EWOD DEVICE WITH INKJET PRINTED 3D PEDOT:PSS ELECTRODE

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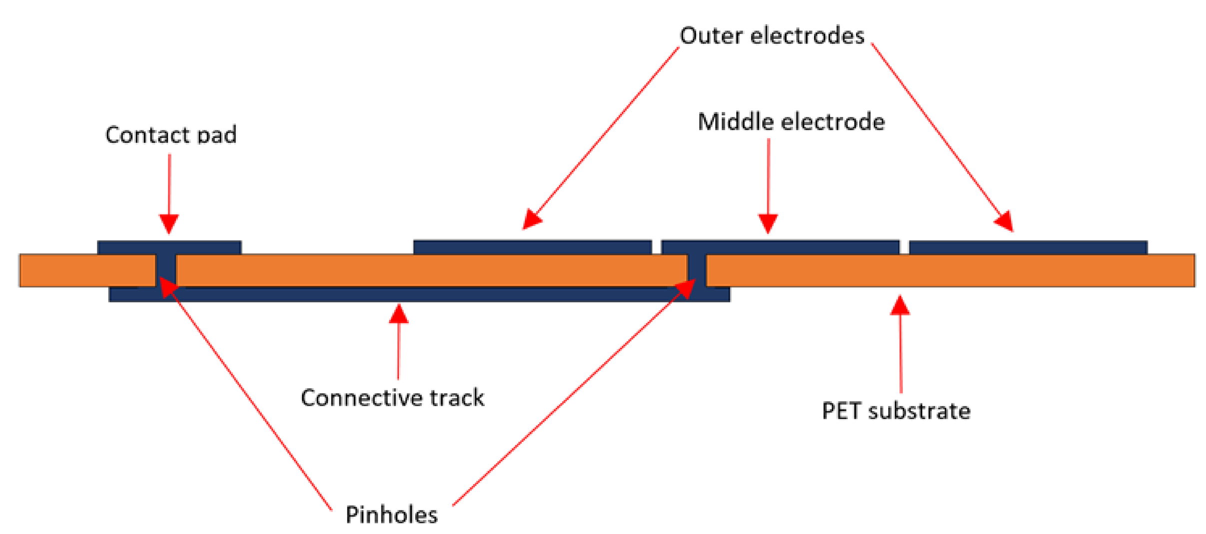
Double Sided Inkjet Printing

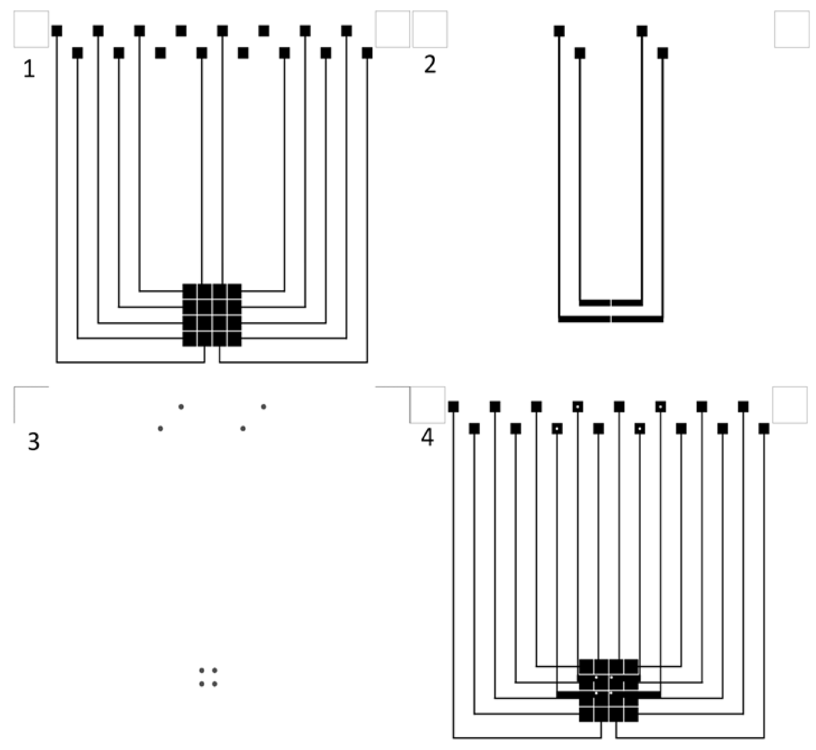
- Goal: To overcome the limitation of single plane design (Ink-on-paper and patterned-on-glass electrodes).
- Double Sided Inkjet Printing to overcome topological constraints.
- LASER-cut via for side-to-side connection.
- PEDOT:PSS chose for versatile properties (conductive, transparent, flexible).
- Low-cost materials - PEDOT:PSS ink and PET Melinex® substrates.

