# IEC 62899-202-7

Edition 1.0 2021-03

# INTERNATIONAL STANDARD



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**Printed electronics –**
**Part 202-7: Materials – Printed film – Measurement of peel strength for printed layer on flexible substrate by the 90° peel method**

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# PRINTED ELECTRONICS –

# Part 202-7: Materials – Printed film – Measurement of peel strength for printed layer on flexible substrate by the 90° peel method

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

| Draft | Report on voting |
|---|---|
| 119/342/FDIS | 119/345/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 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

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- withdrawn,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

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# INTRODUCTION

A printed layer on a flexible substrate is widely employed as an electrode or interconnection for flexible devices. An integral component of this conductive body of the devices is conductive composite material and is commercialized as conductive ink.

A simple tape test method has been widely used for qualitative adhesion measurement, but it cannot be used to measure strong adhesion between the printed layer and the flexible substrate.

A conventional peel test method is widely used in the printed circuits industry to evaluate the adhesion between a thin printed layer with dense microstructure and the flexible substrate.

Peel strength value can be measured after an additional metal electroplating process on a thin printed layer to increase the printed layer thickness to provide a stable grip in an adhesion testing machine. However, it is not suitable for testing a printed layer which has a porous structure susceptible to contamination of the interface between the printed layer and flexible substrate during the electroplating process.

Therefore, a quantitative and reliable adhesion test method is used to measure and understand interfacial adhesion of the printed layer to the flexible substrate and its long-term reliability.

In this document, a new standard test method to measure the peel strength of a printed layer on a flexible substrate is proposed. This method calls for peeling the flexible substrate instead of an additional metal electroplating on the printed layer. It is useful to monitor and compare the thickness dependence of the peel strength of a layer on the same flexible substrate.

# PRINTED ELECTRONICS –

# Part 202-7: Materials – Printed film – Measurement of peel strength for printed layer on flexible substrate by the 90° peel method

## 1 Scope

This part of IEC 62899 provides a test method to measure the peel strength of a printed layer on a flexible substrate. This method calls for peeling the flexible substrate instead of an additional metal electroplating on the printed layer. The method described in this document can be used to compare the peel strengths of the printed layers on the same flexible substrate and thickness conditions. It can be used when the adhesion between the printed layer and flexible substrate is weaker than any other interface between the printed layer and the adhesive, the adhesive and the panel.

## 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**
printable fluid intended for printing in which one or more molecules, polymers, or particles are dissolved or dispersed, which becomes an electrically conductive layer by post treatment such as heating

[SOURCE: IEC 62899-202:2016, 3.2, modified – in the definition, "fluid" has been replaced with "printable fluid intended for printing".]

**3.3**
**printed layer**
conductive body made of conductive ink and of uniform thickness which is very small in proportion to length and width

EXAMPLE Printed Ag, printed Cu.

**3.4**
**peel strength**
strength required to separate the printed layer from the flexible substrate at a constant pulling force

Note 1 to entry: Peel strength is calculated as the average peel load/sample width.

Note 2 to entry: Average peel load is obtained by several measurements at a steady state load displacement after the initial load increase.

**3.5**
**flexible substrate**
substrate with flexibility such that it can bend during the 90º peel test and on which conductive ink is printed

Note 1 to entry: Examples of flexible polymers are polyimide, polyethylene terephthalate, polyethylene naphthalate, and polyester).

## 4 Standard atmospheric conditions

Standard atmospheric conditions for measurement for the peel strength of a printed layer on flexible substrate shall apply as specified in IEC 62899-202:2016, Clause 4:

a) temperature: (23 ± 2) ºC

b) relative humidity: (50 ± 5) %

## 5 Test sample

### 5.1 General

The test sample for the peel strength test shall be prepared using a printed layer on a flexible substrate.

