Application of Inkjet Printing on Preparation of All Polymer Thin Film Transistors[1]

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Droplet ejection is a kind of technology commonly used and rapidly developed in printing, which deposits little-mass liquid to specified position in the form of droplet. As the volume of generated droplet is infinitesimal and no contact occurs between sprinkler and spray-coating substrate, the configuration of the deposited droplet could be well controlled. In Manufacturing Industry, this technology is always utilized to manufacture a number of functional materials and functional devices in Manufacturing Industry, such as films semiconductor, DNA materials and LED.

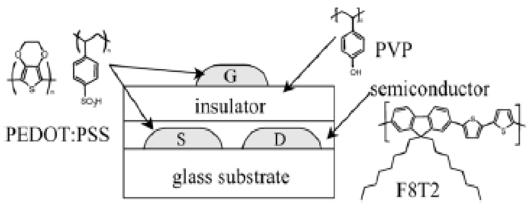
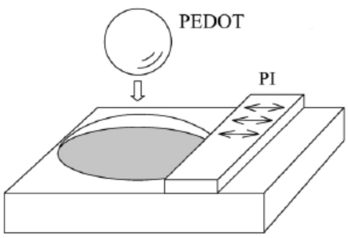


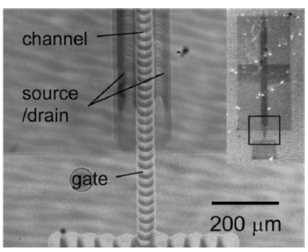
Fig. 1 Structure of all polymers thin film transistors, TFTS

The basic structure of all polymers thin film transistors is shown in Fig.1. All the electrodes, insulated materials and semiconductor materials are polymer solution in all polymers thin film transistors, and the volume of electrodes among these materials is especially tiny. Electrode fabrication is adopted with droplet ejection, and semiconductor layer and insulated layer are both fabricated through spin-coating [1].

It can be found from the structure of transistor shown in Fig.1 that source electrode and drain electrode are located in the same layer and the distance between the two electrodes is quite small. Such small channel width presents a problem for the fabrication of transistors, which will easily result in unexpected contact between droplets during the deposition process and form short circuit. In order to solve this problem, a Polyimide (PI) stripe is often fabricated on the surface of substrate to control the droplets as shown in Fig.2 (a) during the actual process engineering. Owing to Polyimide



(a) Schematic view of PI strip



(b) Shape of TFTS

Fig. 2 Technology for making TFTS

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is not wettable to Polyethylene while substrate is wettable to Polyethylene, it ensures that droplet will diffuse on the substrate and wettablity will be obstructed when the droplet diffuses to the PI stripe. It could lead to form an electrode at each side of PI stripe and avoid short circuit. The shape of fabricated transistor is shown in Fig.2 (b).

Droplet ejection technology has obvious advantages in manufacturing electronic devices [2]. The application of inkjet printing in the making process of all polymer thin film transistors is studied in this paper. Influences of properties of stripe, the space between droplet and stripe *L*, and the speed of droplet *v* on the film deposition are analyzed by numerical simulation.

1 Physical Model

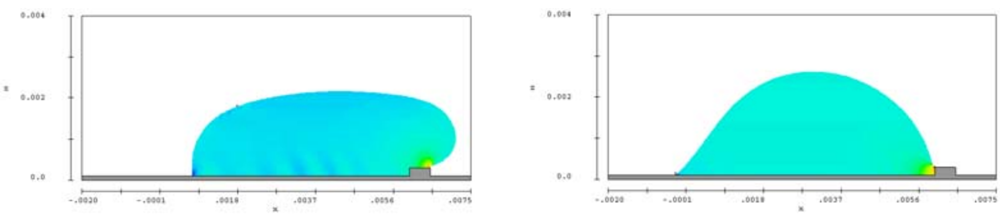
The PI strip shown in Fig.2 (a) is simplified to the 2-D model in the simulation. The viscosity of droplet is 0.2 mPs, density of droplet is 1 100 kg/m^3, surface tension coefficient is 7 N/m, and the distance between contact point and stripe is *L* in the paper. Mesh is generated by using uniform square cells, which has 190 cells in the *x* direction, and 80 cells in the *z* direction.

