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INTERNATIONAL STANDARD

colour inside

Printed electronics – Part 202-5: Materials – Conductive ink – Mechanical bending test of a printed conductive layer on an insulating substrate

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PRINTED ELECTRONICS –

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International Standard IEC 62899-202-5 has been prepared by IEC technical committee 119: Printed Electronics.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
119/227/FDIS	119/235/RVD

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

This document 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 document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

The printing process is a highly promising technology for the fabrication of flexible devices. In particular, a printed conductive layer on an insulating substrate will be widely employed as an electrode or as an interconnect for flexible devices. It will be dealt with and commercialized as a type of composite material in which the conductive layer is formed on the substrate as a conductor.

For a conductive film, the electrical property under mechanical deformation is very important because it is highly sensitive to mechanical stress and degrades well before the mechanical fracture. Therefore, a method for evaluating the conductivity of film materials provided by suppliers, sometimes including an *in situ* measurement system, is required in the industry as these are the basic materials which will be used in printed devices. Although some bending tests already exist, it is necessary to consider the unique characteristics of the printed films that are fabricated on a polymer substrate, which is weak under high temperature. These films are operated under severe mechanical deformations, unlike the conventional Si- or glass-based conductive films.

In this document, a mechanical bending test is described to evaluate the electrical property of a printed conductive layer on a substrate under repeated mechanical deformations. This sliding plate test method can be available for practical application in the industry by enabling the long-term reliability testing of printed film.

PRINTED ELECTRONICS –

Part 202-5: Materials – Conductive ink – Mechanical bending test of a printed conductive layer on an insulating substrate

1 Scope

This International Standard specifies a mechanical bending test for evaluating the electrical properties of a printed conductive layer on an insulating substrate under repeated mechanical deformation.

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 62899-202:2016, *Printed electronics – Part 202: Materials – Conductive ink*

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
conductive material
ingredient of a printing or coating material, which itself is electrically conductive or becomes electrically conductive by post treatment such as heating

[SOURCE: IEC-62899-202:2016, 3.1]

3.2
conductive ink
fluid in which one or more small molecules, polymers, or particles are dissolved or dispersed, and which becomes an electrically conductive layer by post treatment such as heating

[SOURCE: IEC-62899-202:2016, 3.2]

3.3
conductive layer
film-like electrically conductive body made of conductive ink, which is printed or coated on a substrate, followed as necessary by post treatment such as heating

[SOURCE: IEC-62899-202:2016, 3.3]

3.4
conductive film
substrate (sheet or roll) with conductive layer

[SOURCE: IEC-62899-202:2016, 3.4]

3.5
flexible substrate
electrically insulating substrate with flexibility on which conductive ink is printed, such as plastic film, paper, or cloth

[SOURCE: IEC 62899-502-1:2017, 3.1.3, modified – "substrate with flexibility on which conductive ink is printed" is used instead of "substrate with flexibility on which a flexible light emitting element is attached".]

3.6
bending radius
r
radius of curvature of the conductive film measured from the centreline of the bent conductive film

3.7
bending strain
ε
strain in the curved tip in the sample

Note 1 to entry: The bending strain can be calculated by the curvature relation: $\varepsilon = (h + t)/2r$, where ε, h, t, $2r$ are the nominal bending strain, substrate thickness, printed film thickness and gap between the plates, respectively (see Annex A).

3.8
linear motion length
L
length of linear reciprocating motion of the moving plate that grips conductive film

3.9
effective sample length
d
length of the sample from the edge of grip to another edge of grip excluding the sample area for metal grip

4 Standard environmental conditions

Standard atmospheric conditions for measurement shall apply as specified in IEC 62899-202:

a) temperature: (23 ± 2) °C;
b) relative humidity: (50 ± 10) %;
c) air pressure: 86 kPa to 106 kPa.

5 Test sample

5.1 General

The test sample for mechanical tests shall be prepared using a conductive ink on a flexible substrate.

5.2 Size of test sample

For uniform bending deformation and strain distribution, a sample with a rectangular shape shall be used. The sample size of a printed conductive film shall be selected from Table 1 (adopted partially from IEC 62899-202 and ISO 527-3 [3][1]). The effective sample length is the length of the sample from the edge of grip to another edge of grip excluding the sample area for metal grip. The tolerance of width and length is 0,2 mm.

