Flexible electrically conductive coatings for solar textiles

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Abstract

In the present work we have studied the possibilities of obtaining conductive surfaces on polyester fabrics by using two types of commercially available conductive polymers; (Panipol) polyaniline, and PEDOT:PSS. Then aluminium thin film was evaporated on top of the polymer so that the fabric became a conductive substrate for inorganic thin film solar cells. We report an investigation of the electrical conductivity and morphology of knife-over-table polymer coated fabrics and their dependence on heat treatment as well as the mechanical properties.

Objectives

Our objectives were to:

- Coat textile samples to provide electrical conductive fibre and fabric samples.
- Investigate electrical conductivity and morphology of the samples.
- Examine the ability of the coated fabric to survive the PECVD process.
- Then in the next stage we were able to deposit amorphous silicon layers directly to form a flexible solar cell [1,2].

Materials

- The textile substrates were plain weave, 100% polyester with 210 filaments in warp and weft and a total loom-state weight of 250gm^{-2}.
- Two conducting polymers, polyaniline (PANI) and poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) (PEDOT:PSS), were included in our tests

Experimental work

1. Textile substrate cleaning

The polyester fabric samples were placed in a solution of 1% detergent (Decon) and deionised water for 30 minutes in an ultrasonic bath. Then the samples were rinsed in flowing deionised water for 15 minutes before being dried by hot flowing air.

2. Plasma treatment

Samples were plasma treated to modify the surface behaviour of a material while retaining its bulk properties [3].

3. Coating of the textile

Various techniques are available for manually coating fabrics such as spraying, brushing and sinking fabrics in a bath of polymer. Our research used a wet coat process for a conductive polymer applied by a simplified knife-over-table method.

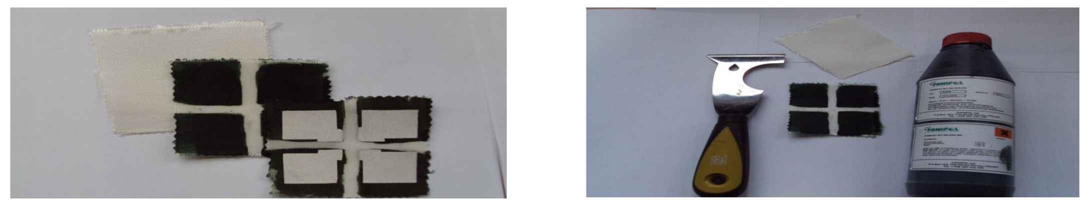


Fig. 1. The left-hand image shows uncoated and polymer coated fabric as well with a metal coating added (sample dimensions (7x7cm) . The right-hand picture shows the knife-over-table coating technique.

4. Metal evaporation

Approximately 100nm of aluminium was evaporated on the polymer coated sample using an Edwards E306A vacuum evaporator.

Fig. 2. Edwards E306A vacuum evaporator which was used to build aluminium layers.

5- Measuring resistances of fabrics and yarns

Surface resistances were measured by a concentric probe in conjunction with a resistance meter.

Yarns were coated with different polymer concentrations by brushing. The resistances were measured for each sample in different lengths in order to analyse the dependence of resistivity on length and polymer concentration.

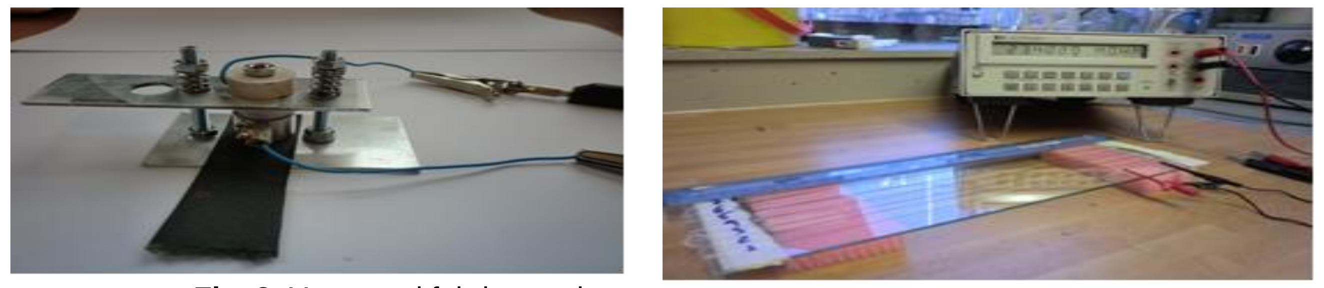


Fig. 3. Yarns and fabrics resistance measurement setup.

6- Contact resistance

Contact resistance measurement of the metal-coated polymer was performed by using the transfer length method (TLM).