2 Results and Discussion

2.1 Influence of distance *L* between droplet and stripe on electrode fabrication

Influence of distance *L* between droplet and stripe on electrode fabrication is investigated. *L* could be changed by adjusting the location of the sprinkler. If *L* is too small, droplet will brim over the stripe to lead to short circuit. Otherwise *L* is too large, the dimension will increase and the device will not meet the requirement although short circuit could be avoided.

Depositions as *L* is too small are shown in Fig.3, here, the collision velocity between droplet and substrate is taken as 4m/s and *L* = 20 μm. In Fig.3 (a), droplet at 2.1×10^{-5} s after the contact between droplet and substrate is deposited on the upper surface of substrate. But after 2.1×10^{-5} s, the right side of droplet begins shortening, and at 5×10^{-5} s droplet's right side is shortened to its left side as shown in Fig. 3 (b) so that droplet will be obstructed by the stripe in the end. But the electrodes on both sides will contact with each other to lead to short circuit when they are fabricated at the same time because droplet has contact with the surface of substrate during the deposition process.



(a) $t=2.1\times10^{-5}$ s (b) $t=5.0\times10^{-5}$ s

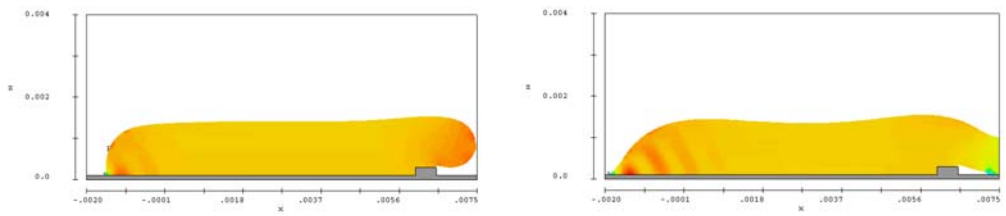
Fig. 3 Droplet deposition with *L* = 20 μm at different time (Unit: cm)

Therefore, the distance *L* also has influence on electrode fabrication when the stripe material is selected as unwettable. Generally *L* is always set as an invariable value, about 30 μm, because of the limit of some factors such the dimension of transistor. Once the distance *L* was fixed, the collision velocity will become the most important factor influencing droplet deposition.

2.2 Influence of the collision velocity between droplet and substrate on electrode fabrication

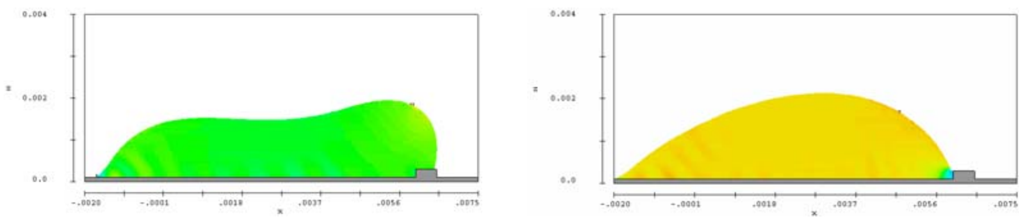
When a collision takes place between droplet and substrate, the magnitude of velocity will exert variant influence on the diffusion of droplet. If the velocity is higher, the efficiency of fabrication will certainly be enhanced. However, too much higher velocity will result in other incidental negative effects.

Different depositions after droplet collides with substrate at higher velocity are indicated in Fig.4 and Fig.5, where *L* is 30μm and collision velocity is 9m/s and 8m/s respectively. The deposition at 8.1×10^{-6} s after collision is given in Fig.4 (a), while the deposition at 1.5×10^{-5} s afterward is shown in Fig.4 (b) when liquid brims over stripe and touches the other side of substrate and the fabrication of device can not go on. The status at about 1.6×10^{-5} s after collision and that at 3.3×10^{-5} s are given in Fig. 5 (a) and Fig. 5 (b) respectively, which is likely to bring short circuit in that droplet contacts with the upper surface of stripe.



