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Scaling Fiber-Level Innovations into Integrated Textile Electronic Systems

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ABSTRACT
The integration of functional electronics into textiles has catalyzed a paradigm shift in human-centric applications, ranging from continuous healthcare monitoring to immersive human-machine interactions. While commercial electronic textiles have traditionally relied on the direct integration of discrete components, the research frontier has moved toward fiber-level electronics, where functionality is embedded directly into the fiber- or textile-based building blocks. However, the realization of high-performance fiber electronics is hindered by several formidable challenges. Key among these is the difficulty of establishing stable interfaces between rigid electronic materials and soft fibrous substrates. Furthermore, it remains critical to create a seamless bridge between human physiology and electronic systems, while simultaneously ensuring long-term environmental sustainability. This presentation will highlight our multidisciplinary efforts to bridge textile engineering and flexible electronics through scalable fiber fabrication and the development of advanced functional materials. These strategies have led to the creation of durable functional fibers and conductive textiles that maintain high performance under demanding conditions. By rigorously investigating materials-structure-performance relations, we establish these fiber-based materials as fundamental building blocks for next-generation textile-based iontronics and electronics. Furthermore, we demonstrate the versatile applications of these integrated systems in rehabilitation, biomedical engineering, and soft robotics, paving the way for more resilient and intelligent wearable technologies.