4 × 4 Electrode Array Design

- 3D structure in a parallel-plate EWOD configuration.
- Connection between the middle electrodes and the respective contact pads.
- Inkjet printing on both sides.
- Laser-cut pinhole vias.

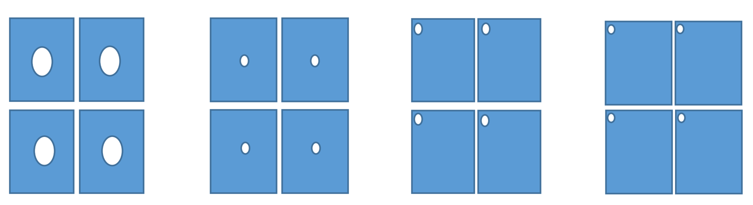


- Pattern printed on the top and bottom surfaces of the substrate.
- Nominal width of the tracks = 150 µm.
- Nominal inter-electrode gap = 180 µm.
- Two electrode sizes = 1.7 mm and 2.0 mm.
- Via diameters ranging from 100-225 µm.
- The patterns were printed using the Fujifilm Dimatix DMP-2850 printer.



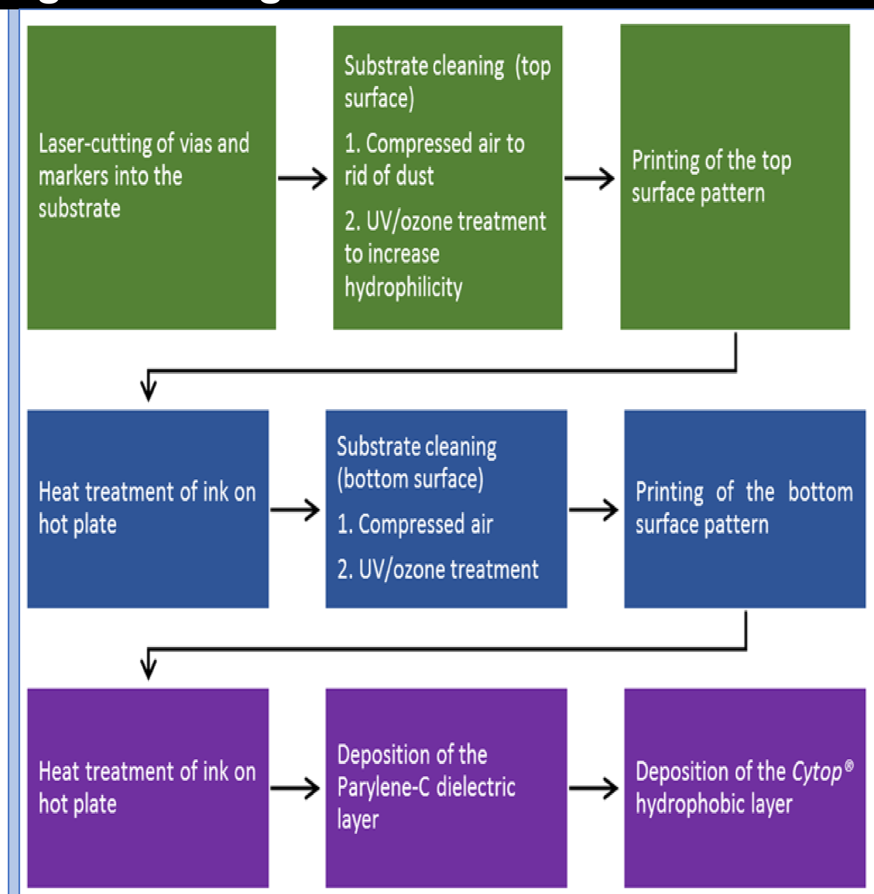
Manufacturing & Testing

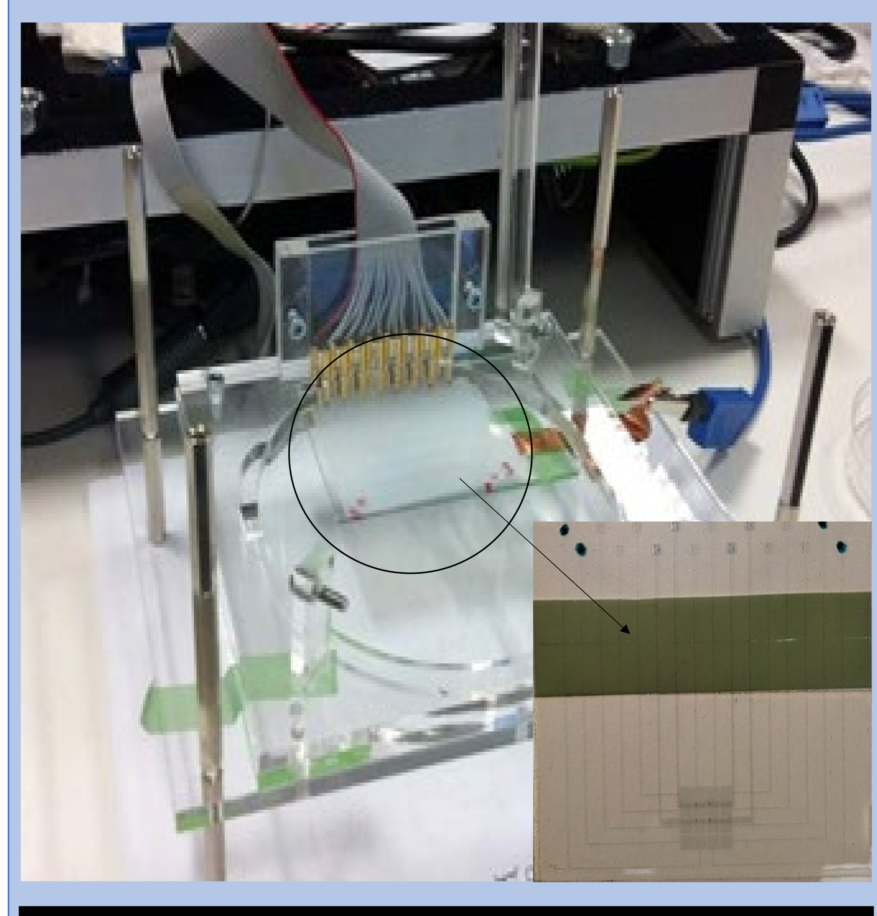
A double-sided substrate EWOD device with a 4×4 electrode array was fabricated to reduce fabrication costs and address topological constraints of electrical connectivity of the middle pads.