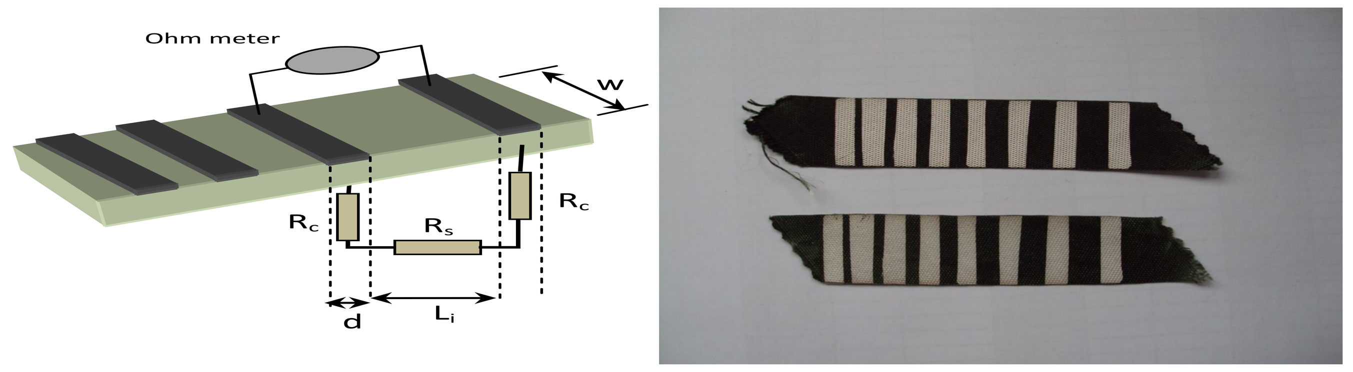


Fig.4. (Right) Real picture for patterned sample. (Left) Transmission line model (TLM) test structure.

7- Mechanical properties

- The first test was to bend the sample vigorously while measuring its surface resistively.
- The second test was to bend the sample systematically over various angles, at the same time measuring its sheet resistivity.

8-Long term stability test

Measuring surface resistivity for a period of time over 2 to 3 days. Resistance was measured by using a UNI-T 60 computerised digital multimeter.

Results and Discussion

- Polymer droplet tests were carried out. As a result, there is an improvement in surface wettability.

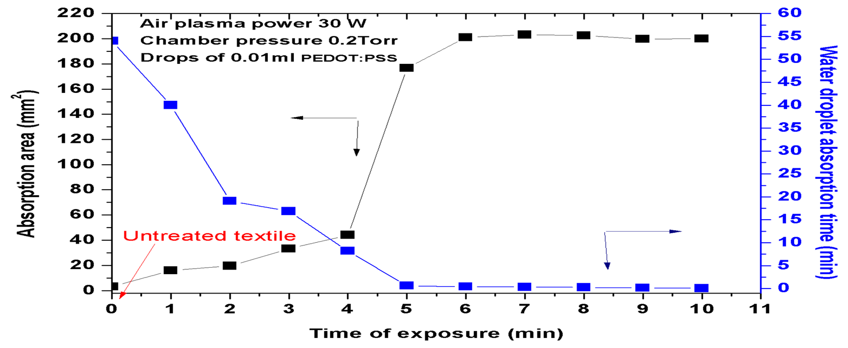


Fig. 5. Droplet absorption area and absorption time as a function of plasma exposure time for polyester fabrics.

- Scanning electron microscopy (SEM) and energy-dispersive X-ray Spectroscopy (EDS), were used to study the deposition of PEDOT:PSS on the surface of the polyester fabric.

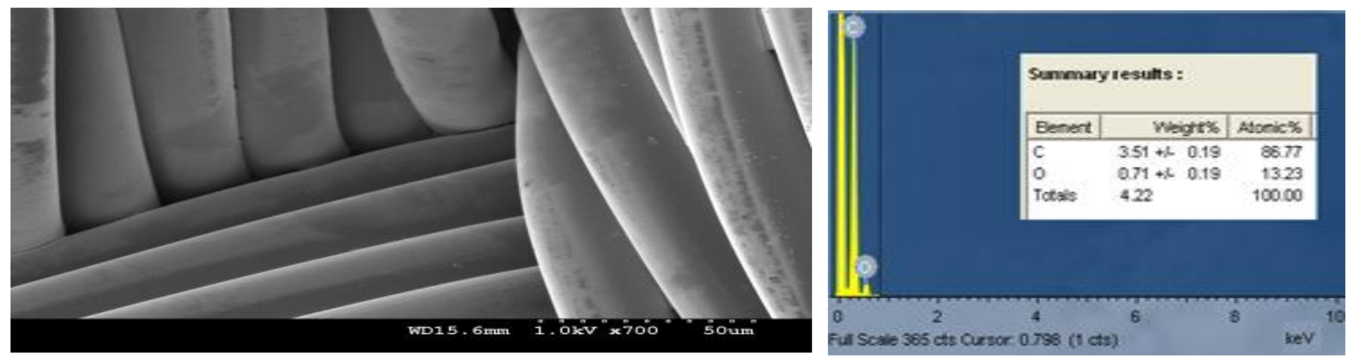


Fig. 6. (Left) SEM for cleaned, heat treated fabrics .(Right)EDS analysis for cleaned, heat treated fabrics

- Changes in the resistance that the Panipol coated textiles exhibited during complete thermal cycling to 200 C and back to room temperature are shown in Figure 7.

