Inkjet printing of stretchable conductor for 3D applications

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Abstract

Electronic circuits can be inkjet printed on a light-weight stretchable substrate that can be integrated on 3D complex geometries by vacuum forming technique. In this work, we developed stretchable, conductive polymer-based PEDOT: PSS ink that was inkjet printed on a stretchable substrate. Additionally, we report on the stretching behavior of the printed conductive layer and its applicability towards 3D-forming.

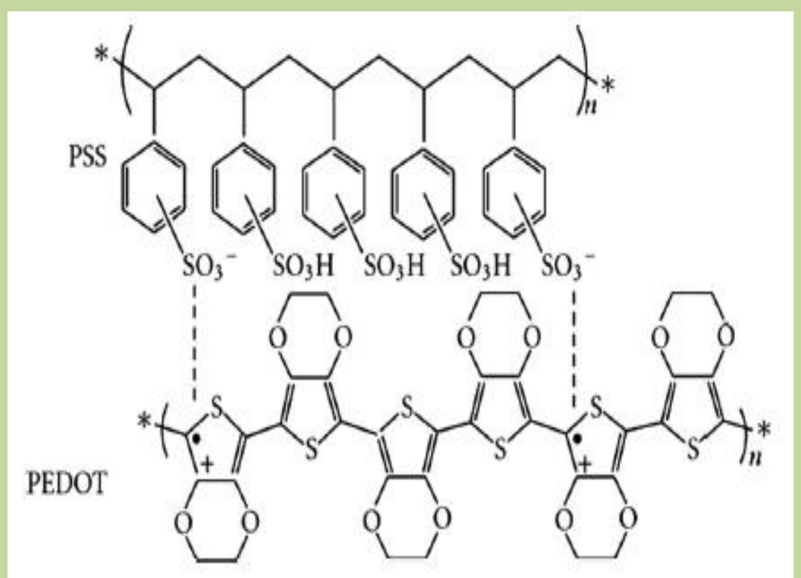
Dimatix DMP-2800

Main Objective

Stretchable electronics have been making progress in photodetectors [1], temperature sensors [2], pressure sensors [3], etc. To prepare these sensors, drop-on-demand (DoD) inkjet printing can be applied. DoD inkjet printing is easy to use, very cost-effective and can fabricate circuits with high resolution (20µm line width).

1. Ink formulation: develop highly conductive inkjet printable polymer PEDOT:PSS
2. Characterization: Printed PEDOT: PSS on stretchable foil (TPU)
3. Application: Integrate the printed conductive lines on 3D geometry

Vacuum forming device (Formech 450dt)



PEDOT:PSS

Ink Formulation

Inkjet printable ink property depends on the Ohnesorge (Oh) number [4].

$$Oh = \eta / \sqrt{\gamma \rho a}$$

where η, γ, ρ, and a are the viscosity, surface tension, density and nozzle diameter respectively.

The amount of solvent decreased from sample 1 to sample 8 accordingly (Fig. 1). Sample 8 was selected for inkjet printing.

