Adaptation of silver-based screen pastes to achieve stretchable, conductive patterns

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Abstract: Commercially available screen pastes were enhanced with elastomers to be able to print layers with persistent conductivity upon stretching. Best layers were achieved after an addition of elastomeric material up to 3 wt% after a sintering procedure of only 3 minutes at mild (130°C) conditions..

Keywords: screen printing, silver ink, curing, stretchability

Introduction

Recent publications already propose smart designs of patterns to elongate the lifetime of stretched and/or bent conductive tracks [1]. Another option is to formulate inks in such a way that the conductive path stays intact upon deformation. This can be achieved by the addition of flexible components such as carbon based material (graphene [2,3], carbon nanotubes [3]) or by the use of elastomers [4]. In this work, elastomers are added to standard silver screen pastes and the optimal elastomer-to-screen paste ratio is deduced. These enhanced inks were then screen printed on PET foil and a curing procedure was optimized for resulting electrical properties. Finally, stretch tests were performed to learn about the degradation mechanism of the elastomer enhanced inks relative to standard inks.

Results and Discussion

Elastomers were added to an existing silver-based screen paste from 1 wt% up to 7 wt%. The thereby printed samples were then cured at 130°C for different amounts of time and at once Van der Pauw measured for surface resistance. An optimal conductivity was found to be 0,56 Ω/□ with 3 wt% elastomer after 3 min @130°C. The surface resistivity vs. curing time unexpectedly rose again after 3 minutes, indicating an optimum.

An added 50% decrease of surface resistivity was observed for all samples after 24h. By achieving the same results separately; once with standard paste and once on glass, influences of the added elastomers and used PET substrate were ruled out.

EDX surface chemical composition measurements then showed that for both pastes, standard and 3 wt%, more oxygen was present after curing for more than 3 minutes, indicating oxidation of the silver particles. The measurements were then repeated with a control group in the glove box. No noticeable change in oxygen levels at the surface was found and further experiments should indicate if the drop is linked to a further room temperature evaporation of solvents.

As a last step in this work, straight path samples of both pastes on PET foil were stretched up to 3% while measuring their resistance. It is shown that for the standard ink, the rise in sheet resistance was less than for the adapted ink. Upon relaxation, all samples returned to their initial resistance.

Conclusions

Stretchable inks were prepared by adding elastomers to an existing screen paste. It was shown that adding 3wt% of elastomers and curing for 3 min @ 130°C resulted in the best electrical and morphological properties. The rise in sheet resistance after longer curing times was attributed to oxygen uptake and thus oxidation of the conductive paths. Further surface resistance drops in time are thought to be attributed to slow solvent diffusion throughout the printed layer. In a last step, the stretch behaviour of the standard and the adapted ink were compared and it was found that a stretch up to 3% is feasible for the adapted inks upon an increase in sheet resistance of more than 100%. Further stretch tests, up to the 10% range, should indicate the difference in behaviour between the standard and the adapted inks.

References

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