APPLICATION NOTE

AN1805

TRILION - APPLICATION NOTE

E-Textiles DIC evaluation

Problem Overview

The advent of flexible/stretchable electronics has cultivated the next generation of sensors, photovoltaics, wearable electronics, e-textiles, etc. Accordingly, stretchable batteries must advance with these developments. The first all-printed stretchable (Zn-Ag2O) rechargeable battery using highly elastic conductive inks reported by *Kumar et.al. The mechanical properties are characterized under different strain conditions, by non-contact optical DIC method.

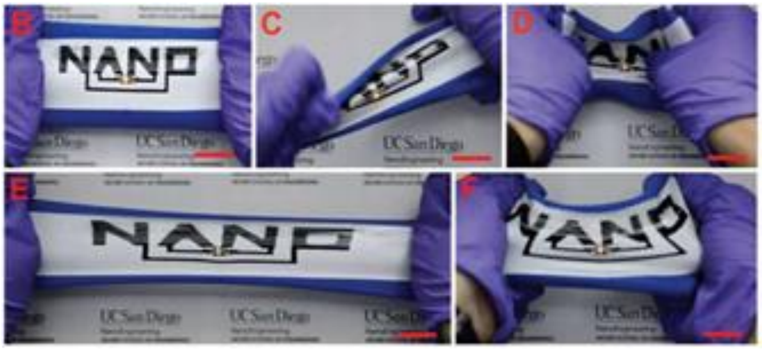

Figure 1. Sealed battery deformation modes.

Notes

The novelty of this work hinges on the attractive hyper-elastic properties (≈1300% elongation) of polystyrene-block-polyisoprene-blockpolystyrene (SIS) as a new elastic binder for stretchable batteries.

Traditional ways to measure displacements and induced deformation and strains, at these ranges, are often shown as inadequate (extensometers contacting samples and influencing measurement, laser extensometer tapes unable to hold at high deformation levels). The ARAMIS Digital Image Correlation (DIC) technology, on the other hand, proved itself useful to map the tensile strain for various stretchable electronic devices, composed of different materials and unique compositions, being a non-contact optical measurement technique.

A DIC strain mapping (εx) of the rectangular carbon electrodes (ratio 1:1, 1:2, and 1:3) is demonstrated from 0% stretching (Fig. 2A,C,E) to 100% stretching in the x-axis (Fig. 2B,D,F). As the electrodes are stretched, there are significant changes in the strain mapping. For all the electrodes, the strain on the textile surface is generally higher than that of the electrode surfaces (Fig. 2G). While a significant drop in the strain is observed at the interface between textile and the electrode, the 1:1 ratio electrode shows the larger drop. Also, the strain distribution on the electrode surface is highly irregular for the 1:1 ratio electrode and is correlated to the physical cracks of the electrode. Such strain distributions are more uniform for the higher SIS-content electrodes, suggesting electrodes with higher SIS content aren't physically cracked in optical scale. Change in resistance during the stretching cycles have been monitored as well (Fig. 2H). At stretched state, the 1:1 ratio electrode has consistently high and unstable resistance due to the electrode cracking observed from the DIC (Fig. 2J). For the other two electrodes, with higher SIS content, the resistance values are stable and similar at the stretched state at around 2.3kΩ. consistently demonstrates the lowest resistance among the three electrodes with 0.65 kΩ (Fig. 2I).

Keywords: E-Textiles, Stretchable batteries, Aramis DIC measurements

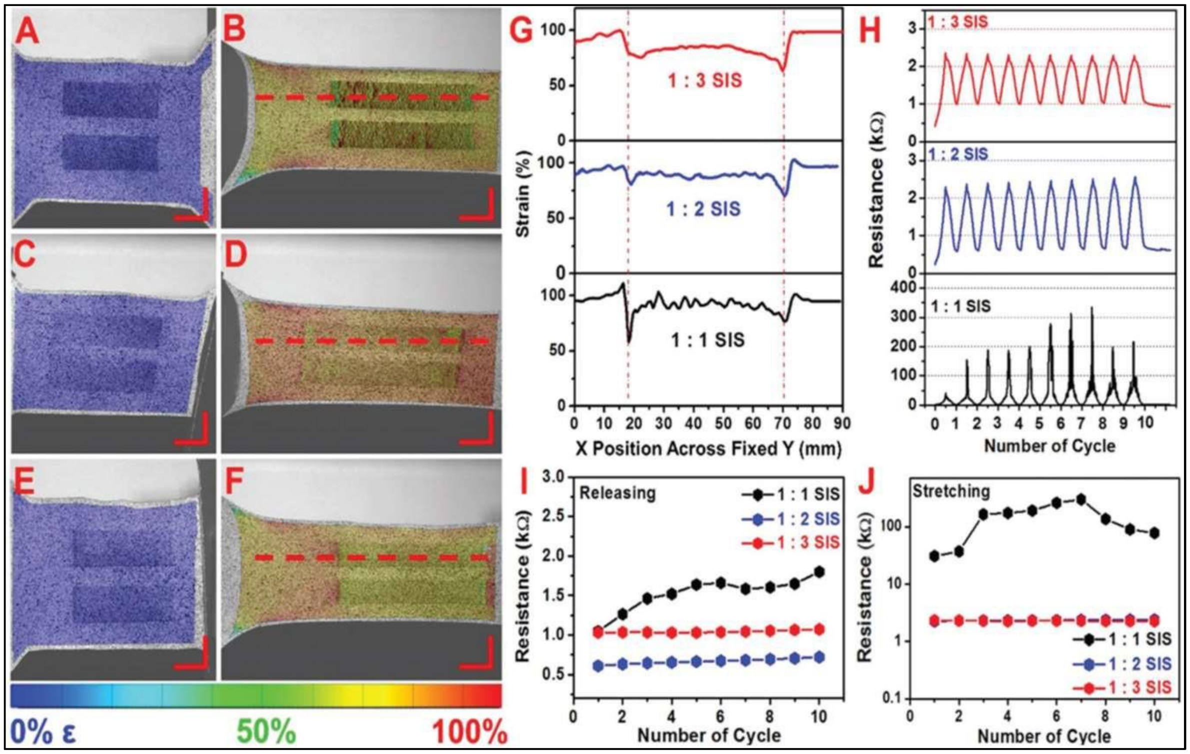

Figure 2 DIC strain mapping of the rectangular carbon electrodes at 0% stretching (A) 1:1 ratio, C) 1:2 ratio, and E) 1:3 ratio) to 100% stretching (B) 1:1 ratio, D) 1:2 ratio, and F) 1:3 ratio). G) The strain plotted over the dotted line. H) Respective resistance monitored during the ten cycles of 100% stretching iterations. Respective resistances at I) release and J) stretching. Scale Bar: 1.0 cm.

Conclusion

The Digital Image Correlation technology was successfully implemented for localized strain analysis of stretchable electronics. Further optimization of the printed deterministic structures, new materials, complemented by non-contact DIC measurements, have the potential to enhance the electrochemical performance and the understanding of the mechanical properties of flexible batteries.

For more information on this application, please contact Trilion Quality Systems, world leader in custom optical metrology.

*R. Kumar, J. Shin, L. Yin, J.-M. You, Y. S. Meng, J. Wang, Adv. Energy Mater. 2017, 7, 1602096.
https://onlinelibrary.wiley.com/doi/abs/10.1002/aenm.201602096

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