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INTERNATIONAL STANDARD

Semiconductor devices – Semiconductor devices for energy harvesting and generation –
Part 8: Test and evaluation methods of flexible and stretchable supercapacitors for use in low power electronics

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FDIS	Report on voting
47/2724/FDIS	47/2733/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 62830 series, published under the general title *Semiconductor devices – Semiconductor devices for energy harvesting and generation*, can be found on the IEC website.

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- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

SEMICONDUCTOR DEVICES – SEMICONDUCTOR DEVICES FOR ENERGY HARVESTING AND GENERATION –

Part 8: Test and evaluation methods of flexible and stretchable supercapacitors for use in low power electronics

1 Scope

This part of IEC 62830 specifies terms, definitions, symbols, test, and evaluation methods used to determine the performance characteristics of flexible and stretchable supercapacitor for practical use in low power electronics such as energy storage devices for energy harvesting, flexible and stretchable electronics, low-power devices, IoT applications, etc. This document is applicable to all the flexible and stretchable supercapacitor for consumers and manufacturers, without any limitations of device technology and size.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 62391-1, *Fixed electric double-layer capacitors for use in electric and electronic equipment – Part 1: Generic specification*

IEC 62576, *Electric double-layer capacitors for use in hybrid electric vehicles – Test methods for electrical characteristics*

IEC 62813, *Lithium ion capacitors for use in electric and electronic equipment – Test methods for electrical characteristics*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

3.1 General terms

3.1.1
flexible and stretchable supercapacitor
electrochemical capacitor which can be incorporated into clothing or worn on the body as accessories

Note 1 to entry: Figure A.1 in Annex A shows classification of the supercapacitor.

3.1.2
electrical double layer capacitor
EDLC
electrochemical capacitor in which energy storage predominantly is achieved by double-layer capacitance

Note 1 to entry: Figure A.2 shows a schematic illustration of the EDLCs.

3.1.3
pseudocapacitor
electrochemical capacitor in which electrical energy is stored faradaically by electron charge transfer between electrode and electrolyte

Note 1 to entry: Figure A.3 shows a schematic illustration of the pseudocapacitor.

3.1.4
hybrid capacitor
supercapacitor which consists of two different types of supercapacitors such as EDLC and pseudocapacitor

Note 1 to entry: Figure A.4 shows a schematic illustration of the asymmetric hybrid supercapacitor.

Note 2 to entry: In the symmetric supercapacitor, both EDLC-like behaving material and pseudocapacitor-like behaving material are on each anode and cathode. In the asymmetric supercapacitor, EDLC-like behaving material is on cathode and pseudocapacitor-like behaving material is on anode.

3.1.5
electrode mass
M
mass of electroactive material for a supercapacitor

3.1.6
cell volume
V
volume of a supercapacitor cell

3.1.7
electrode area
geometric area of electroactive material for supercapacitor

3.1.8
category temperature
range of ambient temperatures for which the supercapacitor has been designed to operate continuously

[SOURCE: IEC 62391-1:2015, 3.8, modified – "capacitor" has been replaced by "supercapacitor" and the note has been omitted.]

3.1.9
lower category temperature
minimum ambient temperature for which the supercapacitor has been designed to operate continuously

[SOURCE: IEC 62391-1:2015, 3.9, modified – In the definition, "a capacitor" has been replaced by "the supercapacitor".]

3.1.10
upper category temperature
highest ambient temperature including internal heating in which the supercapacitor is designed to operate continuously

[SOURCE: IEC 62391-1:2015, 3.10, modified – In the definition, "a capacitor" has been replaced by "the supercapacitor".]

3.1.11
rated voltage
U_r
maximum direct current (DC) voltage or peak value of pulse which may be applied continuously or repetitively to the supercapacitor at category temperature

[SOURCE: IEC 62391-1:2015, 3.12, modified – In the definition, "a capacitor" has been replaced by "the supercapacitor" and "at any temperature between the lower category temperature and rated temperature" has been replaced by "at category temperature"]

3.1.12
charging
storage of energy in a supercapacitor

[SOURCE: IEC 60050-436:1990, 436-01-08, modified – "of a capacitor" has been removed from the term and "capacitor has been replaced by "supercapacitor in the definition.]

3.1.13
charging current
I_{ch}
current which flows during the charging of a supercapacitor

3.1.14
charging time
Δt_{ch}
time needed for accumulating above 90 % of the total charges to the supercapacitor

3.1.15
discharging
release of all or part of the energy stored in a supercapacitor

[SOURCE: IEC 60050-436:1990, 436-01-10, modified – The term and definition have been adapted to supercapacitor.]

3.1.16
discharging current
I_{disch}
current which flows during the discharging of a supercapacitor

[SOURCE: IEC 60050-436:1990, 436-01-11, modified – The term and definition have been adapted to supercapacitor and a letter symbol for discharging current has been added.]

3.1.17
discharging time
Δt_{disch}
time needed for dissolving above 90 % of the total charges in the supercapacitor

3.1.18
energy efficiency
ratio of the electric energy provided from a supercapacitor during discharge to the electric energy supplied to the battery during the preceding charge

[SOURCE: IEC 60050-482:2004, 482-05-53, modified – The definition has been adapted to supercapacitor.]

