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Improved the uniformity of the inkjet-printed polymer film in the bank by Marangoni Flow and Contact Line Sliding

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Supporting information

Figure S1. The 3d optical profile of the patterned bank.

Figure S2. Inkjetted drop formation of (a) TOL/1-CN (b) TOL/CHB (c) TOL/BB (insets show transient behavior of the drops).

Figure S3. The contact angle of drops on the plasma etched ITO/ PEDOT:PSS substrate and the drying process.

Figure S4. The contact angle of drops on the plasma etched ITO/ photoresist substrate and the drying process.

Figure S5. Time evolution of the droplet surface profile in the bank.

Figure S6. Film profiles of different inks dried in vacuum and air.

Table S1. Printed voltage, pulse length, pressure, velocity and diameter of the different ink.

Table S2. The empirical constants number and the calculated saturation vapor pressures of TOL, 1-CN, CHB and BB.

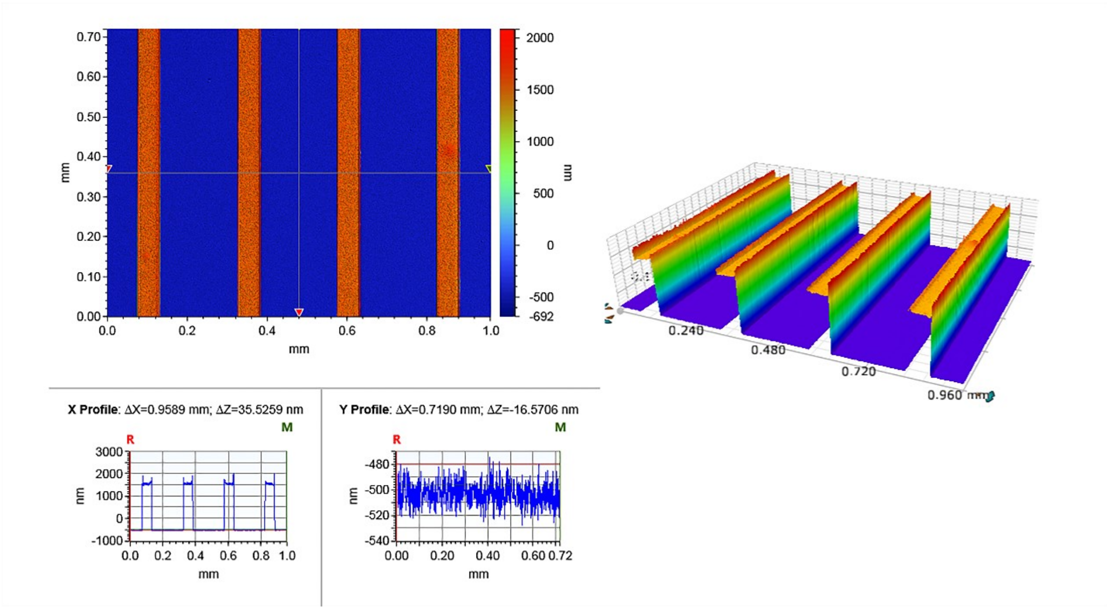

Figure S1. The 3d optical profile of the patterned bank.

Ink Formulation and Drop Behavior

The droplet behavior of the ink has a significant impact on the ability to form uniform and clear patterned films. Different co-solvents with different surface tension are used to observe differences in the drying process. There are three solvent compositions in the studies. Toluene was chosen as the main solvent for its good solubility of F8BT. The addition of different co-solvents substantially increases the viscosity of the ink and enhances the printability of the ink. The priority is to ensure that ink formulations can drop a stable droplet without satellite droplets. Table S1 shows the optimized print voltages and pulse lengths. The print voltages of different inks are similar. A stable single printable droplet can be obtained by slightly optimizing the printing voltage and pulse lengths. Figure S2 shows the distance between the head droplet and the tail droplet from the printing nozzle. The red line is the distance between the tail and the nozzle, and the black line is the distance between the main droplet and the nozzle over time. The inset shows the entire flight of the droplet with different ink formulations. Unlike the droplet behavior of small molecules, even at high pulses the polymer droplet trailing only briefly separates from the main droplet and forms the satellite droplets. The main droplet and satellite droplets rapidly fuse to form a stable single droplet. Therefore, the F8BT droplet without a long tail and satellite droplets is obtained by optimizing the printing voltage of different inks. The velocity and diameter of the flying droplets are shown in Table S1. The final droplets with stable flight velocity and droplet diameter were obtained. Also, the flight velocity is 1 m/s < v < 2 m/s, which is suitable for printing requirements.

