


Chapter 3


Foundations and Emerging Trends in Electronic Textiles: Bridging Conductive Materials With Smart Wearable Applications

Pranshu Saxena

 <https://orcid.org/0000-0002-0822-1532>

Bennett University, Greater Noida, India

Mandeep Singh


 <https://orcid.org/0000-0003-3278-4877>

Bennett University, Greater Noida, India

Sanjay Kumar Singh

Guru Gobind Singh Indraprastha University, East Delhi, India

Aatif Jamshed

 <https://orcid.org/0000-0003-3152-6147>

KIET Group of Institutions, Delhi, India

Pawan Kumar

Ajay Kumar Garg Engineering College, Ghaziabad, India

ABSTRACT

Electronic textiles (e-textiles) embed sensing, actuation, power and communication into fabrics using conductive yarns, polymers and nanomaterials. This chapter consolidates conductor classes—metallic fibers, intrinsically conductive polymers, carbon nanomaterials and hybrids—and compares integration routes such as

DOI: 10.4018/979-8-3373-4287-0.ch003

weaving/knitting and printing/coating with attention to washability and mechanical robustness. It reviews standardized electrical, mechanical and environmental tests and distills lessons from deployments in healthcare, sports and defense. Key gaps include durability after laundering, power autonomy, wearer comfort, data security and scale-up. We outline directions in self-healing and encapsulation, hybrid energy harvesting and storage, stretch-resilient interconnects and on-garment machine learning. Linking material selection to process capability and system integration, the chapter offers a decision-oriented roadmap for sustainable and user-centric smart wearables.

1. INTRODUCTION

The rapid convergence of materials science, electronics, and textile engineering has given rise to *electronic textiles* (e-textiles), a transformative technology with applications spanning healthcare, sports, defense, and everyday life. Unlike conventional wearables, which integrate rigid electronic modules into separate casings, e-textiles embed sensing, actuation, and communication capabilities directly into fabrics through conductive yarns, nanomaterials, and advanced polymer composites. This approach offers unprecedented flexibility, comfort, and adaptability, paving the way for truly ubiquitous and unobtrusive smart wearables (De Fazio et al., 2023; Zaman et al., 2025).

Table 1 summarizes the fundamental categories of conductive materials used in smart textile systems, including metallic fibers, intrinsically conductive polymers, carbon-based nanomaterials, and hybrid composites. Each category exhibits distinct electrical, mechanical, and durability characteristics that influence device performance and application suitability. For example, metallic yarns excel in conductivity but may compromise comfort, whereas carbon nanotube coatings offer high flexibility with moderate conductivity.

Table 1. Application Domains and Requirements for Smart Wearables

Domain	Primary Functions	Material Requirements	Example Technologies
Healthcare	Vital signs monitoring, rehabilitation aids	Biocompatibility, washability	ECG shirts, smart compression bandages
Sports	Performance tracking, injury prevention	Flexibility, sweat resistance	Pressure-sensing insoles, motion capture wear
Defense	Soldier health monitoring, tactical comms	Durability, environmental resistance	Ballistic vests with sensors, GPS uniforms
Consumer	Gesture control, entertainment	Lightweight, aesthetics	Smart gloves, music-responsive clothing

16 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/foundations-and-emerging-trends-in-electronic-textiles/396170

Related Content

Wi-Fi Enabled Textile and Wearable Antennas for Healthcare Devices

Sima Noghianian, Ala A. Alemaryeen, Reem Shadidand Shahid Muhammad Ali (2025). *Design and Simulation of Wearable Antennas for Healthcare* (pp. 1-66). www.irma-international.org/chapter/wi-fi-enabled-textile-and-wearable-antennas-for-healthcare-devices/356814

Remote Robot-Sensor Calibration Service: Towards Cyber Physical Robotics

Tapio Heikkilä, Tuomas Seppälä, Timo Kuulaand Hannu Karvonen (2019). *International Journal of Mobile Devices, Wearable Technology, and Flexible Electronics* (pp. 15-36). www.irma-international.org/article/remote-robot-sensor-calibration-service/268889

AI-Driven Adoption and Management Strategies for Advanced Smart Fabrication in Global Manufacturing Enterprises

Swati Jain, Vishakha Aggarwal, Mansi Agarwal, Priyanka Devi, Soniyaand Ramendra Singh (2026). *Next-Generation Electronic Textiles and Conductive Materials for Smart Wearables* (pp. 371-400). www.irma-international.org/chapter/ai-driven-adoption-and-management-strategies-for-advanced-smart-fabrication-in-global-manufacturing-enterprises/396181

Design and Simulation of Wearable Antennas for Healthcare

Ushaa Eswaran, Vishal Eswaranand Gopinath P. G. (2025). *Design and Simulation of Wearable Antennas for Healthcare* (pp. 163-200). www.irma-international.org/chapter/design-and-simulation-of-wearable-antennas-for-healthcare/356820

Review on the Development of Solid State Transformer

Bharat Bhushan Khare, Rajeev Shankar Pathak, Sanjeev Sharmaand Vinod Kumar Singh (2021). *Emerging Materials and Advanced Designs for Wearable Antennas* (pp. 119-126). www.irma-international.org/chapter/review-on-the-development-of-solid-state-transformer/272987