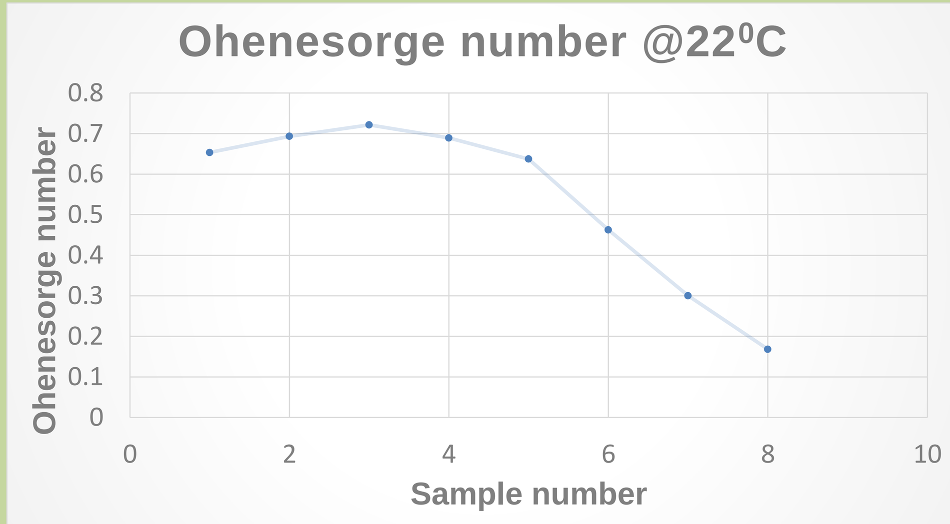


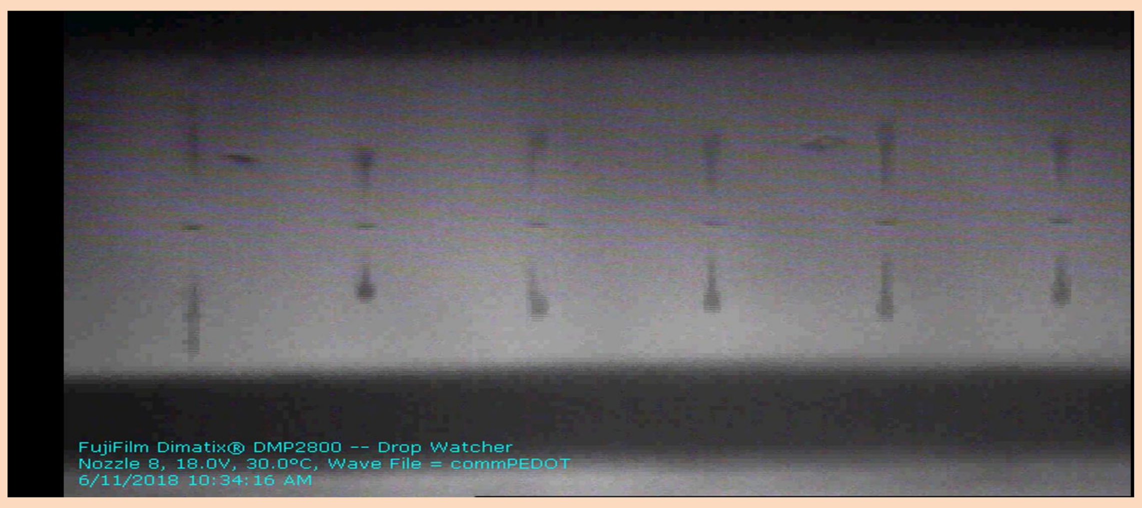
Figure 1: Rheological characterization of the PEDOT:PSS ink

Table 1

Number of Layers	Resistance in [Ω/sq]	Surface Roughness in [nm]
1	1100	6.41
2	500	10.68
3	300	13.14
4	200	12.38
5	150	11.62

Characterization

Rectangle with dimension 70X10 mm² was inkjet printed on thermoplastic polyurethane (TPU) film after oxygen plasma surface treatment. Sheet Resistance, surface roughness and transparency were measured by van der pauw, atomic force microscope, and spectrophotometer respectively (Table 1, Fig. 2).