Electrode Size: 1.7mm
Via Diameter: 225, 110, 126 and 137 µm respectively

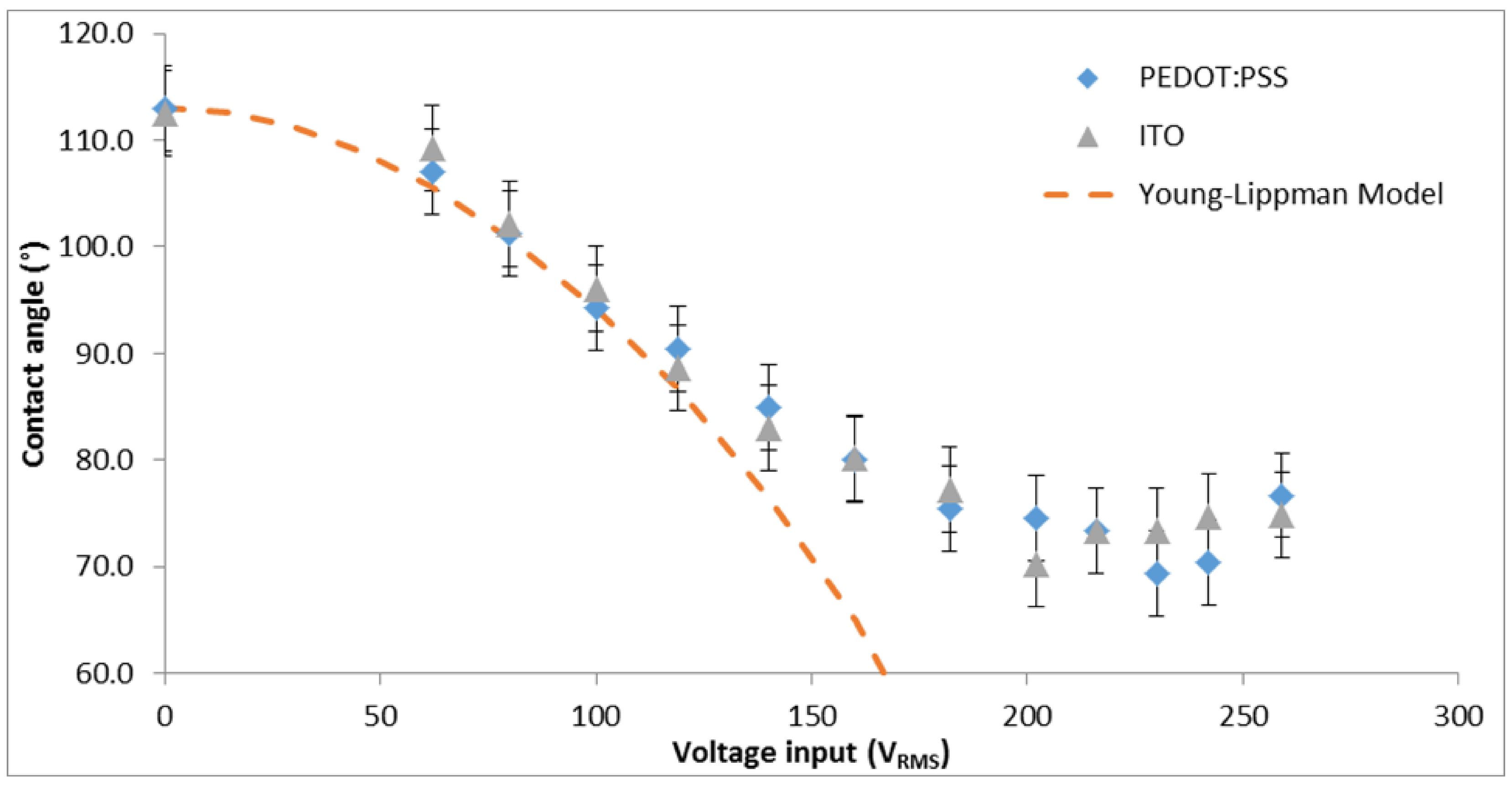
Vias of different dimensions and positions were laser cut into the PET substrate (Trotec Speedy 300, Marchtrenk), cleaned using compressed air and treated under UV/ozone (Novascan PSD, Iowa, US) for 15 minutes. The top PEDOT:PSS ink electrode pattern is printed (Fujifilm Dimatix DMP-2850) onto the substrate, followed by a heat treatment at 110 °C for 5 minutes. For the bottom electrode, the surface of the PET substrate is cleaned and treated with compressed air and UV/ozone and heat treated again at 110 °C for 5 minutes after the printing is completed. Parylene-C (SCS Labcoater® 2) was deposited as the dielectric layer, and Cytop® (Asahi Glass Co., Ltd.) as the hydrophobic layer. The thickness of the dielectric layer employed was approximately 6.0 µm.