### 5.2 Size of test sample

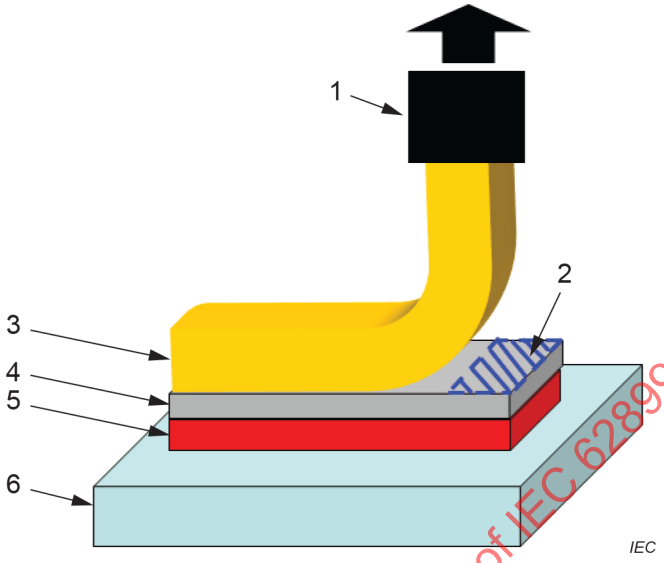
For uniform adhesion test, a rectangular shape is recommended. The size of the test panel can be 50 mm × 120 mm, for example. Stable peel strength data can be obtained with substrate thickness ranges from 25 µm to 125 µm. The size of the printed layer shall be 10 mm ± 0,2 mm in width and 100 mm in length. Measure the print width on three positions to 0,1 mm accuracy and use the average width for peel strength calculation.

### 5.3 Applicability of the method

The schematic of the peel test is illustrated in Figure 1. With the peel test, the adhesion between printed layer and flexible substrate can be measured. The flexible substrate is fixed by narrowing the gap in the grip part in Figure 1. This measurement method is applicable only when the peel strength between the flexible substrate and the printed layer is smaller than the cohesive force of the printed layer, the peel strength between the printed layer and adhesive, the peel strength between the adhesive and panel and the strength of the flexible substrate.

- F (sub-layer) < F (layer), F (layer-ad), F (ad-panel), F(sub);
- F (sub-layer): peel strength between the flexible substrate and printed layer;

- F (layer): cohesive force of the printed layer;
- F (layer-ad): peel strength between the printed layer and adhesive;
- F (ad-panel): peel strength between the adhesive and test panel;
- F (sub): tension strength of the flexible substrate.




1 Grips
2 Initial delamination
3 Flexible substrate
4 Printed layer
5 Adhesive
6 Test panel

**Figure 1 – Schematic of peel test of the printed layer on a flexible substrate**



## 6 Testing method and test apparatus

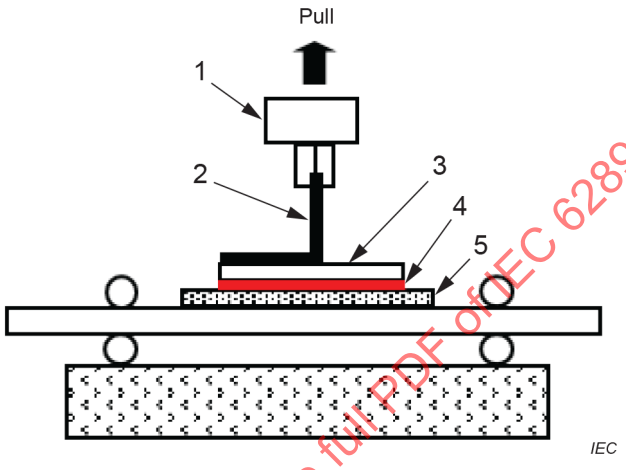
### 6.1 General

The 90° adhesion test requires a 90° peel tester fixture to determine the adhesive strength between a flexible substrate and printed layer, where the printed layer lies together with the flexible substrate on the test panel. The gripped end of the flexible substrate is stuck on perpendicularly to the printed layer while the rest of the substrate is bonded to the printed layer so that it forms a 90° bend.

### 6.2 Test apparatus

Using a peel tester as shown in Figure 2, a peeling force shall be applied to a flexible substrate. As shown in Figure 2, a peel tester to apply a peeling motion on samples shall be used. The linear length shall be at least 50 mm.