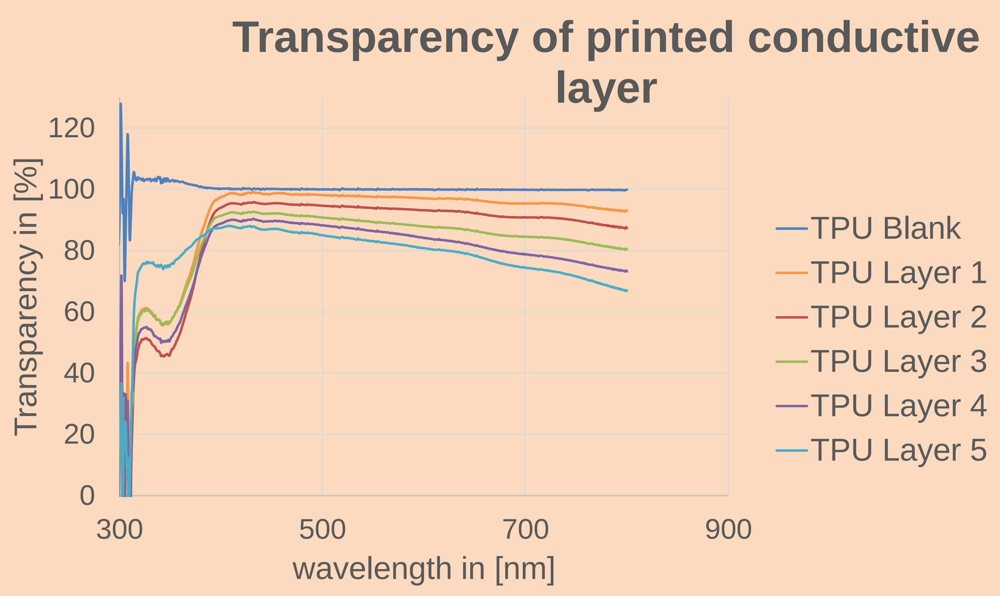


Figure 2: Transparency of inkjet printed conductive layers.

Application

- A rectangle was printed on thermoplastic polyurethane (TPU) foil and stretched with our home build stretch device (Fig. 3).
- Three lines of one layer with dimension 70X20 mm² was inkjet printed on TPU film and integrate it on 3D printed cone by vacuum forming technique. The resistance of first, second, and third line was 8.72 KΩ, 17.90 KΩ, and 3.7 MΩ respectively (Fig. 4).

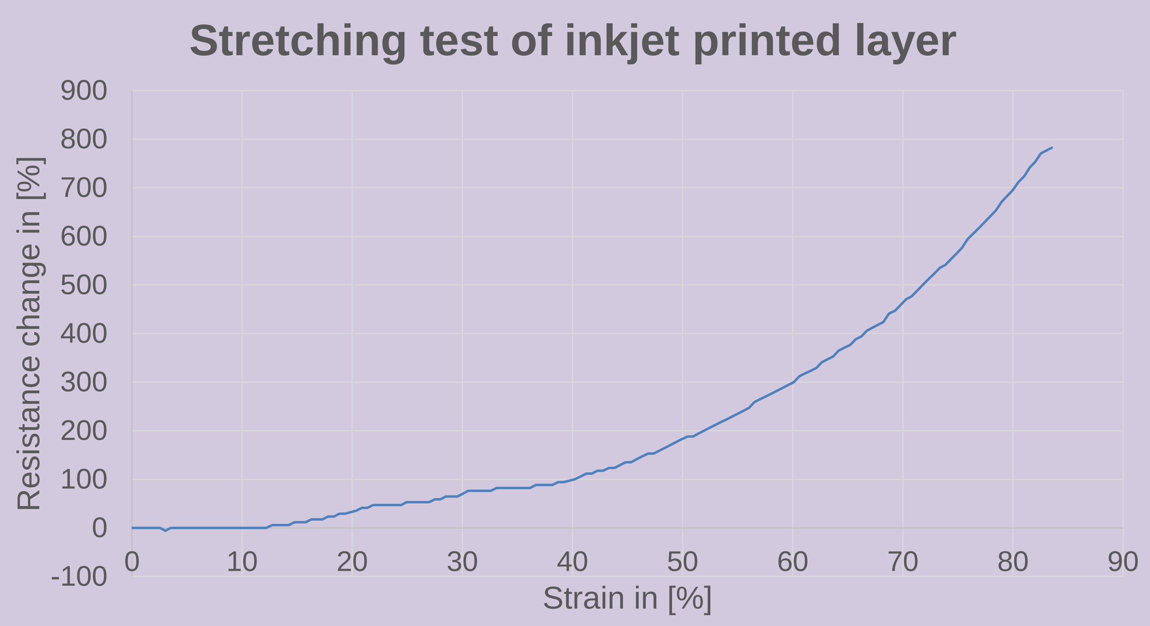


Figure 3: Stretching test of printed conductive layer.