3.1.19
voltage drop
U_{drop}
instantaneous change of voltage when the operation condition of a supercapacitor changes from the charging to discharging process

3.1.20
strain
change of the relative positions of parts of a supercapacitor, excluding a displacement of the body as a whole under stretching status

$$\sigma = \frac{l - l_0}{l_0} \times 100\ \% \tag{1}$$

where

σ is the strain;

l is the stretched length of supercapacitor after elongation;

l_0 is the original length of supercapacitor before elongation.

[SOURCE: IEC 60050-113:2011, 113-03-57, modified – The definition has been adapted to supercapacitor, and Equation (1) added.]

3.1.21
radius of curvature
bending radius
r
point of a curve, radius of the osculating circle under bending status

Note 1 to entry: The osculating circle is the circle tangent to a curve at a point that approaches at best the curve in the vicinity of the point. Figure 1 shows a schematic of curvature radius.

Note 2 to entry: The other methods to bend the supercapacitor are indicated in Annex C.

[SOURCE: IEC 60050-113:2011, 113-01-30, modified – The admitted term, letter symbol and Note 2 to entry have been added.]

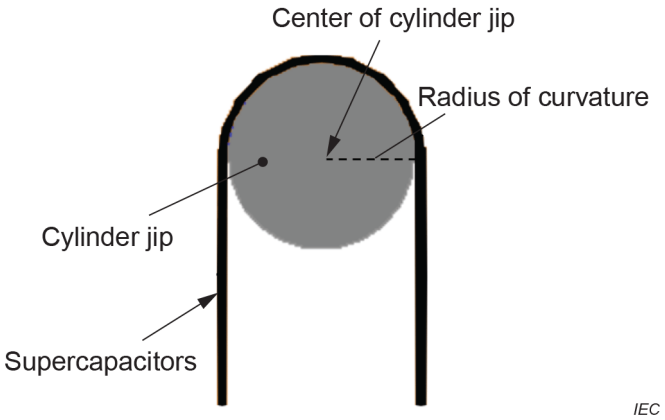

Figure 1 – Schematic of curvature radius

3.2 Characteristic parameters

3.2.1
nominal capacitance
C_N
calculated capacitance value from galvano charging/discharging curve

3.2.2
specific capacitance
capacitance per unit mass/area/volume of the supercapacitor, F/g, F/cm^2, F/cm^3

3.2.3
equivalent series resistance
internal resistance
ESR

resistance component in an equivalent series circuit of capacitance and resistance of the supercapacitor

Note 1 to entry: The internal resistance in given in ohms (Ω).

[SOURCE: IEC 62391-1:2015, 3.20, modified – The terms "equivalent series resistance" and "*ESR*" have been added and in the definition, "a capacitor" has been replaced by "the supercapacitor".]

3.2.4
energy density
ε
amount of energy that can be stored per area/mass/volume of the supercapacitor, Wh/cm^2, Wh/kg, Wh/cm^3

3.2.5
maximum power density
P_{max}
speed at which energy can be delivered per area/mass/volume of the supercapacitor to/absorbed from the load, W/cm^2, W/kg, W/cm^3

3.2.6
life cycle
certain number of repeated charging and discharging processes resulting in 90 % of capacitance retention

3.2.7
critical strain
strain at which the capacitance starts to decrease a predefined limit, and/or fracture of the supercapacitor caused by delamination or initiation of the cracks occurs

Note 1 to entry: It is the minimum strain that the supercapacitor can tolerate.

Note 2 to entry: Manufacturer should indicate predefined limit of strain.

[SOURCE: IEC 62951-1:2017, 3.1.2, modified – In the definition, "bending radius", "electrical resistance", "exceed", and "film" have been replaced by "strain", "capacitance", "decrease", and "supercapacitor", respectively. In addition, Note 2 to entry has been added.]

3.2.8
critical radius of curvature
bending radius at which the capacitance starts to decrease a predefined limit, and/or fracture of the supercapacitor caused by delamination or initiation of the cracks occurs

Note 1 to entry: It is the minimum radius of curvature that the supercapacitor can tolerate.

Note 2 to entry: Manufacturer should indicate predefined limit of radius of curvature.

[SOURCE: IEC 62951-1:2017, 3.1.2, modified – In the definition, "electrical resistance", "exceed", and "film" have been replaced by "capacitance", "decrease", and "supercapacitor", respectively. Note 2 to entry has been added.]

4 Essential ratings and characteristic parameters

4.1 Identification and type

The wearable electrochemical glucose sensors shall be clearly and durably marked in the order given below:

a) year and week (or month) of manufacture;
b) manufacturer name or trade mark;
c) terminal identification (optional);
d) serial number;
e) factory identification code (optional).

4.2 Limiting values and operating conditions

The manufacturer shall clearly announce the operating conditions and its limitations for the use of the wearable glucose sensor. Table 1 shows a list of specification for operating conditions and its limitation.