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Printed electronics

Part 250: Material technologies required in printed electronics for wearable smart devices

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National foreword

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Printed electronics – Part 250: Material technologies required in printed electronics for wearable smart devices

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PRINTED ELECTRONICS –

Part 250: Material technologies required in printed electronics for wearable smart devices

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IEC TR 62899-250, which is a Technical Report, has been prepared by IEC technical committee 119: Printed electronics.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
119/104/DTR	119/123/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62899 series, published under the general title *Printed electronics*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,
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INTRODUCTION

Recently, along with a variety of other expanding electronic technology applications, one in particular has gained a lot of attention from different angles. It is referred to as "wearable electronics". As the name of this new application implies, unlike other electronic technologies, these are to be attached or applied directly to the human body, such as traditional eyewear. Due to the particular characteristics of the human body, such as flexibility, this new technology requires a variety of new and unique capabilities, which other electronics applications do not need.

In order to realise such applications, electronic technologies are evolving in many areas. One area of special interest in electronic technology is a new process for producing devices themselves, called "printed electronics". Unlike conventional production processes called "subtractive processes", which use subtracting techniques to produce functional devices, printed electronics (PE) use an additive process using additional techniques by putting functional materials onto base materials.

Since these electronic technologies are new and rapidly evolving, there are no established means for their evaluation. This Technical Report intends to resolve this situation from certain angles and give some guidance for future standardization work in wearable electronics.

PRINTED ELECTRONICS –

Part 250: Material technologies required in printed electronics for wearable smart devices

1 Scope

This part of IEC 62899, which is a Technical Report (TR), explores a new technological field to establish standardization activities in TC 119 (Printed electronics) in particular, and to contribute to the development and market expansion of wearable smart device (WSD) technology.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

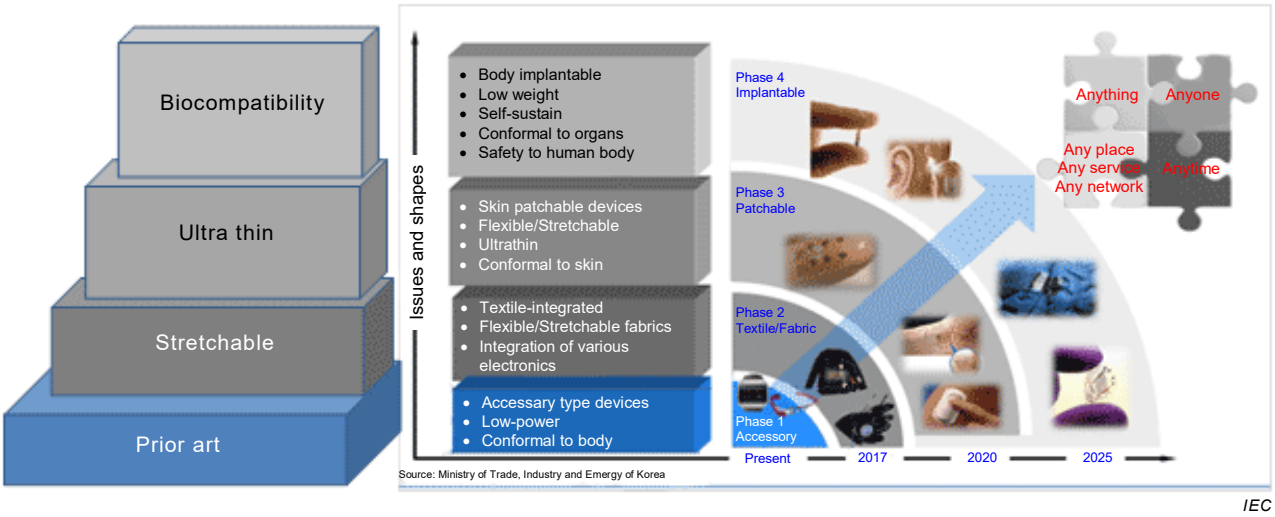
4 What are WSDs?

Wearable smart devices are a newly evolving electronic application field where standards for conventional electronic devices may not be smoothly applicable. In this new field, electronic devices are applied or attached directly to the human body like eyewear, contrarily to conventional electronic devices, such as TV sets, that are most likely to be used away from the body. Due to the particular characteristics of the human body, these new devices are required to have new physical characteristics, such as flexibility and salt resistance (anti-sweat). In order to address those demands, the electronics industry has come up with new processes to produce those new devices.

