature Communications 5, 3573 (2014).