Adhesion Enhancement of Conductive Inks on Non-porous Substrates for Printing Application

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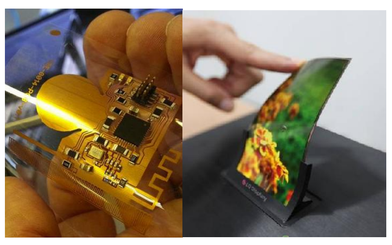
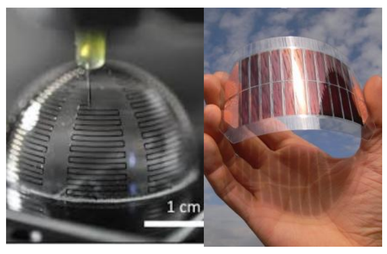
Introduction

Applications of Flexible Electronics

- Flexible Displays and Circuits
- RFID Tags
- Low Cost Sensors
- Organic Thin Film Transistors
- Solar panels (busbars and interconnects)
- Other disposable electronic devices.



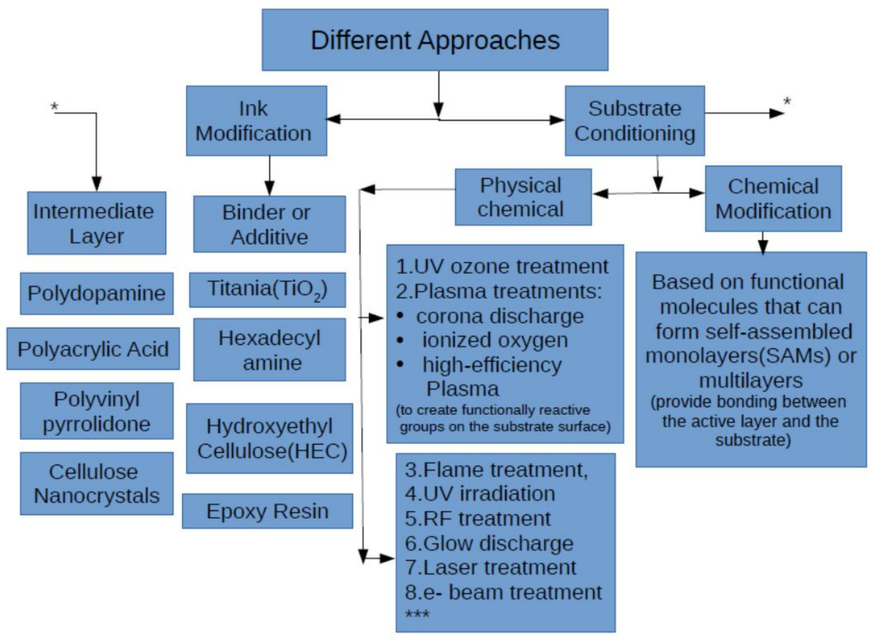


Motivation behind Printing

- High cost associated with photo-lithography
- Polymers show low conductivity
- Low materials consumption
- Simple and accurate process with high resolution and high speed

Objective

- To enhance adhesion between the hydrophobic, inert polymer surfaces and the deposited electrically conducting structures, such as metal interconnects and electrodes.
- To optimize between high adhesion and low wettability such that the line width of the interconnects can be further reduced.