5 WSDs

5.1 General

Figure 1 shows an overview of WSDs, including categorization and examples. This graphic introduces categories based upon characteristics, such as ‘prior art’, ‘stretchable’, ‘ultra-thin’ and ‘biocompatibility’, and some examples in each category. Technologies and challenges for those examples are discussed in Subclauses 5.2 to 5.5.



Source: http://iecetech.org/issue/2015-01/What-s-up

Figure 1 – WSD technologies and market

5.2 Accessory type devices

Accessory type devices are designed to be a good fit for the shapes of the human body. The major functions of these devices are to acquire vital data and/or movement of the body, and to transfer data to other devices and/or networks without human interaction, unlike cell phones or portable music players, which require human interaction. For example, the following WSDs are already commercialized:

– bracelets, watches and wristbands;
– eyewear and headmounted devices;
– earphones;
– finger rings, necklaces and the like.

In order to realize these devices, adaptation of the following characteristics is required:

– a small footprint,
– lightness,
– lower power,
– mechanical flexibilities to follow body movement, and
– if needed, display functions with higher resolution and/or mechanical flexibilities.

Obviously and most importantly, in addition to fulfilling these electrical or mechanical needs, additional safety requirements and regulations need to be developed, since WSDs will operate in close contact with the human body.

5.3 Textile integrated type

Textile integrated type WSDs combine integrated biomedical signal acquisition functions with communication functions attached to clothing such as sportswear or underwear. This type of WSD needs complementary technologies compatible with the electronic components and textile products that make up the clothes. Specifically, highly flexible and stretchable wiring technologies are required. Furthermore, electronic components need to withstand stresses similar to those general clothing is subjected to, such as stresses which occur during washing and drying.

5.4 Skin patchable type

WSD types used in patches directly applied to the skin or mucous membranes of the body surface have been proposed. Such WSDs, in addition to the necessities of functional shape and flexibility, require technology for obtaining very thin electronic elements. Additionally, in order to evaluate the very thin electronic elements, new evaluation methods will be required. Furthermore, because these types of WSDs are in continuous direct contact with the human body, they require resistance to secretions from the body such as sweat or saliva.

5.5 Body implantable type

In Figure 1, WSDs are shown to be expected to eventually develop into types which are implanted into the human body. High biocompatibility is required for WSDs at this stage.

6 New standardization project for WSD technologies

6.1 Current WSD technologies and standardization activity

Table 1 shows a summary of electronic technologies and materials applied to portable electronic equipment and WSDs. WSDs are used in different environments and under different conditions compared to conventional electronic devices. New standards are required for the construction and material performance of such devices, as are new evaluation and testing methods, which existing standards fail to meet.

