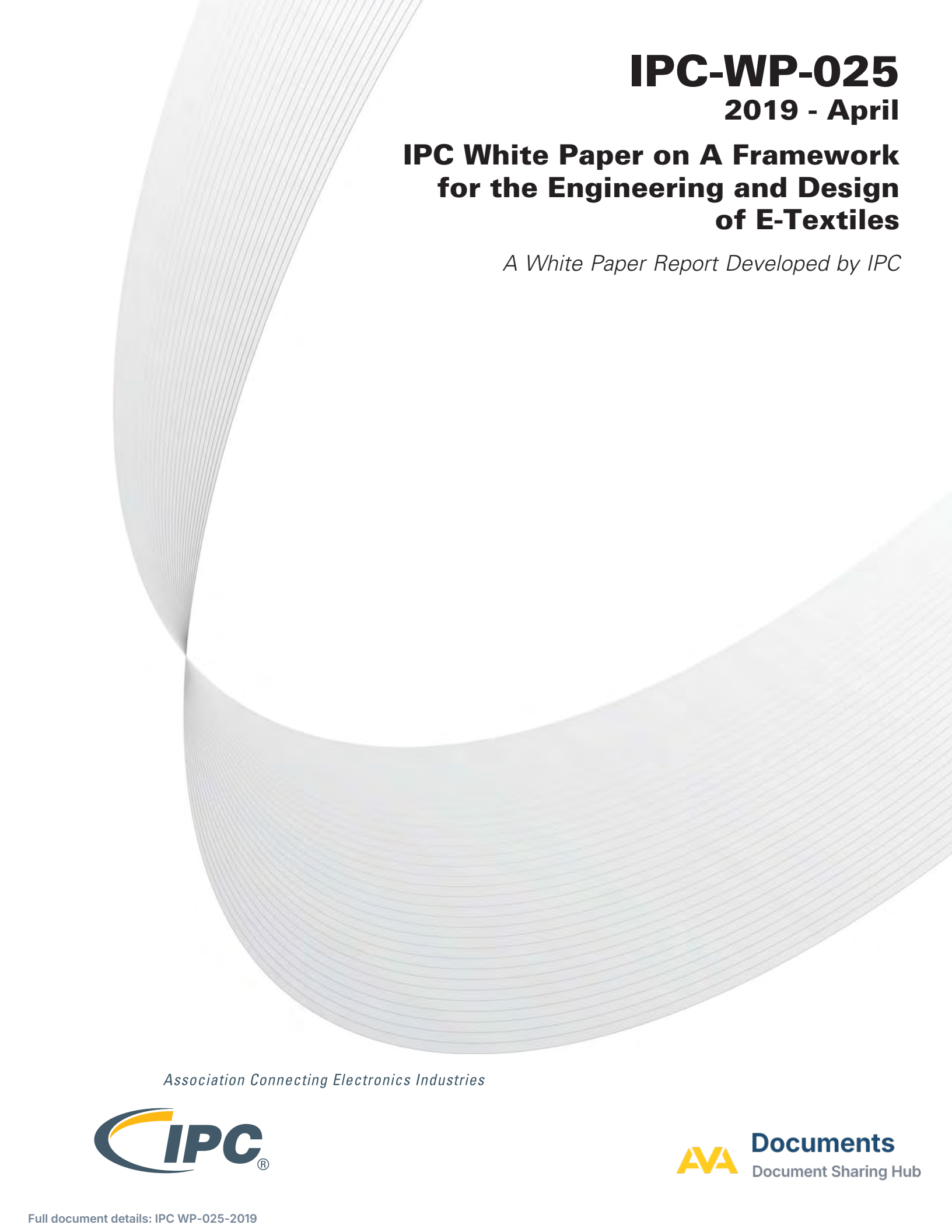




IPC-WP-025

2019 - April

IPC White Paper on A Framework for the Engineering and Design of E-Textiles

A White Paper Report Developed by IPC

Association Connecting Electronics Industries



The Principles of Standardization

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Standards Should:

- Show relationship to Design for Manufacturability (DFM) and Design for the Environment (DFE)
- Minimize time to market
- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feedback system on use and problems for future improvement

Standards Should Not:

- Inhibit innovation
- Increase time-to-market
- Keep people out
- Increase cycle time
- Tell you how to make something
- Contain anything that cannot be defended with data

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IPC-WP-025

IPC White Paper on A Framework for the Engineering and Design of E-Textiles

Developed by the E-Textiles Committee (D-70) IPC-WP-025 White Paper
Review Team of IPC

Users of this publication are encouraged to participate in the
development of future revisions.

Contact:

IPC
3000 Lakeside Drive, Suite 105N
Bannockburn, Illinois
60015-1249
Tel 847 615.7100
Fax 847 615.7105



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**E-Textiles
Committee**

Co-Chairs

Stephanie Rodgers
Apex Mills, Inc.

Carole Winterhalter

US Army, AFC, Combat Capabilities
Development Command Soldier Center

**Technical Liaison of the
IPC Board of Directors**

Bob Neves

Microtek (Changzhou) Laboratories

IPC-WP-025 White Paper Review TeamMaryAlice Gill, Nypro Consumer
Health

Birgit Leitner, Propel LLC

Pratyush Rai, Nanowear, Inc.

Stephanie Rodgers, Apex Mills, Inc.

Sharon Tracy, Steelcase, Inc.

IPC-WP-025 Author

This white paper was authored by Madison Maxey, LOOMIA Technologies, Inc.