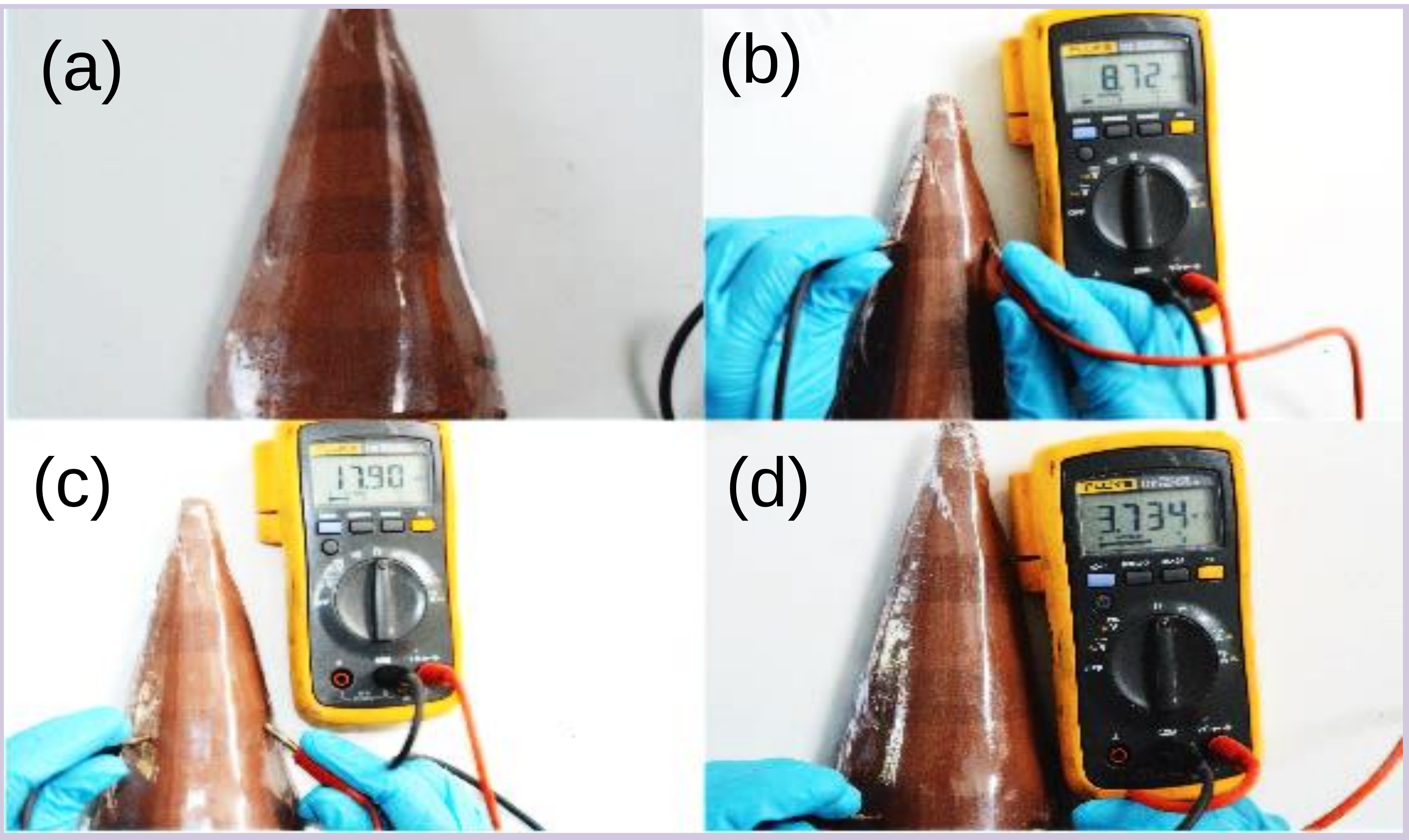


Figure 4: Printed lines integrated on cone (a); Resistance of first, second and third line was measured by multimeter (b, c, d).

Conclusion:

- Curvature of front part of 3D printed cone was low compared to end part, so that resistance of front part was lower than end part.
- Resistance can be decreased by printing more than one layer.

Future work:

A touch sensor will be printed on stretchable foil and integrate it on complex 3D geometry that have an application in the automotive industry.

References

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