Capacitive touch sensor for packaging application

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Introduction

Stretchable electronics have been making progress in photodetectors [1], temperature sensors [2] and pressure sensors [3]. To prepare these sensors, drop-on-demand (DoD) inkjet printing can be applied. DoD inkjet printing can fabricate circuits with high resolution (20 µm line width), is easy to use and very cost-effective. However, ink formulation is complicated and the property window for jettability is small. Therefore it's important to tune all parameters (viscosity, surface tension, density, …) when formulating a functional ink.

Objectives

1. Develop highly conductive inkjet printable polymer poly(3,4-ethylenedioxy-thiophene):polystyrene sulfonate (PEDOT:PSS) by mixing PEDOT:PSS in different proportions with selected solvents.
2. Characterize printed PEDOT:PSS on TPU stretchable foils.
3. Integrate printed capacitive touch sensor on a 3D geometry.

Fig. 1 Dimatix DMP-2800 ink jet printer

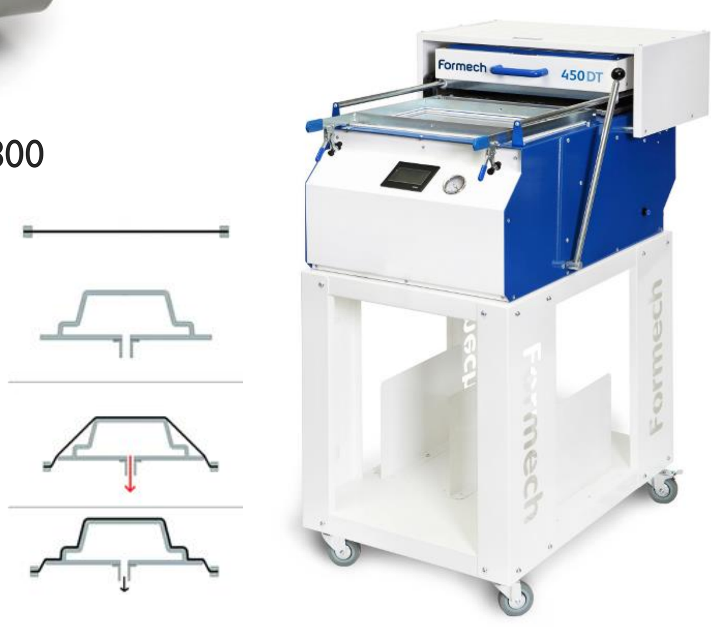

Fig. 2 Vacuum forming device (Formech 450dt)

Ink Formulation

To account for the liquid viscosity in droplet formation, the **Ohnesorge number** (Oh) is a non-dimensional number representing the ratio of internal viscosity dissipation to the surface tension energy [4]. The lower Oh, the weaker the friction losses are due to viscous forces, meaning that most of the inserted energy converts into surface tension energy, i. e. a droplet can be formed.

$$Oh = \frac{\sqrt{We}}{Re} = \frac{\eta}{\sqrt{\gamma \rho a}}$$

with ***We****, Weber number,* ***Re****, Reynolds number,* ***η****, viscosity,* ***γ****, surface tension,* ***ρ****, density and* ***a****, nozzle diameter.*

The Oh number of printable PEDOT:PSS plus solvent was analyzed. The volume of solvent increased from sample 1 to 8 accordingly (Fig. 3). Sample 8 was selected for inkjet printing.

