

Investigation of the Interdiffusion Behavior in Multilayers for Organic Electronics

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Extended Abstract:

Wet film deposition is a highly attractive method for the manufacturing of organic electronics like organic photovoltaics (OPV) or organic light-emitting diodes (OLEDs) that has many advantages over state-of-the-art thermal evaporation. Energy-efficient solution-based fabrication methods like slot die coating are superior regarding low material loss and the opportunity to use small molecules and polymers. OLEDs consist of several 10 – 100 nm thin layers with different functionalities like hole injection or electron transport to maximize recombination in the emissive layer. For solution-processed OLEDs, the big challenge is realizing the required multilayer architecture to obtain highly efficient and long-life devices. Therefore, it is crucial to apply homogeneous nanolayers with precise thickness and defined interfaces. In order to avoid undesired inhomogeneities caused by dewetting effects or crystallisation, the influence of fluid formulation, coating parameters and subsequent drying conditions has to be considered. The second focus is the prevention of intermixing of the different layers as this would negatively influence the charge transport. The slot die coating process of multilayer OLEDs and its challenges is shown in figure 1a. In this work, slot die coating for solution-processing of a multilayer OLED stack with up to four functional layers is investigated (figure 1b). The focus is on the suitability of different concepts to obtain separated multilayers like the orthogonal solvent approach or the use of crosslinking material. Small molecule OLEDs (SMOLEDs) with different multilayer architectures were produced and device efficiencies were

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compared, since an increase in efficiency for more complex architectures means separate layers have successfully been produced.

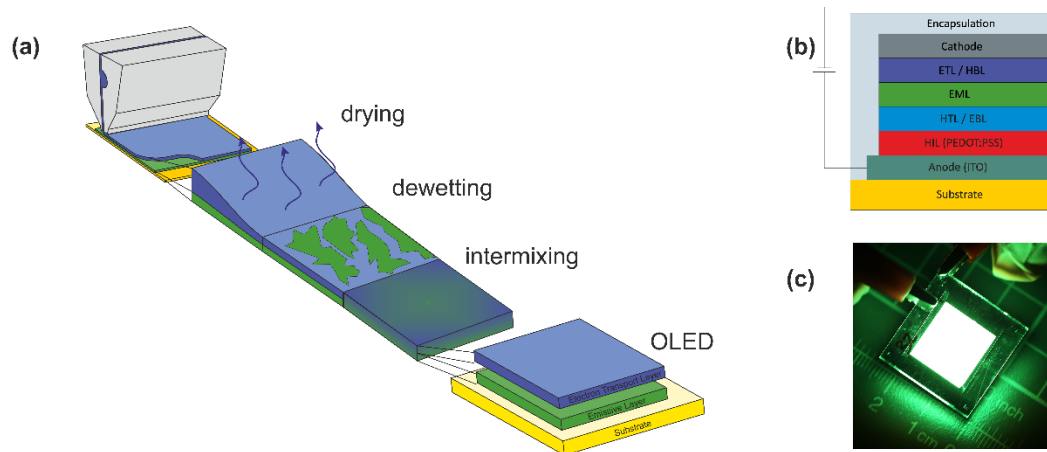


Figure 1: (a) Slot die coating process and its challenges for the manufacturing of multilayer OLEDs. (b) Stack of the investigated OLEDs consisting of four slot die coated layers. (c) SMOLED during light extraction.

Understanding and predicting the intermixing of multilayer systems is also of fundamental importance for many applications beyond organic electronics. Therefore, a model was developed to describe the intermixing behavior of organic double layers in presence of a solvent. The model was validated with Raman spectroscopy experiments of different polymer-polymer-solvent systems in the micrometer range. The bottom layer consisted of a first polymer film and as top layer a wet film consisting of a second polymer and solvent was used. The double layer was sealed to prevent solvent evaporation and thus ensure a constant solvent content (figure 2a). The concentration profiles of the components were measured at different times with Raman spectroscopy. Thereby, the influence of solvent content and molar weight of the polymers on the intermixing behavior of the three components was studied. Figure 2b clearly shows that the intermixing zone strongly widens with increasing solvent content for the miscible PVAc-PMMA-Toluene system. A 10 μm wide intermixing zone is reached after 30 hours with a double layer containing 35% toluene while a double layer with 10% more solvent achieves the same intermixing zone after just 10 minutes. The model was verified by double layer experiments on the micrometer scale and can be used for simulations on the nanometer scale.

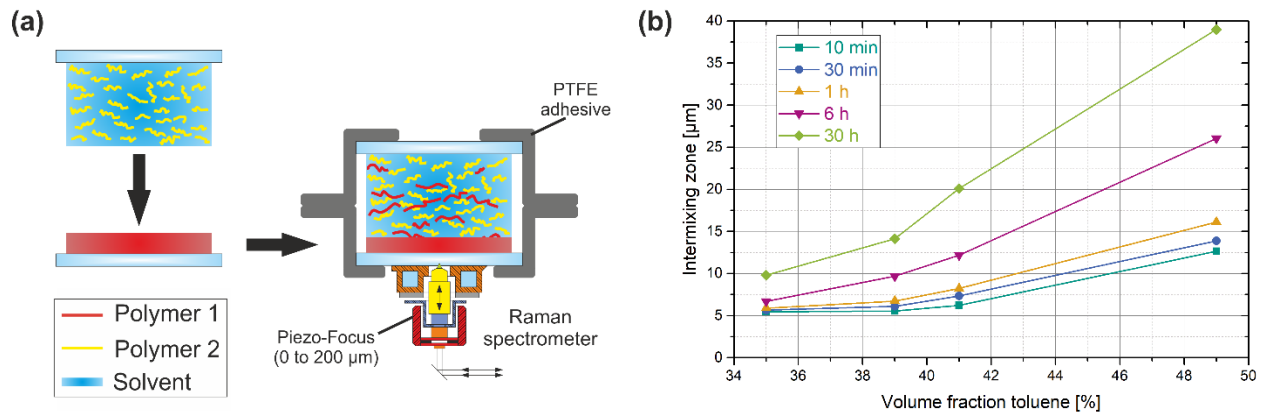


Figure 2: (a) Schematic procedure for measuring interdiffusion of double layers consisting of a dry polymer1 layer and a wet polymer2-solvent layer with Raman spectroscopy. (b) Influence of the solvent content on the width of the intermixing zone at different times for the miscible PVAc-PMMA-toluene system [1].

References

- [1] S. M. Raupp, D. K. Siebel, P. G. Kitz, P. Scharfer und W. Schabel, „Interdiffusion in Polymeric Multilayer Systems Studied by Inverse,“ *Macromolecules*, 2017.

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