(a) $t=8.1\times10^{-6}$ s (b) $t=1.5\times10^{-5}$ s

Fig. 4 Droplet deposition with u = 9 m/s at different time (Unit: cm)



(a) $t=1.6\times10^{-5}$ s (b) $t=3.3\times10^{-5}$ s

Fig. 5 Droplet deposition with u = 8 m/s at different time (Unit: cm)

It could be found that the selection of the length of space *L* and the collision velocity will lead to various influences on device fabrication during the fabrication process of source electrode and drain electrode.

2.3 Influence of the stripe materials on electrode fabrication

During the fabrication process of film transistors through droplet ejection technology, etching on substrate in advance is the trait of this technology. The choice of the stripe materials is also the critical factor for manufacturing device. Three-dimensional results of droplet diffusions on two different substrates are illustrated in Fig. 6 and 7. Stripe in Fig.6 is selected as wettable materials, while that in Fig.7 is not wettable. Under both conditions, droplet's velocity and the distance *L* are reasonably collocated. It is clear that under reasonable collocation, the stripe would not perform completely and the droplet would diffuse to the upper surface of obstruction if the material is wettable. While if the material is not wettable, when droplet diffuses to the brim of stripe, droplet will stop diffusion due to the unwettability of stripe and play the role of holding diffusion back.

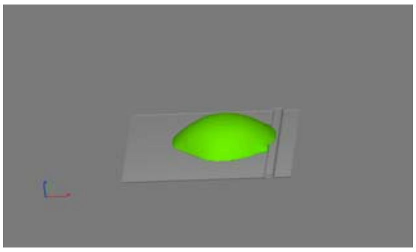


Fig. 6 Spreading with wettable strip

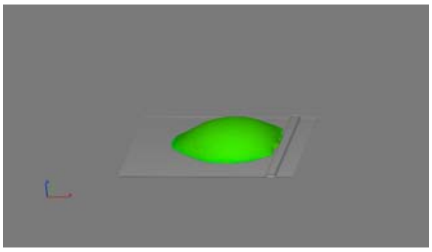
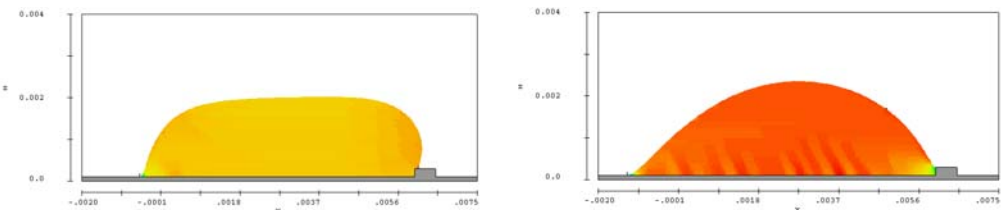


Fig. 7 Spreading with unwettable strip

2.3 Droplet deposition over reasonable collocation

It is obtained from the simulation in the paper that the reasonable droplet velocity is 4m/s as shown in Fig.8 when the width keeps 5 μm needed by normal channel, the distance *L* remains 30μm, and the stripe material is adopted as polyimide. The status at 1.2×10^{-5} s and 5×10^{-5} s afterward are given in Fig.8 (a) and (b) respectively. Droplet is obstructed at the left side all the time in Fig.8 (a) which means that the droplet does not contact with the upper surface of stripe as well as the other side of substrate and could help electrodes fabricated at both sides of stripe to make the stripe do play the role of separating the two electrodes. In this way, the fabricated electrodes could accord with practical requirements.



(a) $t=1.2\times10^{-5}$ s (b) $t=5.0\times10^{-5}$ s

Fig. 8 Droplet deposition in a reasonable condition at different time (Unit: cm)

3 Conclusions

In the process of manufacturing thin film transistors through the droplet ejection technology, it is always to restrict the range of droplet diffusion by the way of etching a wettable stripe on substrate in advance in order to ensure the channel width between source electrode and drain electrode in transistor to accord with requirements. Once the stripe width was fixed, devices could be successfully manufactured through selecting reasonable collocation on the distance between droplet and stripe and droplet's collision velocity. The results in this paper provide reference to TFTS fabrication and enrich the research in Inkjet Printing.

References

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Acknowledgement

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