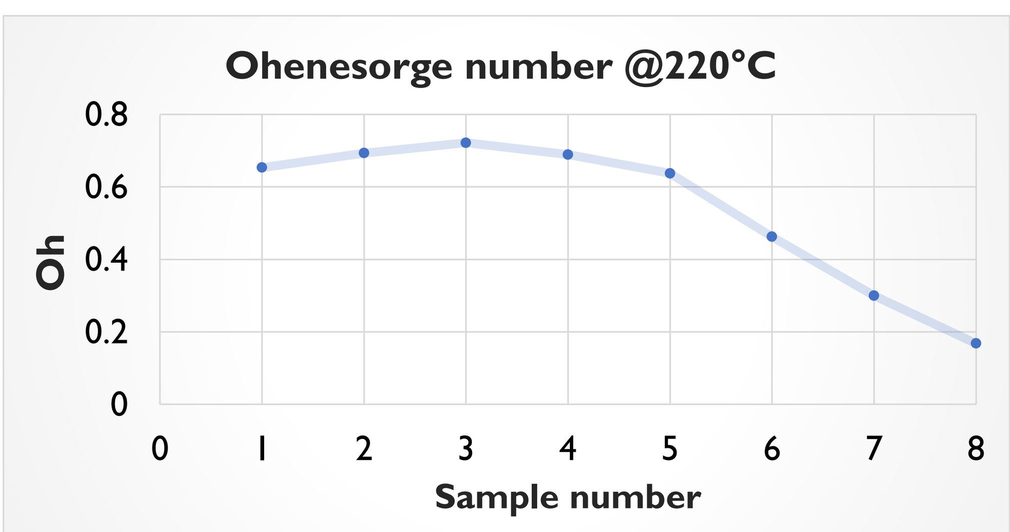

Fig. 3 Rheological characterization of the PEDOT:PSS ink

Characterization

Different rectangles with dimension 70x10 mm^2 were inkjet printed on a plasma treated thermoplastic polyurethane (TPU) film using a Digitix DMP-2800 in jet printer (Fig. 1) and sintered in an oven (Fig. 4). Sheet resistance, surface roughness and transparency were measured by multi meter, atomic force microscopy (AFM), and spectrophotometry respectively (Table 1, Fig. 5).

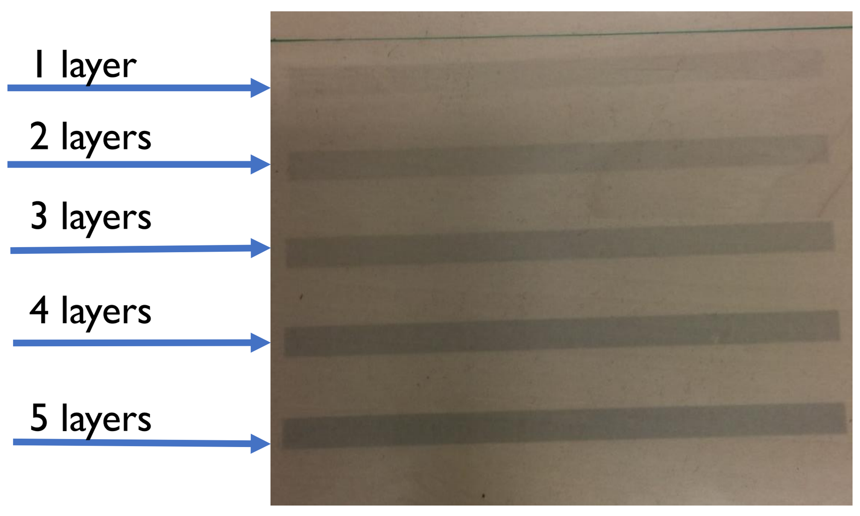

Fig. 4 Inkjet printed PEDOT:PSS rectangles

Table1 Characterization of inkjet printed layers

Number of Layers	Resistance [KΩ]	Surface Roughness [nm]
1	25.5	6.41
2	11.8	10.68
3	7.5	13.14
4	5.5	12.38
5	4.9	11.62

