Inkjet printing of thin film libraries of PPV's

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Introduction

Microdrop Autodrop piezoelectric inkjet printer

AD-K-501 Micropipette

MD-K-130 Dispenser Head

The Microdrop Autodrop consists of an XYZ-stage on which a holder is mounted for up to 8 print heads. The stage has a positioning accuracy of 3 µm. Liquids with viscosities between 0.5 and 20 mPas can be dispensed using micropipettes and print heads. The micropipette can aspirate small quantities of fluid (25 µL) from a 96-well microtiter plate and can subsequently dispense them at any desired place *e.g.* on glass plates, silicon wafers, polycarbonate, a second microtiter plate. Dispensers have their own reservoir (4 mL) and they are used when the solutions are not changed frequently. The droplet diameter is approximately equal to the pipette diameter, *i.e.* 70 µm, which corresponds to 180 pL volume.

Inkjet printing technology is applied to deposit small quantities of functional materials with specific electrical, optical, chemical, biological or structural functionalities onto well-defined locations on a substrate. In many cases, these materials are processed from a liquid solution or dispersion. Therefore, inkjet printing is becoming a more attractive technique for many applications: fabrication of electronic circuits, LED's, biochips, to name only a few.[1] Moreover, it can be considered as a library preparation technique for functional polymers or nanoparticles allowing a systematic variation of parameters (*e.g.* thickness or chemical composition) for combinatorial studies.[2,3]

Well-defined and flat thin films of MEH-PPV for potential device applications, *e.g.* as polymer field effect transistors were obtained by patterning the solutions using inkjet printing The effects of interchain interactions of MEH-PPV in different organic solvents on the processibility, film formation and electrical characteristics were investigated.[4] PPE-PPVs (polyphenylene ethylene-polyphenylene vinylene) with different alkoxy side chains are attractive materials since they have a relatively low band gap and tunable emission color.[5] Printing of PPE-PPV's was performed and their thin film properties were investigated.

Selected stroboscopic camera images of ejected droplets of MEH-PPV solutions (2.5 mg/mL) from different solvents: **a)** *o*-xylene, **b)** chlorobenzene, **c)** THF.

Printing of MEH-PPV Lines and Films

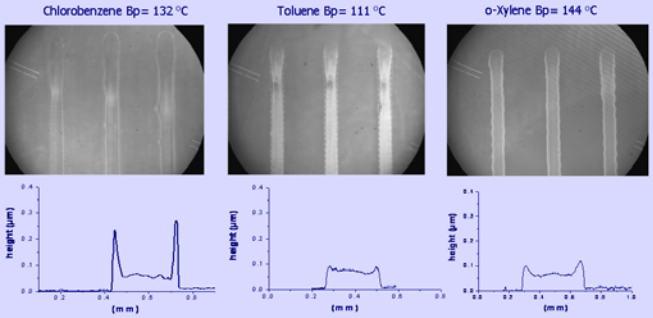
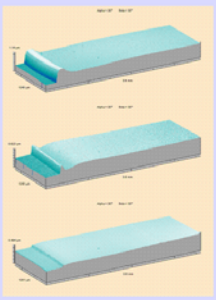
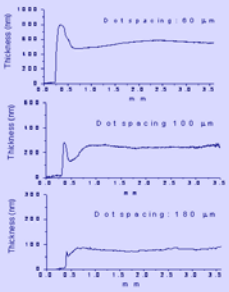


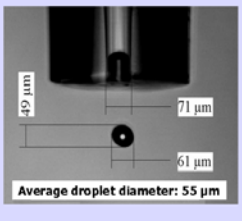
Figure 1. Top: Microscope images of MEH-PPV lines printed from different solvents. Bottom: Corresponding cross-sections, which were obtained utilizing an optical profilometer. The results illustrate that the optimal topographies were obtained from toluene and o-xylene, suppressing the ring formation effect. This effect was explained by the increased inter-chain interactions in these non-polar aromatic solvents. [4]