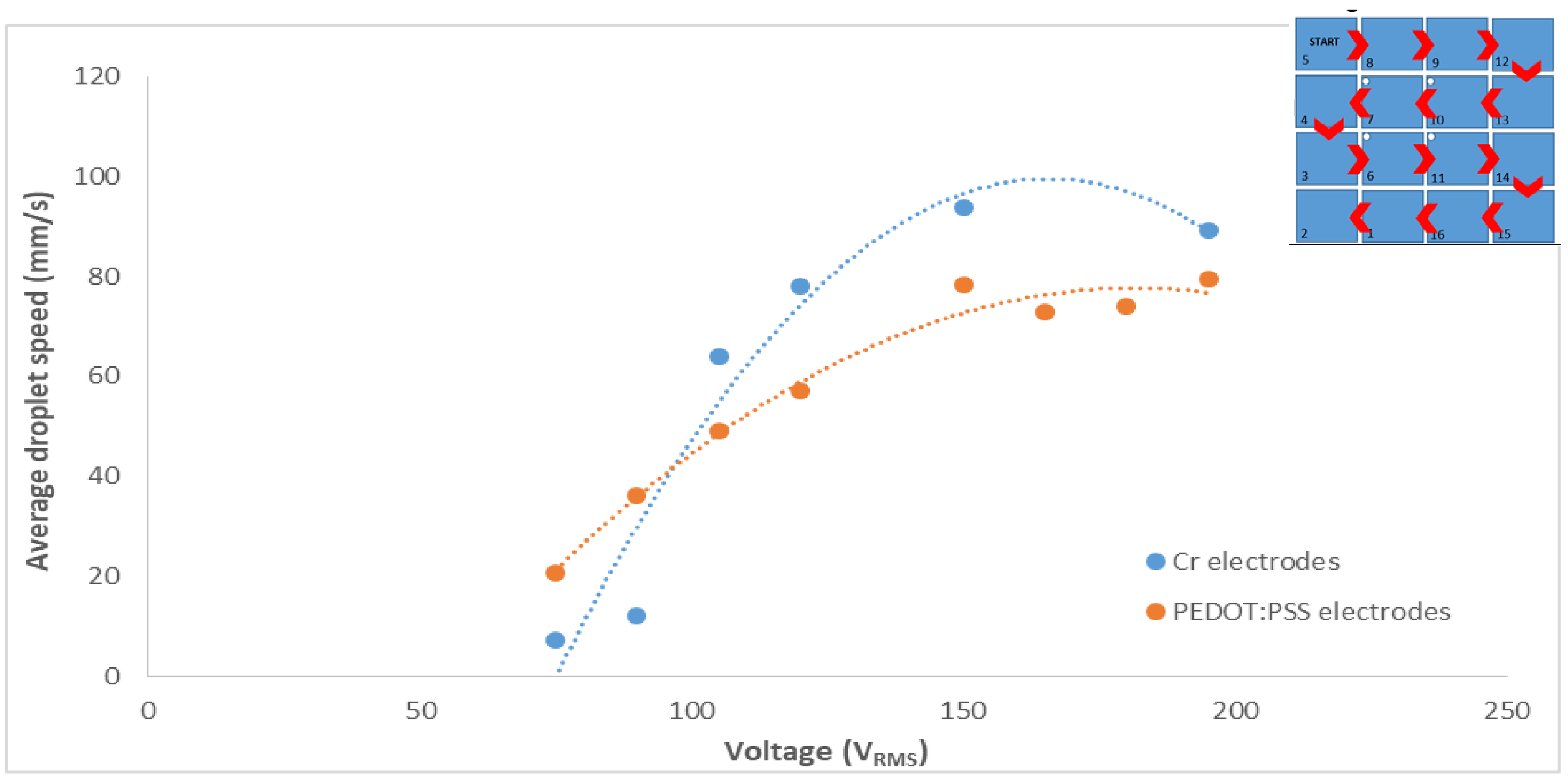


Results

The electrowetting performance of the PEDOT:PSS electrodes was evaluated by measuring the change in contact angle (CA) with varying applied voltage of a 2.5µl DI water droplet sitting on the electrode surface and the average droplet movement speed.

