

博士論文 (要約)

**Nanofiber-Reinforced Tough Elastic Conductors
for Electronic Textile Applications**

(ナノファイバーによる伸縮性導体の高耐久化と電子テキスタイル応用)

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Abstract

Stretchable conductors are soft, elastic material which can conduct electricity under mechanical deformations. One of the promising approaches is a composite material which consists of conductive fillers and elastomer because of its excellent performance and a capability of simple printing process. It has been studied and exploited as an essential component of biometric sensors to build a conformable interface between human and sensor devices. However, trade-off relationship between conductivity and stretchability is a major technical challenge of stretchable conductors. Especially, mechanical durability such as cyclic durability remained as a challenging reliability issue because improving conductivity tends to make the material stiffer and brittle. Here, we developed mechanical durability of stretchable conductors and demonstrate reinforcement of stretchable conductors with textile fibers and electro-spun nanofibers. Newly developed elastic conductor is designed to permeate fibers easily and form fiber reinforced composites. Fiber reinforcing effect enhanced the toughness, and stretchability of composite material. And the printed tough elastic film enabled strain-dissipative buckling structures. As a result, highly durable electrodes against repeated strain were demonstrated. Initial conductivity of nanofiber-reinforced composite material is 9903 S cm^{-1} in average (11744 S cm^{-1} highest). Initial sheet resistance of $0.04 \Omega/\text{sq}$ and maximum stretchability is up to 450% (800% with buckling structure). It shows excellent cyclic durability. The resistance of printed stretchable wiring increased 1.9 times after 50% strain in 1000 cycles and increased 4.2 times after 100% strain 1000 cycles. Finally, multimodal sensing suits were fabricated by transferring highly durable elastic conductor on textile. Continuous long-term monitoring of ECG, EMG, and motions were demonstrated. This robust stretchable conductor was exploited as electrodes and wirings of wearable strain sensor and EMG monitoring garments.