Table S1. Printed voltage, pulse length, pressure, velocity and diameter of the different ink.

Ink formulation	Voltage (V)	Pulse length	Pressure (mbar)	Droplet velocity (m/s)	Droplet diameter (μm)
TOL/1-CN=5/5	72	35.8	-8	1.64	82
TOL/CHB=5/5	72	35.9	-8	1.45	82
TOL/BB=5/5	76	35.9	-8	1.48	82

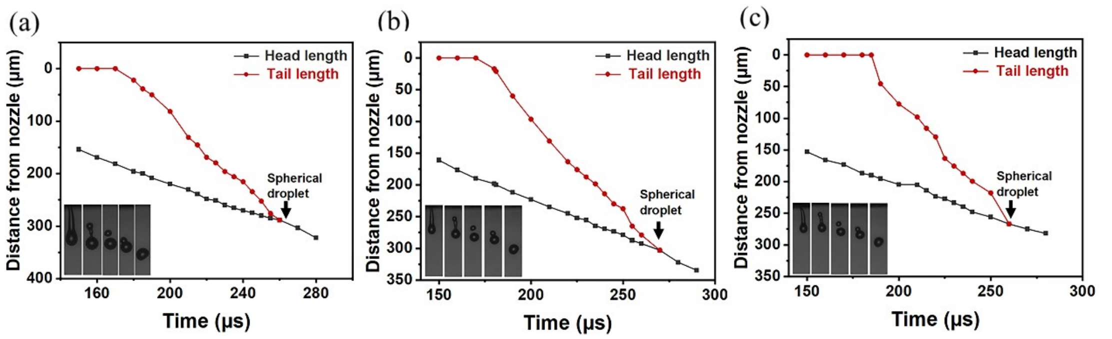

Figure S2. Inkjetted drop formation of (a) TOL/1-CN (b) TOL/CHB (c) TOL/BB (insets show transient behavior of the drops).

Wettability and the drying process of the droplet on the substrate

The wettability and the drying process of the droplet on the substrate are influenced by the characteristics of the substrate and the composition of the solution. Conditions such as the physical properties of the solvent, particle interactions of the solute, additives, and substrate modification all affect the contact line of the droplet on the substrate and evaporation kinetics. As the droplets dry in the bank, the droplet contacts and interacts with the photoresist bank and substrate. Therefore, the interaction of different droplets and the evaporation process on the ITO substrate and photoresist substrate were studied. The ITO substrate and photoresist substrate were surface-modified with oxygen plasma and CF_4 plasma, the same process as the patterned substrate.

The fluorescence microscopy images of the contact angle and the evaporation process of droplets with different ink formulations on the ITO substrate are shown in Figure S3. The contact angles of the drop with TOL/BB, TOL/CHB, and TOL/1-CN ink on the substrate are 18.0 °, 16.0 °, and 16.9 °. The contact angle shows that different inks are fully wetted on the substrate. Also, there is no significant change in the diameter of the droplet during the whole drying process. This means that each droplet is in a constant contact area drying mode. The droplet spreads completely and the contact area does not change, without movement of the contact line. The drying process of different ink droplets is all from the outside to the inside. However, the final drying profile is not the same. There is no obvious solute flow within the droplet with TOL/BB and TOL/CHB and the brightness of the final dried pattern is uniform in every place. However, for the droplet with TOL/1-CN ink, it is obvious that there is more solute in the edge than in the center. This is mainly because the surface tension of

1-CN is larger than CHB and BB and the difference-driven Marangoni flow on the surface is stronger, thus forming the coffee ring finally. Meanwhile, the contact angle and drying process of droplets were tested on the CF_4 etched photoresist substrate, as shown in Figure S4. The contact angles of the drop with TOL/BB, TOL/CHB, and TOL/1-CN ink on plasma etched photoresist are 50.9 °, 60.4 °, and 60.1 °. The droplets of all inks did not undergo contact line slide and the contact area did not change. The contact angles of TOL/CHB and TOL/1-CN ink are similar. Meanwhile, the final film shows a slight coffee ring effect. However, the interface between the drying droplet and the photoresist in the bank is vertical, which could be affected by gravity. Therefore, the evaporation of the droplets in physically restricted spaces may be different.