Table 1 – List of the size of the specimen

	Effective sample length mm	Width mm
Type A	30 ± 0,2	10 ± 0,2
Type B	30 ± 0,2	30 ± 0,2
Type C	50 ± 0,2	10 ± 0,2
Type D	50 ± 0,2	25 ± 0,2
Type E	80 ± 0,2	50 ± 0,2

Another size sample the length of which is at least four times larger than the linear motion length may be used for the mechanical bending test.

6 Testing method and test apparatus

6.1 General

A printed conductive layer on a flexible substrate shall be placed between two plates and bent as a half circle shape between two plates as shown in Figure 1. The repeated linear motion of one plate results in cyclic bending/unbending in the sample. The electrical property of the conductive film shall be evaluated by metal grips and an electrical connection.

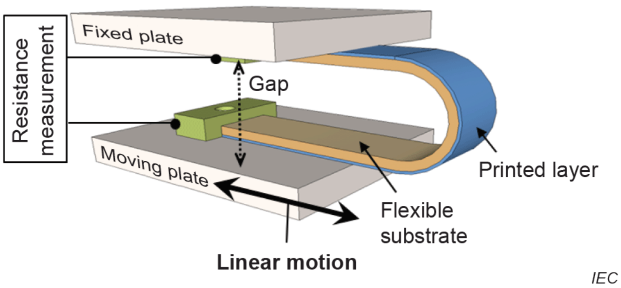

Figure 1 – Schematic diagram of mechanical test of printed film

6.2 Test apparatus

As shown in Figure 1, a bending tester is used to apply a repeated sliding motion on samples. The gap between two plates may be adjustable to the target value. The linear motion length shall be variable from 0 mm to 30 mm.

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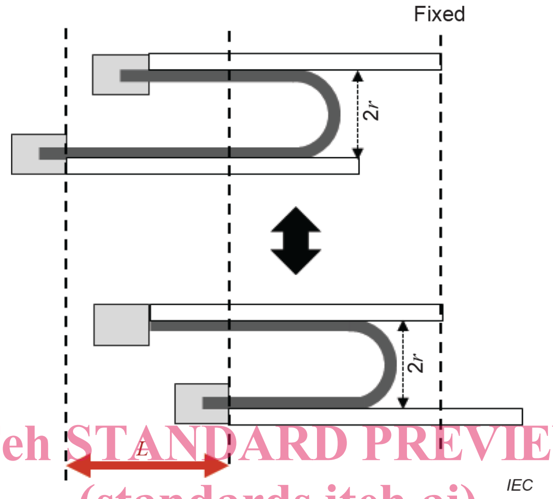
1 Numbers in square brackets refer to the Bibliography.

The plates shall be clean, smooth, and rigid to avoid mechanical damage on samples. For electrical measurement, the grip shall be made from a conductive metal grip for electrical connection, but the plate shall be made from insulating materials such as the resin series, polycarbonate, mono-cast nylon, etc. The plate shall have a resistance larger than 10^6 Ω and no deformation is allowed during the bending test.

While one plate is stationary, the other plate repeats reciprocating linear motions as shown in Figure 2. Owing to the asymmetric linear motion of the moving plate, the repeated bending deformations are applied to the samples.



Key

r bending radius

L linear motion length

Figure 2 – Apparatus for mechanical test of printed film

6.3 Test procedure

The test procedure is as follows.

a) Place the sample between two plates and grip the edges of the sample. When mounting the sample, the gap between the plates shall be larger than 10 mm to avoid damage formation before testing. The longitudinal direction of the test piece shall be aligned with the linear motion direction of the test apparatus, and the deviation angle shall be less than 5° (adopted from IEC 62951-1 [4]).

b) Change the gap between the two plates, thereby decreasing the bending radius values from large to small. The test shall be conducted under the condition of the gap not interfering during the cyclic motion.

c) Fix the gap as a proper bending radius and measure the initial electrical resistance of the sample before the bending test. Start the repeated asymmetric sliding motions.

NOTE The mechanical property of printed films generally depends on the bending direction (inner or outer bending) [5]. Also, the linear motion length can affect the electrical reliability of the flexible electrode [6].

For mechanical tests of printed film, the bending radius (related to the gap) and the linear motion length shall be selected from a combination of the following values based on the operation of the product:

r (bending radius): (0,1; 0,2; 0,5; 1; 2; 3; 5; 7,5; 10; 15; 20) mm;

t (time of one bending/unbending): (0,5; 1; 2; 3; 5; 10) s;

L (linear motion length): (5, 10, 15, 20, 30) mm;