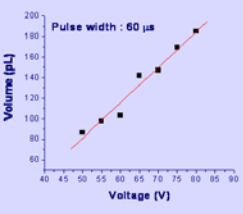




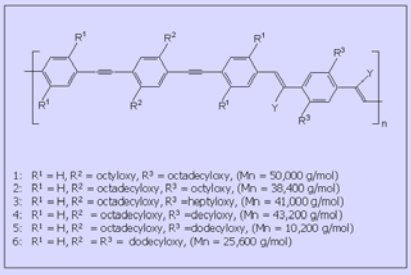
A printed rectangular film can be defined by the number of droplets in the X- and Y-directions, and the spacing between each droplet (dot spacing) . Films can be printed by reducing the spacing between the droplets, so that they merge on the surface. When we decrease the dot spacing *(Δr)*, the film thickness *(h)* should increase as the amount of deposited droplets will be increased. Therefore, to obtain thickness libraries, the arrays in each row of the library were printed with varied dot spacing from 60 to 180 µm which yields thickness variation approximately from 600 nm to 80 nm.

The volume of an ejected droplet depends on the nozzle diameter and the voltage applied to the piezo element. The graph illustrates that the volume of a droplet significantly increases with an increase of the applied voltage. The duration of voltage (pulse width) has no effect on droplet volume.



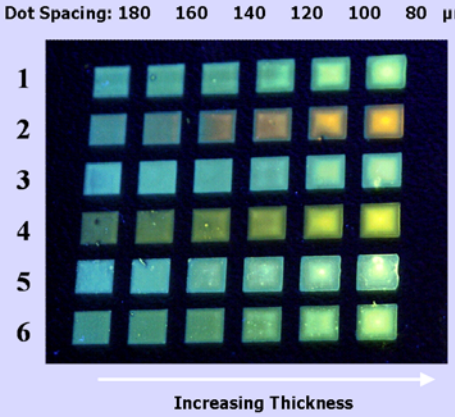


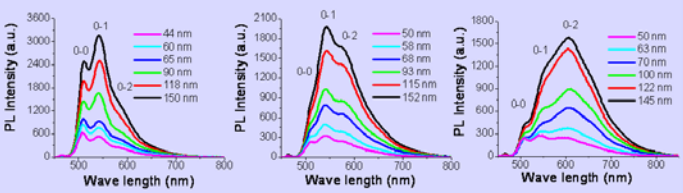
Printing of Libraries of PPE-PPV's



1: R¹ = H, R² = octyloxy, R³ = octadecyloxy, (Mn = 50,000 g/mol)
2: R¹ = H, R² = octadecyloxy, R³ = octyloxy, (Mn = 38,400 g/mol)
3: R¹ = H, R² = octadecyloxy, R³ =heptyloxy, (Mn = 41,000 g/mol)
4: R¹ = H, R² = octadecyloxy, R³ =decyloxy, (Mn = 43,200 g/mol)
5: R¹ = H, R² = octadecyloxy, R³ =dodecyloxy, (Mn = 10,200 g/mol)
6: R¹ = H, R² = R³ = dodecyloxy, (Mn = 25,600 g/mol)

A series of PPE-PPV's were synthesized, whose side chains were varied to give different emission colors. These were inkjet printed using a toluene/o-dichlorobenzene solvent mixture on glass substrates at room temperature to form thin film librairies. The aim of this project was to investigate ink formulations, different substrates as well as to optimize the printing conditions to obtain homogeneous and reproducible polymer films and finally to screen their optical properties.





The optical properties of the luminescent films were rapidly screened utilizing an UV/fluorescence plate reader. We studied the combinatorial effects of side chains and film thickness on the absorption and emission behaviors of six alkoxy-substituted PPE-PPVs that are shown above. There is a clear increase in the intensity of 0-2 transitional with increasing thickness, especially in the case of polymer **2** which is due to the superposition of the 0-2 vibrational transition with an excimer emission.

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