Temperature and Strain evaluation of screen-printed Ag and Carbon-based inks on flexible substrates

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Nowadays the printed electronics technology attracts enormous interest from both the research and the industrial community as it offers the possibility of manufacturing cost-effective innovative devices on flexible substrates [1]. In the context of this work, the behavior of two of the most commonly used commercial ink types inks was studied in detail in relation to temperature and strain [2]. Specifically, the inks that were used in this work are the water based HPR-059 Carbon Black (Carbon content 10 wt%) and the HPS-FG77 Silver Nanoflake (Ag content 85 wt%) from Noavacentrix – USA. Line-shaped devices of different thicknesses were printed using a screen printing semi-automatic machine (Ever-bright, S-200HFC). For the thermoelectric characterization, a standard probe-station system was used in combination with a thermal camera (UNI-T, UNi690B), which was employed to remotely monitor the temperature of the samples. The characterization of the samples under tension was performed by a custom-made system which utilizes a high precision x-y motorized stages with integrated motor and controller system. The Ag-based devises were printed on three different substrates, namely HP premium plus Photo paper (280gr/m^2), Polyamide (PI) film (DuPont Kapton HN, thickness 125μm) and Polyethylene terephthalate film (Polyester, PET, thickness 125μm). In the case of Carbon-based ink, no stable structures could be obtained on glossy paper, thus the evaluation was performed on Kapton and PET substrates.

Fig. 1 presents the relative resistance change as a function of temperature for Ag-based ink structures with three different line-widths (1.0, 1.3 and 1.5mm) on the three different substrates. A positive TCR can be extracted in all the cases with mean values: 2.23×10^{-3}, 3.02×10^{-3}, 4.17×10^{-3} Ω/°C for paper, Kapton and PET substrates respectively. The corresponding evaluation for the Carbon-based ink on Kapton and PET substrates is illustrated in fig. 2, where samples with two different line-widths are indicated (1.3 and 1.5mm). The TCR in this case is negative and can be extracted as: -31.84 and -4.87 Ω/°C for Kapton and PET respectively. The Ag-based ink showed no significant change with strain. In particular, some insignificant changes were presented, that were not systematic and are essentially of no interest. On the contrary in the case of Carbon-based ink quite interesting results were found. Fig. 3 presents the relative resistance change as a function of tension (fig3a) - compression (fig.3b) distance for samples on Kapton with 1.0mm line-width. The graph indicates the response in three successive cycles (push and withdraw). It can be observed that the response in the first cycle is different for the others, which is a behavior that occurs in all samples. Fig. 4a,b presents the corresponding results in the case of PET substrate. A detailed discussion and analysis of all the experimental results will be carried out in the related paper.

References

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[2] Tatiana Treputneva et al., MATEC Web of Conferences 143, 01015 (2018).

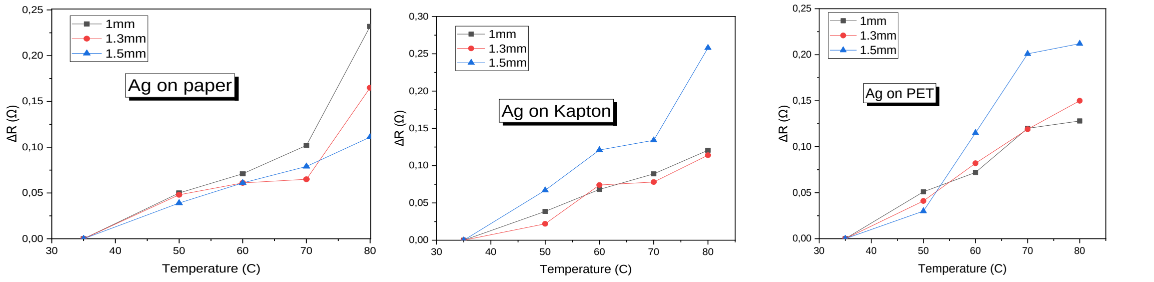


Figure 1: Relative resistance change as a function of temperature for Ag-based ink structures.

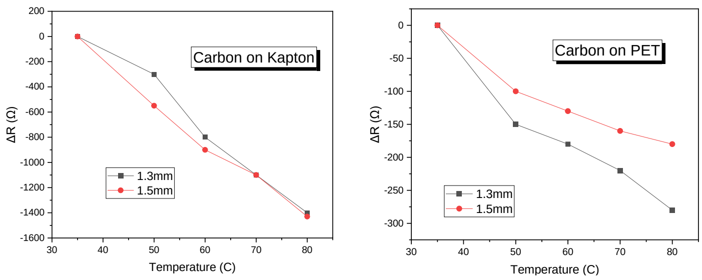
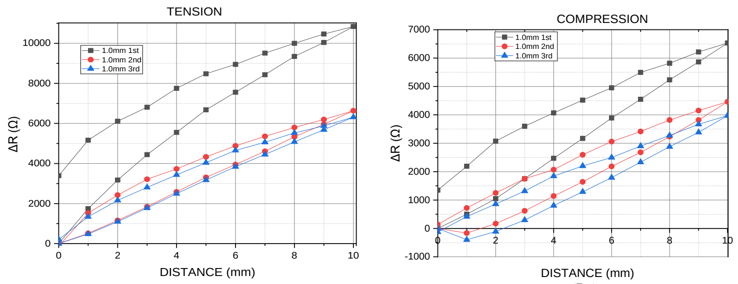
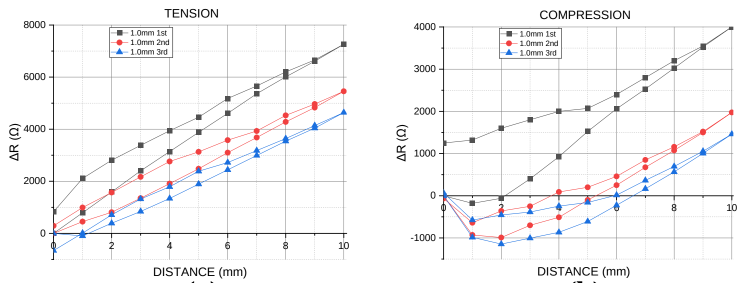


Figure 2: Relative resistance change as a function of temperature for Carbon-based ink structures.



(a) **(b)**

Figure 3: Relative resistance change as a function of compression-tension distance for samples on Kapton



(a) **(b)**

Figure 4: Relative resistance change as a function of compression-tension distance for samples on PET