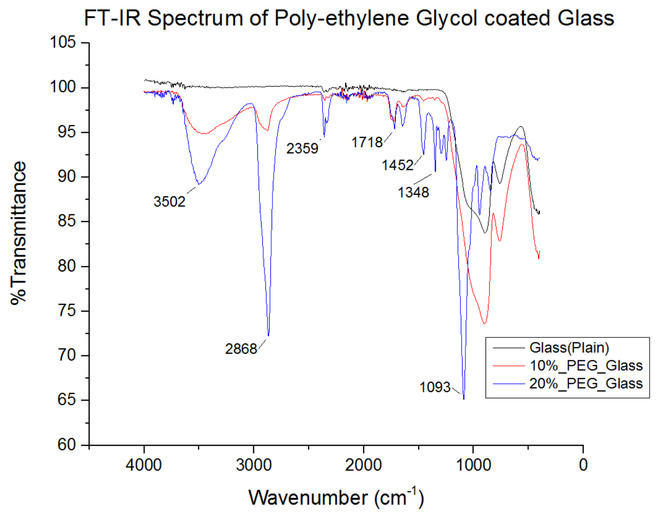
Literature Review

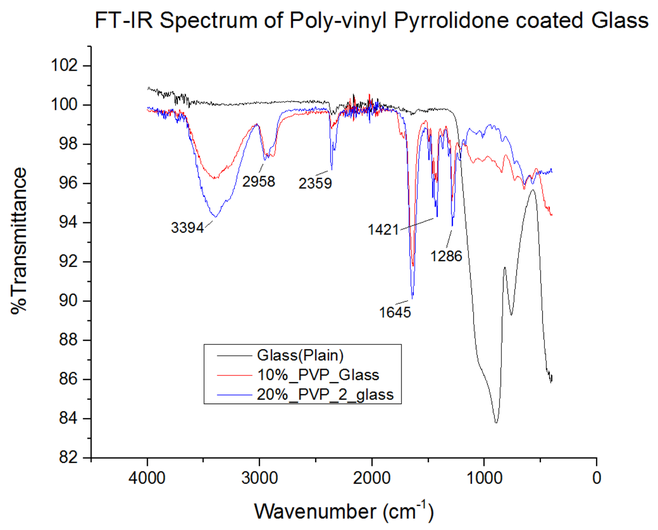
- Addition of binders or additives to the ink results in a compromise with the conductivity of the printed features.
- Pre-treatment procedure like UV-Ozone, RF, Laser, Electron beam or Plasma treatments are both expensive and add an extra step to the fabrication process.
- Silver and copper have a great affinity towards carbonyl bonds and nitrogen atoms. They can thus be utilised in intermediate layers to assist in chemisorption.
- The sintering temperature of the nanoparticles should be well below the Tg of the substrates to avoid their loss of integrity.

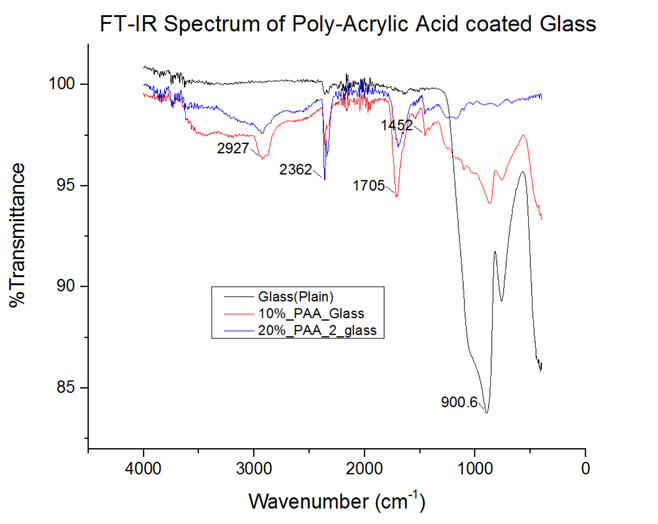
Procedure

1. Substrate preparation(Glass, PET, PI)
2. Substrate characterisation
3. Preparation of intermediate layer (PAA, PEG, PVP; 20%wt in ethanol) for adhesion enhancement
4. Deposition of the polymer layer by spin-coating (@1000rpm for 30 sec.)
5. Characterisation and analysis of the layer
6. Preparation and Spin coating of the Silver Ink
7. Adhesion, Conductivity and FT-IR analysis of the silver ink layer

Characterisation (FTIR)