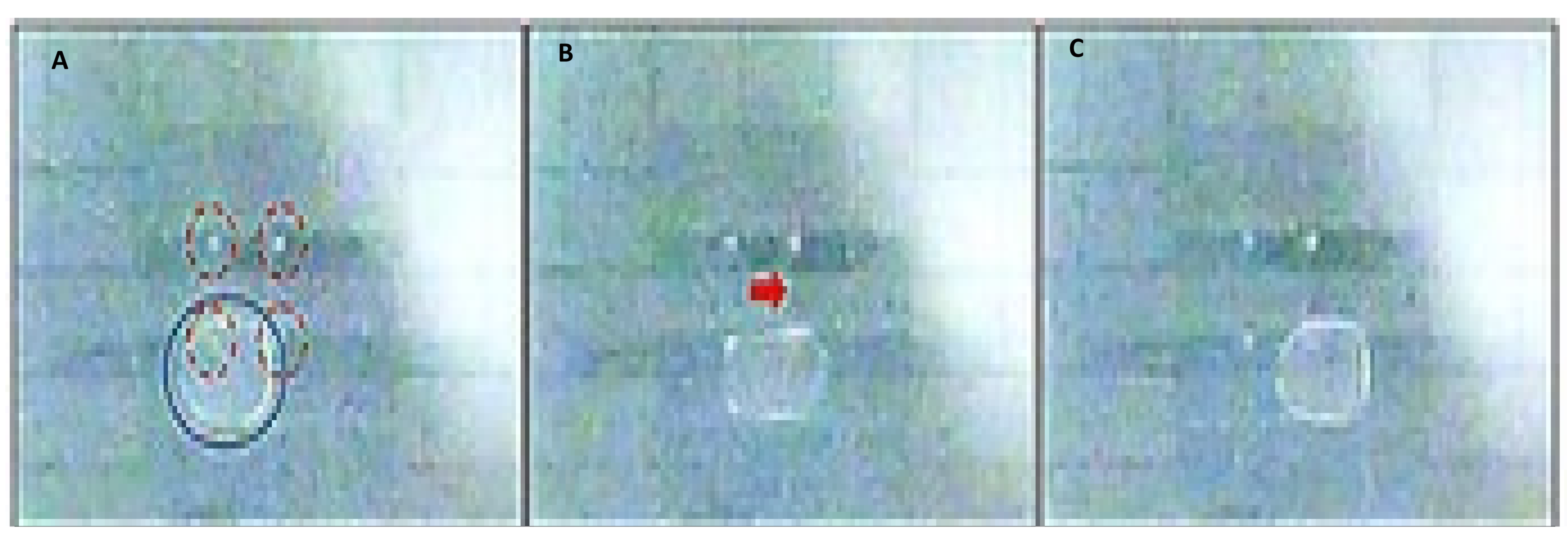


The change in DI water droplet contact angle with applied voltage for PEDOT:PSS and ITO electrodes. The results are compared with the contact angle predicted using the Young-Lippmann equation.



Velocity measurements of a 2.5ul DI water droplet.

Droplet shown in the blue circle below. Vias are indicated inside the dashed red circles. Image A shows the droplet starting position on electrode 6. Image B indicates the direction of movement when electrode 11 is activated. Image C shows the droplet in its final position.



Conclusions

A minimum voltage of 75V was required to actuate the droplet across one electrode reliably. However, the droplet could not reliably move more than one or two electrodes.

To transverse one complete cycle across all electrodes, a voltage of 120V was required for the PEDOT:PSS electrodes, while 90V was needed for the chrome-on-glass device.

The droplet transversed all electrode pads and completed 50 cycles at 150V.

The 2 mm electrodes and smaller vias sizes (<140 µm) were the most effective for consistency in transporting water droplets across the entire electrode configuration.

References

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