Table 1 – Wearable technologies map

Electronics Technplogies Materials, Process		Portable	Wearable Smart Devices							PE potential	Related standards organizations
		Portable	Accessary type				Textile-integlated	Skin patchable	Body implantable		
			Hands	Head, Eyes	Ears	Others					
Examples		Mobile phone, Tablet	Wristband	HMD Eyeglass	Hearing aids	Ring Necklace	Smart Ware	Biosensors	Artificial organ		
Compact and lightweight	Small components	3	3	3	3	3			3	Thin parts	IEC/TC47, IEC/TC40(C&R), IEC/TC51WG9
	High-density 3D electronics packaging	3	3	3	3	3			3	Multilayer PE	IEC/TC91,IPC·JPCA, SEMI
	Compact system	3	3	3	3	3			3	Thinner	IEC/TC100
Low power consumption	Small and thin battery	3	3	3	3	3	3	3	2	Thin battery	IEC/TC21
	Non-contact power supply	3	3	3	3	3	3	3	2		WPC:Wireless Power Consortium
High-definition curves display	High resolution	3	3								IEC/TC110
	Near the eye			1						Near Eye Display	IEC/TC110
	Flexible display	1	1							Film substrate device	IEC/TC110, IEC/TC119WG5
Free 3D design	High flexion	2	2	2			2	2		Film substrate device	IEC/TC91, IPC·JPCA
	3D molding and wiring		2	2	2	2			1	3D printer, 3D molding	(MID)
	Deformation and stretch						1	2		Stretchable	
	Ultrathin						2	1		Ultra-thin device, process	
Adhesion	Skin contact							1		Ultra-thin device, process	
Environmental compliance	EMC	3	3	3	3	3	3	3	2		IEC/TC77
	Weather (light) resistance						2	2			ISO/TC38, ISO TC42 WG5
	water resistant						2	2	1		ISO/TC38
	Waterproof property	3	3	3	3	3			1		IEC/TC70
	The resistance to body fluids (sweat, blood, etc.)						1	1	1	Anti-sweat, anti-blood	ISO/TC38
	Environmental pollution, 3R / LCA	3	3	3	3	3	3	3	2	Additive process	IEC/TC111
Safty	Electrical safety	3	3	3	3		3		2		IEC/TC108
	Electromagnetic wave exposure, SAR	3	3	3			3		2		IEC/TC106, CISPR
	Static electricity						2				IEC/TC101
	Optical and ultraviolet light exposure			2							IEC/TC108
	Biological skin safty		2	2	2	2	2	1		Biocompatibility	IEC/TC62, ISO/TC194, ISO/TC210
	In vivo safty								1		IEC/TC106, ISO/TC194, ISO/TC210

Urgency
High 1
Medium 2
Low 3

6.2 Required standardization for WSD

A variety of portable electronic devices are available and commonplace, as consumers have become comfortable using them in their daily lives. Manufacturing technologies for portable electronic devices are studied with safety requirements and product performance criteria in mind, which have been developed by each TC under the IEC or one of many other organizations.

Required technologies for manufacturing portable electronic devices include those related to the following: downsizing and weight reduction, small power supplies, inductive power supplies (wireless charging), power-saving, high-definition displays, sustainable design, product safety performance. These listed technologies will apply to WSDs and additional requirements will be determined.

Below, individual technical elements and their correspondence to existing standardization activities are shown.

a) Compact and lightweight

Technologies for compact and lightweight electronic devices are further classified into the following areas:

- small components,
- high-density 3D electronics packaging, and
- compact systems.

Small components are covered by IEC TC 47, IEC TC 40 (Capacitors and resistor), and IEC TC 51. Similarly, standardization for high-density 3D electronics packaging is handled by IEC TC 91 and IEC TC 100.

b) Low power consumption

Power supply technologies to small electronic devices are divided into two areas:

- small, thin and flexible batteries,
- non-contact power supplies.

Standardization of batteries is covered by IEC TC 21. Standardization for non-contact power supply technologies is handled by the WPC (Wireless Power Consortium).

c) High-definition curved display

When displays are used for WSDs, display equipment is required for the following technologies:

- high resolution,
- near the eye,
- flexible displays.

Standardization for display devices are handled by IEC TC 100.

d) Free 3D design

To achieve high shape flexibility, the following technologies are needed:

- high flexion,
- 3D moulding and wiring,
- deformation and stretch,
- ultra thinness.

Standardization for high-flexion flexible printed circuits has been carried out by IEC TC 91, IPC and JPCA.

MID technology refers to the combination of 3D moulding and wiring technology. This technology has been proposed by MIDIA (MID International Association).

The standardization activity for technology using 3D printers for the electronic circuit formation is undetermined. 3D technology that combines printing and embossing are newly developed so the standardization activity for the technology is yet to be defined. Very thin electronic devices will achieve higher shape freedom in the future, as to date, however, they are difficult to evaluate by the existing standards.

e) Adhesion

Standardization of adhesives is covered by ISO TC 61 / SC 11 (polymeric adhesive). However, technology for the direct patching of electronic devices on human skin is not included.

f) Environmental compliance

There are a number of standardization activities for environmental compliance:

- EMC,
- weather (light) resistance,
- water resistance,
- waterproofness,
- resistance to bodily fluids (sweat, blood, etc.),
- environmental pollution, the 3 Rs (reduce, reuse and recycle) / LCA (life-cycle assessment).