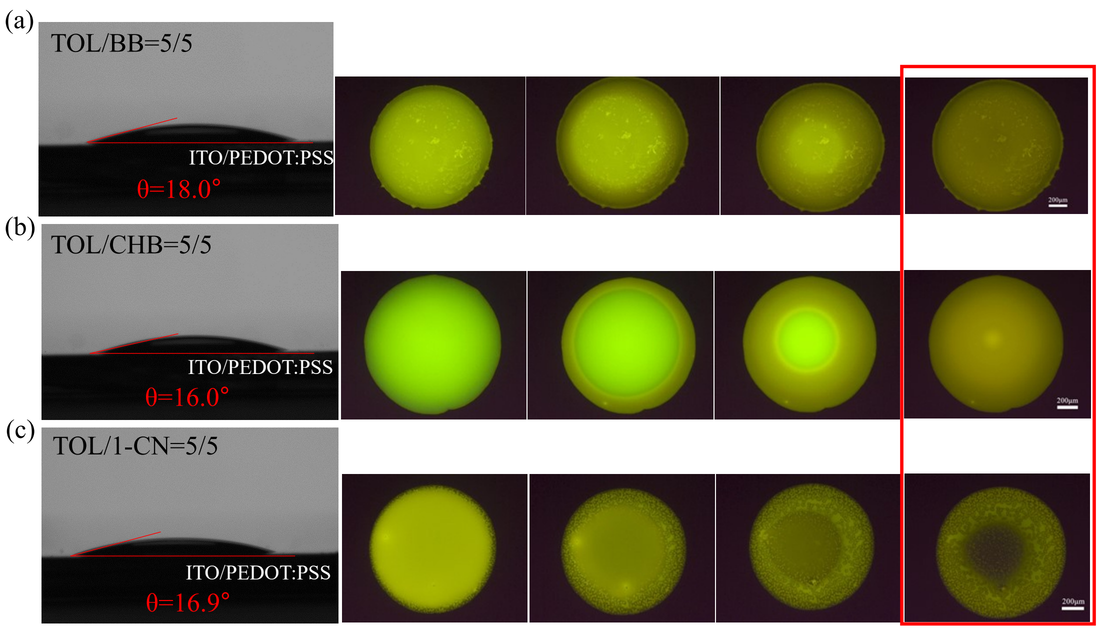

Figure S3. The contact angle of the (a) TOL/BB, (b) TOL/CHB, (c) TOL/CN drop on the ITO/PEDOT:PSS substrate and the fluorescence images of the drying process.

