


Chapter 4


Nanomaterials and Conductive Polymers in E-Textiles Toward Smart and Sustainable Wearables

Manu Mehrotra

 <https://orcid.org/0009-0003-4841-1589>


Sharda University, Agra, India

Manish Baboo Agarwal

 <https://orcid.org/0000-0003-1177-2738>


Sharda University, Agra, India

Seema Agarwal

 <https://orcid.org/0000-0002-5655-207X>

SRM Institute of Science and Technology, Ghaziabad, India

Shahjad Ali

 <https://orcid.org/0000-0002-9725-3498>

Sharda University, Agra, India

ABSTRACT

The integration of nanomaterials and conductive polymers is transforming electronic textiles (e-textiles) by combining textile attributes like softness and comfort with advanced functionalities such as physiological monitoring, interactive interfaces and energy storage. Nanomaterials like carbon nanotubes (CNTs) and graphene enhance electrical conductivity and mechanical robustness, allowing for the de-

DOI: 10.4018/979-8-3373-4287-0.ch004

velopment of flexible textile sensors, batteries, and heating textiles. Conductive polymers, such as polyaniline and polythiophene, offer durability and breathability without the oxidation issues of metals, enabling specific applications like physiological monitoring. However, challenges remain, including stability under mechanical stress, long-term functionality and ecological concerns related to nanomaterials. Addressing cost-effectiveness and sustainability through recyclable designs is also essential. Ultimately, the goal is to create smart fabrics that seamlessly integrate advanced electronic capabilities while enhancing health monitoring and communication functions.

INTRODUCTION

Electronic textiles, often termed e-textiles, mark an innovative blend of everyday fabric and state-of-the-art electronics. By weaving or printing sensors, batteries, microcontrollers and tiny lights directly onto cloth, developers turn passive textiles into responsive surfaces that can measure temperature, light up, or even notify a smart phone. The idea is not as modern as it seems, the first related patent appeared in the 1930s, but the progress waited until the twenty first century (Ehrmann & Ehrmann, 2021). Since then smaller chips, flexible circuits and low cost production have gained interest in hospitals, athletes and soldiers that has pushed e-textiles to the heart of research and the marketplace.

Introduction and Significance of E-Textiles

E-textiles are a mixture of the softness, stretch and breathability of everyday fabric with built in electronic capabilities, opening doors that only gadgets and typical textiles cannot reach. These intelligent fabrics wrap around the body much like a second skin, allowing data exchange and control to occur in a quiet, almost invisible way. Manufacturers attach sensors and circuits to threads by weaving, knitting, embroidering, or printing them directly onto the cloth surface (Dulal et al., 2022). Conductive inks, carbon nanofibers and flex friendly polymers are used through the yarn, while miniature batteries and microcontrollers slip between fabric layers.

This set up turns the fabric into a wearable hub that tracks heart rate, skin temperature and movement, heats up on cold days, lights up for safety at night, stores power and chats with smartphones, all without sacrificing the familiar feel of a cotton fabric.

Electronic textiles already serve in several vital areas, each of which insists on a distinctive blend of properties. In health care, for example, seamless garment sensors monitor heart and breathing rates or track muscle strain, making them equally useful

26 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: www.igi-global.com/chapter/nanomaterials-and-conductive-polymers-in-e-textiles-toward-smart-and-sustainable-wearables/396171

Related Content

Design and Analysis of a High-Bandwidth Wearable Antenna With Rectangular DGS on Jeans Fabric for Advanced Healthcare Applications

Ajay Tiwari, Somesh Malhotra and Shiv Mohan Mishra (2025). *Design and Simulation of Wearable Antennas for Healthcare* (pp. 91-116).

www.irma-international.org/chapter/design-and-analysis-of-a-high-bandwidth-wearable-antenna-with-rectangular-dgs-on-jeans-fabric-for-advanced-healthcare-applications/356816

A Diamond Cut Leather Substrate Antenna for BAN (Body Area Network) Application

Raghav Agrawal, Pramod Sharma and Anurag Saxena (2021). *Emerging Materials and Advanced Designs for Wearable Antennas* (pp. 54-59).

www.irma-international.org/chapter/a-diamond-cut-leather-substrate-antenna-for-ban-body-area-network-application/272981

Wearables for Performance Support and Learning

Byron Havard and Megan Podsiad (2018). *International Journal of Mobile Devices, Wearable Technology, and Flexible Electronics* (pp. 37-50).

www.irma-international.org/article/wearables-for-performance-support-and-learning/235487

Blockchain-Empowered Data Security and Privacy-Preserving Framework for Wearable Medical Devices

A. Sasikumar, P. Selvakumari, P. Rajasekar, S. Wilson Prakash and Imran Javeed Settu (2026). *Wearable Medical Device Security and Network Protection for Reliable Healthcare* (pp. 167-194).

www.irma-international.org/chapter/blockchain-empowered-data-security-and-privacy-preserving-framework-for-wearable-medical-devices/397143

Investigation of Smart Wearable Technology for Healthcare Educational Analytics and Applications

Nilamadhab Mishra, Anand Motwani, Saroja Kumar Routand Arul Kumar Natarajan (2025). *Wearable Devices and Smart Technology for Educational Teaching Assistance* (pp. 169-190).

www.irma-international.org/chapter/investigation-of-smart-wearable-technology-for-healthcare-educational-analytics-and-applications/366858