EMC is covered by IEC TC 77. Weather (light) resistance, water resistance, the resistance to bodily fluids (sweat, blood, etc.) are the challenges unique to WSDs. ISO TC 38 is the standardization activity for textiles, and deals with many of the related issues. Waterproof properties are covered by IEC TC 70. Environmental pollution, the 3 Rs/LCA is covered by IEC TC 111. Weather-resistance of print is covered by ISO TC 42.

g) Safety

Safety from various angles is required for WSDs:

- electrical safety,
- electromagnetic wave exposure, SAR (specific absorption rate),
- static electricity,
- optical and ultraviolet light exposure,
- biological skin safety, and
- in vivo safety.

The safety of electrical, optical and ultraviolet light exposure is a common requirement for general electronic devices. These issues are covered by IEC TC 108. The issues of SAR and electromagnetic wave exposure are handled by IEC TC 106 and CISPR. Static electricity is covered by IEC TC 101. For biological skin safety and in vivo safety, standards related to medical fields should apply. They have been handled by IEC TC 62, ISO TC 194, ISO TC 210, and IEC TC 106.

Existing TC-developed standards cover some of these technologies. However, these standards do not cover specific requirements of WSDs technologies.

For materials, WSD requirements are demanding. Miniaturization (reduced thickness in particular), human body suitability, and biocompatibility are examples of such requirements. High-performance demands apply to the following technologies:

a) 3D-formed and wired technologies;

b) materials for large deformation and stretchable electronic circuits;

c) materials and processes for making extremely thin electronic devices;

d) materials for electronic devices applied in direct contact with human skin surfaces.

Existing standards for materials and technologies are not sufficiently covered. Standardization for new material requirements and safety performance testing methods for each technology should be launched.

7 Possible WSD standardization items in TC 119

7.1 3D-shaped formed and wired technologies

Standardization for 3D wiring technology constructed by injection moulding using electro-plating wiring has been discussed by MIDIA (MID International Association). Standardization for 3D printing technology, however, which makes 3D-shaped devices with such functions as conductive wiring, have not been discussed by existing standardization organizations. Standardization of 3D circuit technologies constructed by in-mould technology and printed wiring has not been discussed by the existing standardization organizations either.

7.2 Materials for large deformation and stretchable electronic circuits

Standardization of materials used for large deformation and stretchable electronic circuits has been discussed in the following three different technologies:

- flexible printed circuit board technologies,
- conductive fibres, and
- stretchable conductive circuits by printing.

To date, materials for large deformation and stretchable electronic circuits have not been listed in printed electronics standardization activities so far.

7.3 Materials for making extremely thin electronic devices

It is likely there will be many cases in which existing evaluation methods do not apply to materials for extremely thin electronic devices. Extremely thin electric devices are one of the most promising application areas for printed electronics (PE). Technologies for making extremely thin film devices are not necessarily limited to PE, as numerous evaluation methods can be applied to thin films.

7.4 Materials for electronic devices used in direct contact with human skin

Electronic devices used in direct contact with the human body are recognized as a promising application field for PE technologies. Standardization on the effects of electronic devices on the human body has been studied by existing TCs. However, standardization on the effects of the human body on electronic devices has not. These standardization items will not only be related to PE technologies but, also to all other wearable equipment that comes into contact with the human body.

8 WSD market and PE material standardization

Figure 1 shows the relationship between required technology trends for WSD and market growth expectations. When stretchable technologies are integrated with conventional

technologies, textile-integrated fields are expanded. Furthermore, as ultra-thin technologies are developed, the generation of skin-patchable type electronic devices will follow. Implantable devices will require further biocompatible technologies. Integration of new and existing technologies of WSDs will bring new applications and products, which will naturally promote market expansion.

9 Conclusion

A future vision for WSD technologies and their required standardization areas has been reviewed. Items to be added to existing standards were discussed based on comparisons between material technologies required for portable devices and those required for WSDs.

In the printed electronics area, TC 119 should urgently handle the following items:

a) 3D-formed and wired technologies by 3D printers,

b) 3D circuit technologies in combination with printed wiring and in-mould technology, and

c) materials for stretchable electronic circuits by PE.

It is also necessary to consider the following matters in the process of creating standardizations:

a) applicability to extremely thin devices,

b) effects from the living body on electronic devices.

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