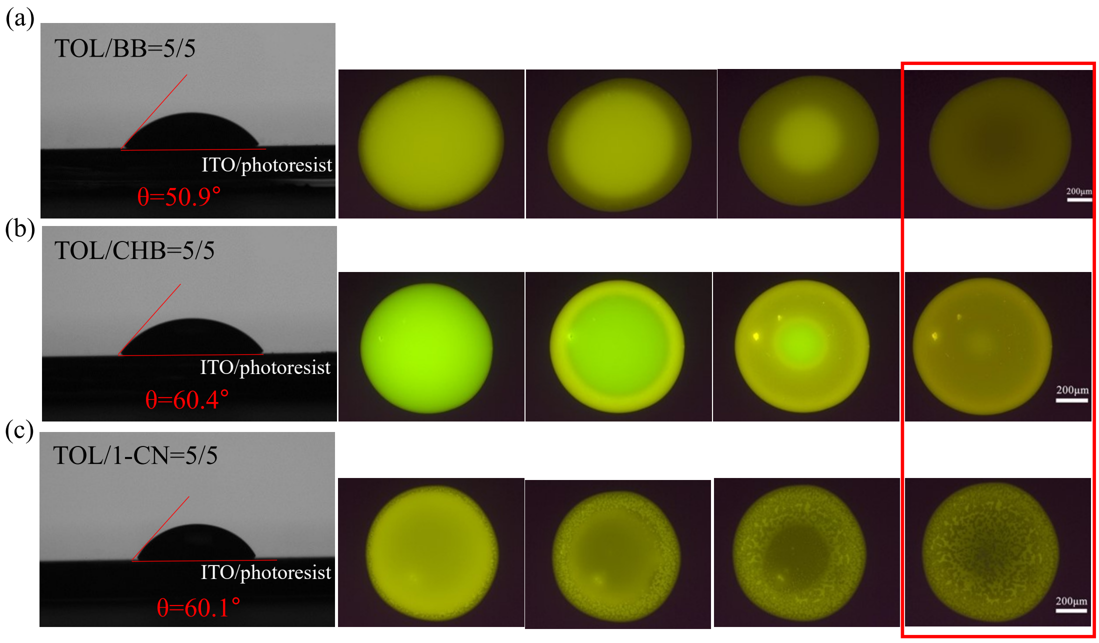

Figure S4. The contact angle of the (a) TOL/BB, (b) TOL/CHB, (c) TOL/CN drop on the plasma etched ITO/photoresist substrate and the fluorescence images of the drying process.

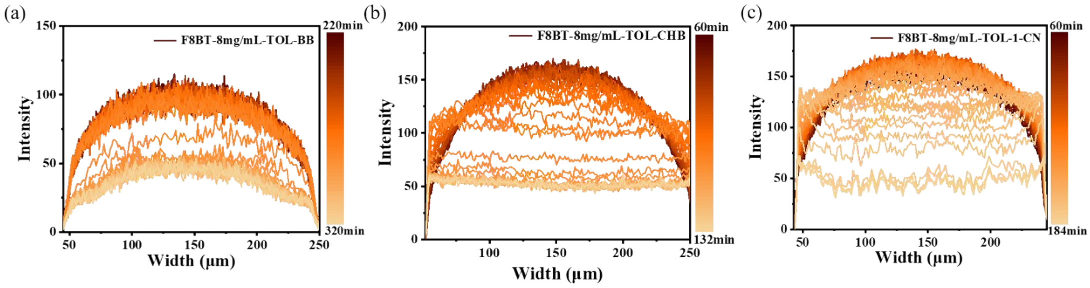

Figure S5. Time evolution of the droplet surface profile in the bank with (a) TOL/BB, (b) TOL/CHB, (c) TOL/1-CN.

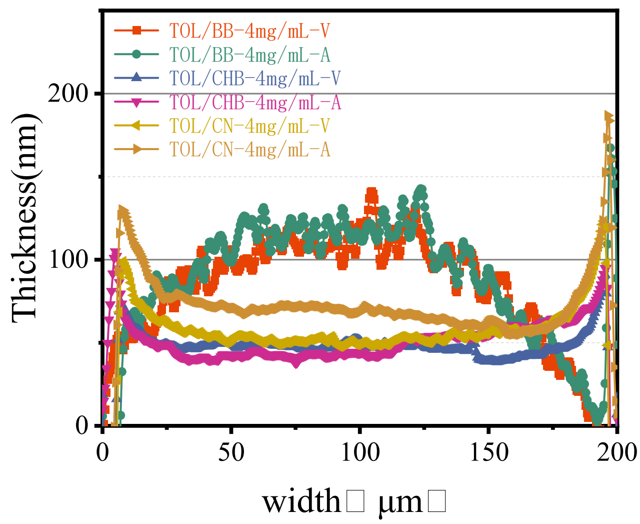

Figure S6. Film profiles of different inks dried in vacuum and air.

Table S2. The empirical constants number and the calculated saturation vapor pressures of TOL, 1-CN, CHB and BB.

Solvent	A	B	C	P (120 °C)
TOL	7.137	1457.287	231.827	131.33
1-CN	7.696	1953.172	184.470	2.54
CHB	7.145	1932.038	193.790	1.29
BB	7.596	2225.320	221.955	1.63