Flip over the test sample and attach a printed layer on the test panel and cure at (23 ± 2) ºC and (50 ± 5) % humidity. Place the test panel with the test sample applied on it on the table of the peel tester. Fasten the test panel using a bolt and nut to perform the peel test with a peel force applied to the test sample. The sample to be tested is held on a table which moves horizontally and at the same velocity is pulled from the specimen vertically. As the peeled layer is pulled vertically up and off, the sample is free to move horizontally, maintaining a 90° angle. The flexible substrate is fixed by narrowing the gap in the grip part in Figure 2. The load and the displacement shall be measured using a load cell and displacement sensors installed on the universal testing machine during the test. The range of the load cell is from 20 N to 100 N. Stable peel strength data can be obtained with ranges from 0,01 N/mm to 2,0 N/mm. Perform preliminary tests in order to achieve the appropriate failure mode. Specify the requirements of related equipment such as a load cell, and allow setting up the appropriate speed.




1 Load cell

2 Flexible substrate

3 Printed layer

4 Adhesive

5 Test panel

**Figure 2 – Apparatus for peel test of the printed layer on a flexible substrate**

### 6.3 Test procedure

The test procedure is as follows.

a) Initiate the edge delamination formation by marking with a typical marker pen (permanent marker or indelible marker) on the flexible substrate edge (approximately 30 mm long) before ink printing.

b) Apply conductive ink printing and curing to form the printed layer. The printed layer should be uniform and adhere to the substrate perfectly.

c) Apply adhesive on the printed layer surface. The thickness of the cured adhesive shall be (500 ± 50) µm. The thickness of the adhesive may be decided between the supplier and the consumer.

d) Flip over the specimen and attach a printed layer on the test panel and cure at room temperature in air. The liquid adhesive becomes solid when cured. The size of the test panel is 50 mm × 100 mm.

e) Place the test panel with the specimen applied on it on the table of the peel tester. Fasten the test panel using a bolt and nut to perform the peel test with a peel force applied to the specimen. The gripped end of the flexible substrate is stuck up perpendicularly to the printed layer while the rest is bonded to the test panel so that it forms a 90° bending.

f) Measure the value of the load cell against the displacement

For example, the conditions can be selected as below:

The peeling speed shall be 50 mm/min.

However, if there are special requirements, the peeling speed can be determined by a reasonable agreement between the user and the supplier.

## 7 Data analysis

### 7.1 Peel strength calculation

As shown in Figure 3, the peel strength is defined as the average peel load value divided by the sample width for more than three sample measurements of the steady-state load-displacement behavior after the initial load increase. Steady-state is a section in which the load is constant. After the peel test of three or more samples, the derived data shall be checked and similar values of peel strength shall be used.

$$P = F/W$$

where

$P$ is the peel strength, in N/mm,

$F$ is the average load in N,

$W$ is the width of test sample in mm.

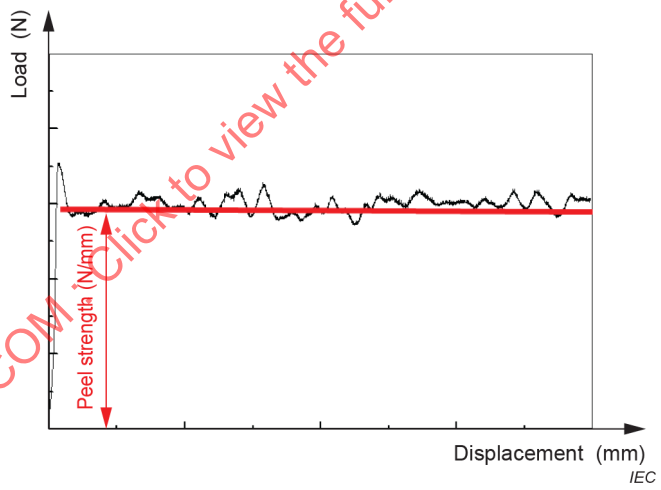



**Figure 3 – Typical peeling curve measured during the peel test**



### 7.2 Report of the results

The report shall include the following items:

a) test environment (temperature, humidity)

b) specimen identification (including film thickness, sample size and film materials)

c) material of the adhesive layer (type, thickness and rigidity of the adhesive)

d) peeling speed

e) peel strength

f) identification of the peeling interface selected from the following:

1) printed layer / substrate