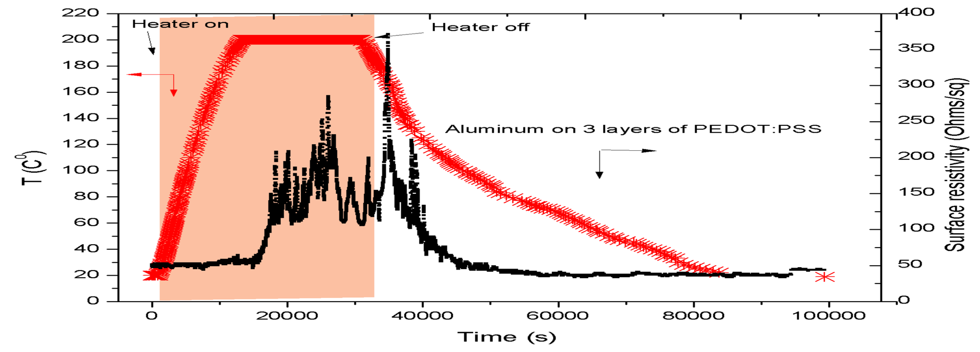


Fig. 7. Thermal annealing test for PEDOT:PSS coated fabric.

- A long term stability test for polyaniline and PEDOT:PSS coated fabrics was performed by measuring surface resistivity for a period of time of 2 to 3 days. Resistance was measured by using a UNI-T 60 computerised digital multimeter.

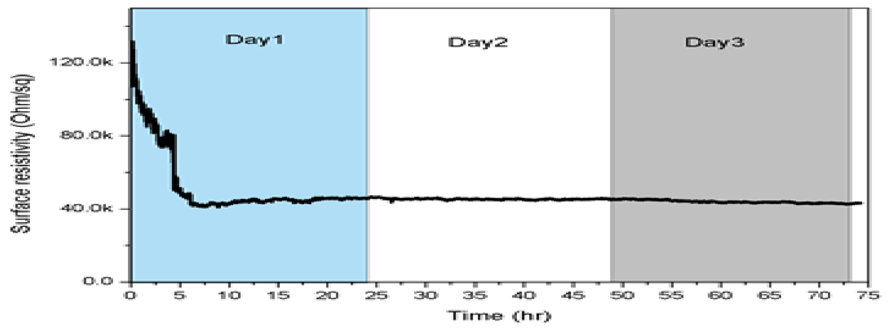
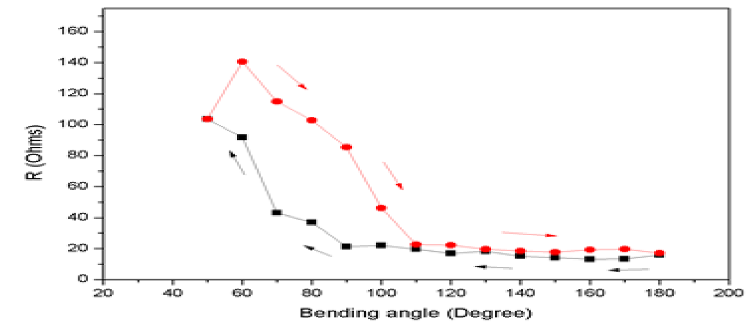


Fig. 8. Time variations of surface resistivity of 3 layers of PEDOT:PSS coated fabric in air ambient at room temperature.

- Two types of bending test were performed. The first type was to bend the sample vigorously while measuring its surface resistivity. The other test was to bend the sample systematically with varying angles, at the same time measuring its sheet resistivity.

Fig. 9. Vigorous bending test of Al/PEDOT:PSS/ fabric sample.



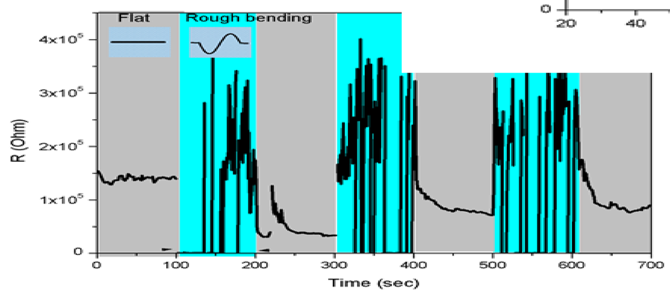


Fig. 10. Bending reliability tests with changing bending angles of PEDOT:PSS coated fabrics.

Conclusion

In order to achieve high quality conductive polymer on fabrics, four important treatment stages were reported in this work: Cleaning the fabrics, thermal calendering of the fabrics, plasma treatment, and degassing the polymer. As a result PEDOT:PSS exhibited better stability than the Panipol. We can confirm that these coated fabrics still possessed their former morphology and flexibility as well as electric conductivity of the polymer/metal contact.

References

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Acknowledgements

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