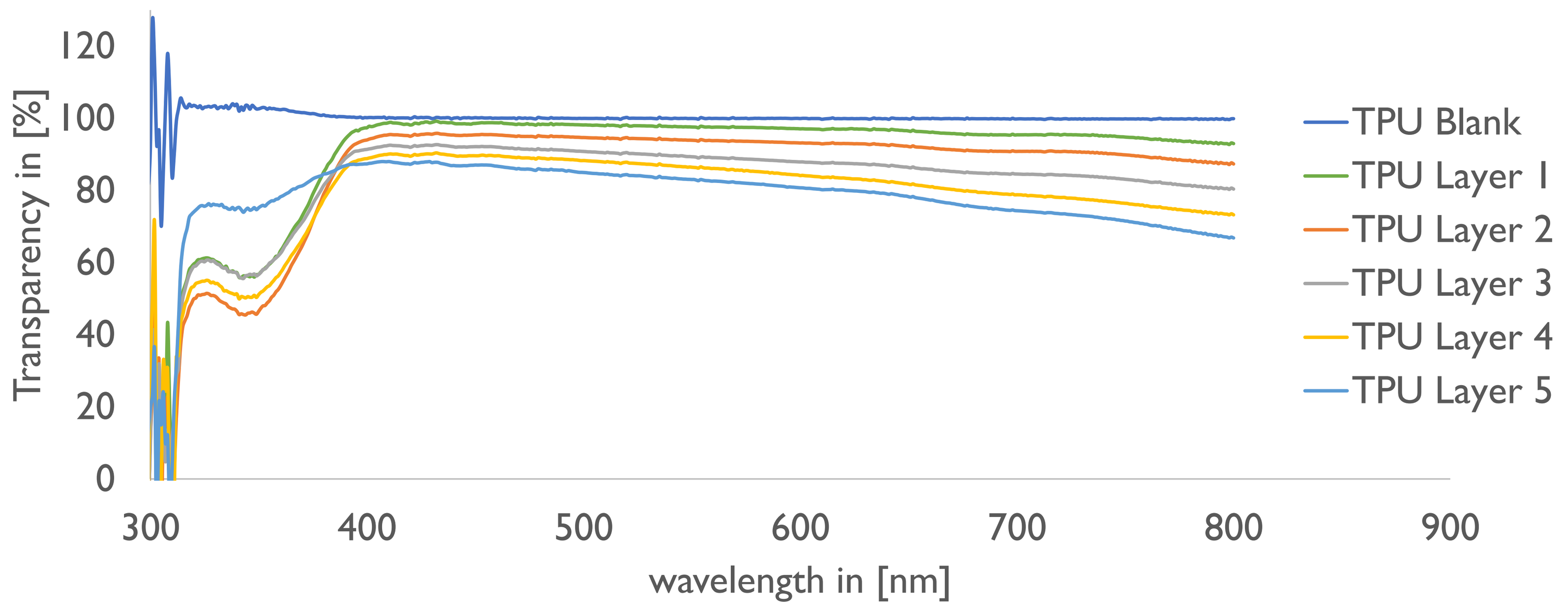

Fig. 5 Transparency of inkjet printed conductive layers

Application

To show its applicability towards 3D integration for packaging applications, a capacitive touch sensor with three layers printed on top of each other for better conductivity was printed on a thermoplastic polyurethane (TPU) foil, which was subsequently integrated on a 3D printed geometry by vacuum forming device (Fig. 2). After integration, the 1x1 cm^2 square was converted into 1.3x1.3 cm^2, the total stretching was therefore 30%. The resistance change upon stretching was investigated and shows promising results (Fig. 6).

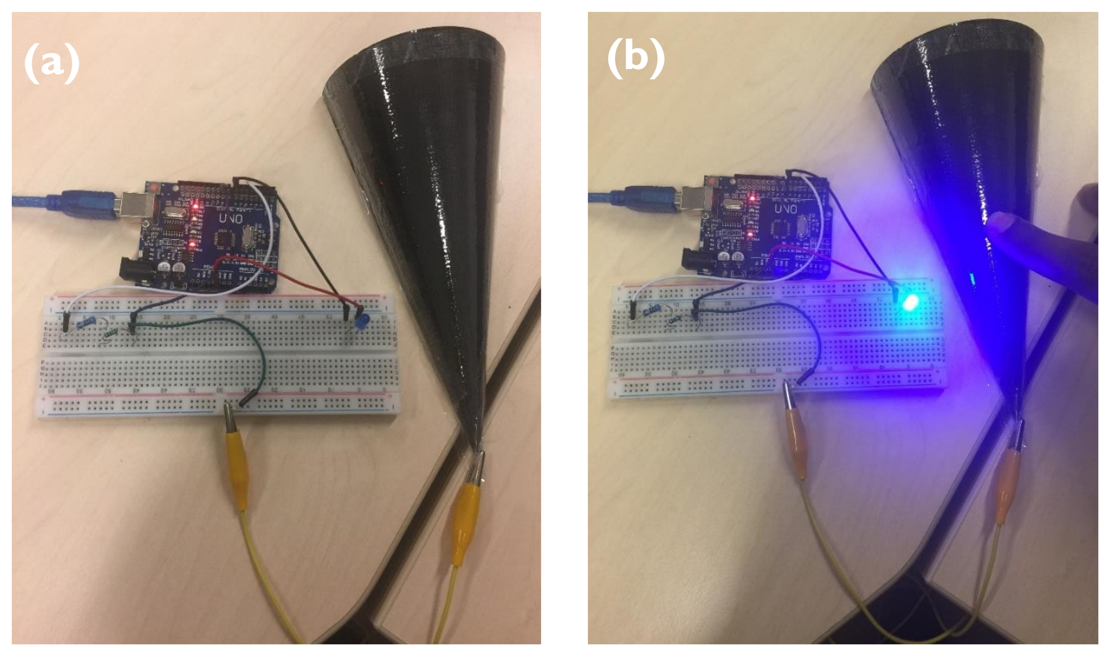

Fig. 6: Inkjet printed capacitive touch sensor without touch (a) and with touch (b).

Conclusion and future work

The developed inkjet printable and stretchable conductor shows the capability to be formed around 3D parts, which can be useful for innovative 3D-packaging applications or other markets. Also other sensors (e.g. humidity, temperature) with capacitive reading will be designed and printed on stretchable foils for packaging applications.

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