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Kirigami Designs for Enhancing the Electromechanical Performance of E-Textiles

Authors : Braden M. Li, Inhwan Kim, Jesse S. Jur

Abstract : One of the fundamental challenges in the electronic textile (e-textile) industry is the mismatch in compliance between the rigid electronic components integrated onto soft textile platforms. To address these problems, various printing technologies using conductive inks have been explored in an effort to improve the electromechanical performance without sacrificing the innate properties of the printed textile. However, current printing methods deposit densely layered coatings onto textile surfaces with low through-plane wetting resulting in poor electromechanical properties. This work presents an inkjet printing technique in conjunction with unique Kirigami cut designs to address these issues for printed smart textiles. By utilizing particle free reactive silver inks, our inkjet process produces conformal and micron thick silver coatings that surround individual fibers of the printed smart textile. This results in a highly conductive (0.63 Ω sq-1) printed e-textile while also maintaining the innate properties of the textile material including stretchability, flexibility, breathability and fabric hand. Kirigami is the Japanese art of paper cutting. By utilizing periodic cut designs, Kirigami imparts enhanced flexibility and delocalization of stress concentrations. Kirigami cut design parameters (i.e., cut spacing and length) were correlated to both the mechanical and electromechanical properties of the printed textiles. We demonstrate that designs using a higher cut-out ratio exponentially softens the textile substrate. Thus, our designs achieve a 30x improvement in the overall stretchability, 1000x decrease in elastic modulus, and minimal resistance change over strain regimes of 100-200% when compared to uncut designs. We also show minimal resistance change of our Kirigami inspired printed devices after being stretched to 100% for 1000 cycles. Lastly, we demonstrate a Kirigami-inspired electrocardiogram (ECG) monitoring system that improves stretchability without sacrificing signal acquisition performance. Overall this study suggests fundamental parameters affecting the performance of e-textiles and their scalability in the wearable technology industry

Keywords : kirigami, inkjet printing, flexible electronics, reactive silver ink
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