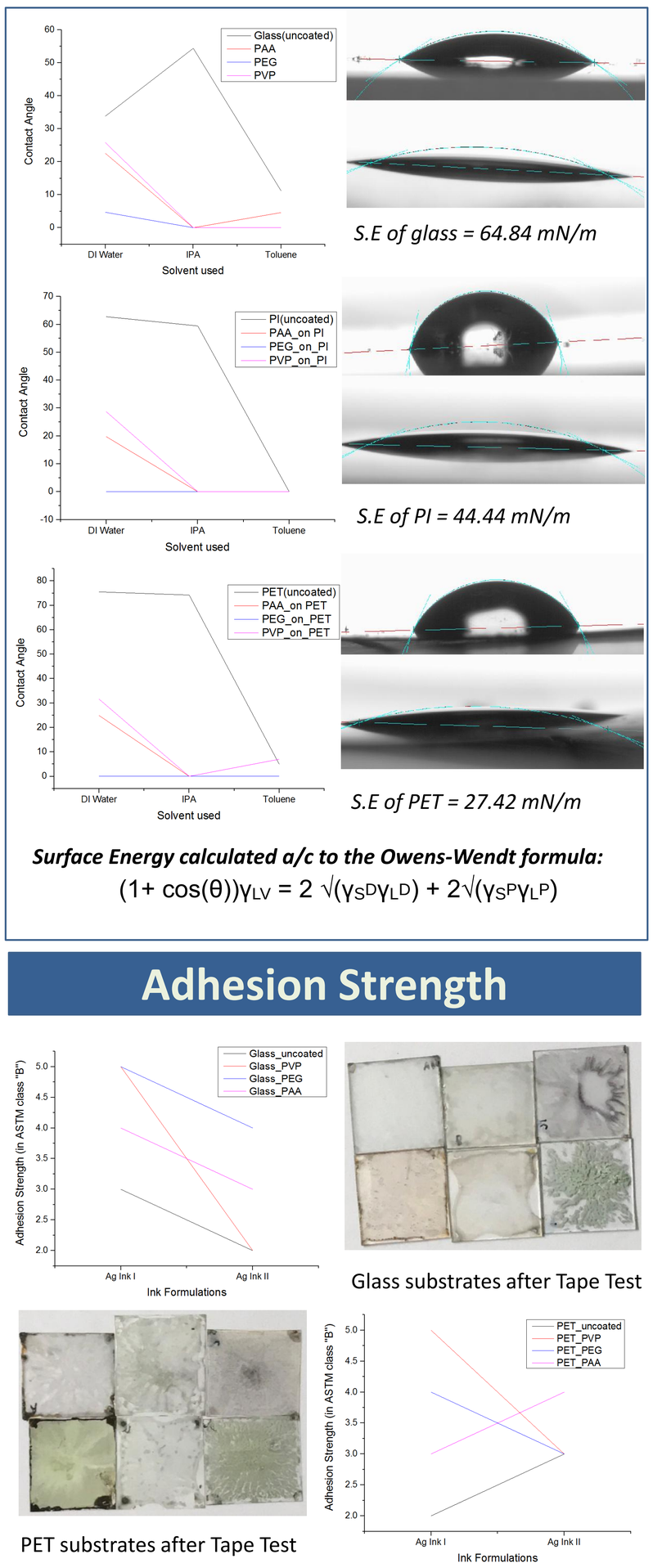






FT-IR Analysis of the substrates indicates the chemical composition of the surface. The diminishing value of the glass peak with inreasing conc. Indicates film deposition.

Contact∠ & Surface Energy



Surface Energy calculated a/c to the Owens-Wendt formula:

$$(1+\cos(\theta))\gamma_{LV} = 2\sqrt{(\gamma_S^D\gamma_L^D)} + 2\sqrt{(\gamma_S^P\gamma_L^P)}$$

Adhesion Strength

Glass substrates after Tape Test

PET substrates after Tape Test

According to the ASTM standards the degree of adhesion is decided by the % of area that gets affected after the peel off test. (5B => above 65% and 0B => no change)

Results

• The FT-IR results indicated the formation of an even and uniform film in the case of PAA and PVP. However, PEG deposition was both patchy and non-uniform, which is confirmed by 1093 cm^{-1} peak.

• Upon modification of the substrates with the intermediate polymer layers, the wettability increased indicating a high surface energy. One reason could be the compatibility with the solvent i.e. ethanol, comprising both polar and non-polar parts.

• Neither of the substrates (coated or uncoated) showed any conductivity, whatsoever. Spin-coating more layers of the ink should make up or dip-coating could be a better alternative.

•Adhesion strength enhanced in all cases of coated substrates compared to the uncoated ones.

References

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