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IPC White Paper on A Framework for the Engineering and Design of E-Textiles

IPC-D-70 E-Textiles Committee White Paper Introduction

This white paper is a benchmarking exercise of e-textile integrations, providing an introductory categorization of how the current market sector is using textile-based electrical components to achieve integrated functionality. This peer assessment provides a baseline understanding of e-textile process techniques, requirements and resources within this emerging sector.

The D-70 Committee seeks your feedback on this white paper and your interest in writing similar white papers on your research and activities involving e-textiles-based materials, design concepts, technologies and end-products.

Email white paper proposals, feedback on this white paper or issues and questions about e-textiles standards to etextiles@ipc.org.

Executive Summary

Established technical industries, such as software development or garment production, have common pools of knowledge that create a design framework. For example, any garment designer or manufacturer would understand that behind every garment there is a paper pattern, a sewn sample with edits and a final tech pack that is used for production. Any one of those parts of the framework can be pointed to and edited along the path of making the final garment. For software, one might know that any website you use has a front end and back end. Server and software engineers often specialize in one part of this stack, allowing deep discovery in one area. For e-textiles, we often refer to the entire e-textile product with one term. There lacks a sense of clarity around the parts that make up an electronic textile, and the purpose that each part serves. When we better specify each element that goes into an e-textile, we can better communicate with engineering teams, manufacturers and suppliers. This white paper suggests a framework—or a stack—that can be used to think about e-textile development.

Introduction

“Very few users get deeply immersed in flexible circuit boards. It takes five to seven years working with it every day before you understand all the aspects of flexible circuit designs.” – Mark Finstad, vice chair of the IPC D-11 Flexible Circuits Design Subcommittee

As Mark Finstad states, it can take five to seven years of working with flex printed boards every day to understand their complexity. Similarly, e-textiles can take years to fully grasp. Because the e-textiles industry is not fully developed, few people have experience making scalable, robust and reliable e-textiles at affordable costs for such a period of time. Forster Rohner and OhmaTex are examples of groups that have been focused on manufacturability and scalability for at least five years.

The framework in this paper has been developed through extensive research and testing. This includes teardowns, knitted circuits, stenciled circuits, plotted circuits and others. This white paper includes references to projects and products that support the conclusions drawn.

Applicable Documents

IPC¹

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronics Circuits

UL²

UL 130 Standard for Electric Heating Pads

UL 964 Standard for Electrically Heated Bedding

UL 746C Polymeric Materials – Use in Electrical Equipment Evaluations

UL 2595 General Requirements for Battery-Powered Appliances

1. www.ipc.org
2. www.ul.com

American Association of Textile Chemists and Colorists (AATCC)³**AATCC EP13** Electrical Resistance of Electronically Integrated Textiles**Acronyms List**

AATCC – American Association of Textile Chemists and Colorists

AFFOA – Advanced Functional Fabrics of America

CE – Conformité Européenne

FCC – Federal Communications Commission

FTC – Federal Trade Commission

I/O – Input/output

IEC – International Electrotechnical Commission

IFAI – Industrial Fabrics Association International

ISO – International Organization for Standardization

LED – Light-emitting diode

NFC – Near-field communication

PDMS – Polydimethylsiloxane

PPE – Personal protective equipment

RH – Relative humidity

TPU – Thermoplastic polyurethane

USB – Universal serial bus

Terms and Definitions

Printed board – A composite structure incorporating point-to-point interconnections for electronic circuits. It may include embedded components. (This includes single-sided, double-sided, multilayer, rigid, rigid-flex, and flex constructions.) Source: IPC-T-50

Lining – A fabric lining in a garment is the layer of fabric that is closest to the skin and covers internal seams of the garment shell.

Flexible printed board – A printed board using a flexible base material only. May be partially provided with electrically nonfunctional stiffeners and/or coverlay. Source: IPC-T-50

Bend radius – The radius limit that a material can bend before exhibiting signs of permanent change or damage.

Multidimensional flex – The ability to flex in more than one direction at a time.

Common Descriptions for E-Textiles

In addition to the industry terms listed in the Terms and Definitions section, there are many evolving terms used in the e-textiles sector.

The most popular terms used in the industry are functional fabrics, e-textiles, smart fabrics and soft circuits. Advanced Functional Fabrics of America (AFFOA) prefers the term functional fabrics, which covers a wide range of active and passive materials. Yoel Fink, the CEO of AFFOA, has a background in fiber optics and focuses on making fiber optic threads that have function to be woven into textiles. Industrial Fabrics Association International (IFAI) prefers to use the term smart fabrics. Both terms, smart fabrics and functional fabrics, include passive materials in their definitions. This paper focuses specifically on active materials that are essentially circuits with additional mechanical properties.

Soft circuits is a term that is mostly used by makers in the space. This term mostly represents conductive thread, or hand-made circuits that are developed onto or into a textile substrate. Famed makers in this space include Hannah Perner Wilson of KOBAKANT, Lara Grant and Maggie Orth. Ben Cooper of FLEX is expanding the definition of this term with the word soft systems. Soft is also used by Stretchsense to define their soft sensors.

Others in the space are technical designers who focus less on the enabling technology and more on the larger category of wearable technology. Yuchen Zhang and Hellyn Teng at Wearable Media Group are a great example of this category.

E-textiles is a more technical term (meaning electronic textiles or electronically integrated textiles) that seems to be used by both the maker and engineering communities. One can find this term used to name papers (such as “E-Textile Technology,”

3. www.aatcc.org