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INTERNATIONAL STANDARD

Printed electronics –
Part 101: Terminology – Vocabulary

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PRINTED ELECTRONICS –

Part 101: Terminology – Vocabulary

FOREWORD

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International Standard IEC 62899-101 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
119/279/FDIS	119/285/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- withdrawn,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.

INTRODUCTION

Due to the trend towards a globalized, technological and connected society, there is a rising demand for a new breed of technologies enabling low-priced, flexible and new-concept products. Some conventional technologies (including silicon-based microelectronics) have reached their limits due to their high fabrication costs and environmental issues. Armed with new printing technologies and innovative materials, printed electronics has recently emerged as a promising environmentally friendly alternative route for producing electronic products at low cost and with new possibilities of such creative technologies as flexible electronics. Currently, this technology is beginning to be used in the manufacturing of products such as sensors, photovoltaic devices, signage, RFID, batteries, lighting devices, and some parts of display devices, where cost, flexibility and recycling are critical issues.

For successful industrialization of printed electronics, not only the reliability and repeatability in equipment and processes should be provided under global standardization, but also the harmonization of terminology and definitions is a key element for a successful transition of printed electronics to the market.

PRINTED ELECTRONICS –

Part 101: Terminology – Vocabulary

1 Scope

This part of IEC 62899 defines terms used in the field of printed electronics, addressing topics including, but not limited to, materials, printing processes, and print characterization. It focuses on terms that are of particular importance to printed devices. Therefore, terms that are already defined in relation to conventional electronics materials, processes, devices, components or systems that can be used in the field of printed electronics without alteration are not included in this document. Similarly, established terms and definitions in relation to printing technology that apply to the field of printed electronics are not included.

Definitions in this document are the primary reference for printed electronics terminology.

2 Normative references

There are no normative references in this document.

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
1-d qualification feature
feature that is qualified by single directional parameters

3.2
2-d qualification feature
feature that is qualified by area-based qualification parameters

3.3
4-probe measurement
method to measure the resistance of a material while eliminating lead and contact resistance from the measurement result by employing separate pairs of current-carrying and voltage-sensing electrodes

3.4
annealing
<metals> treatment that alters the microstructure of a metal, causing changes in properties such as strength and hardness, in order to induce ductility and to relieve internal stresses

3.5
annealing
<polymers and plastics> treatment that alters the microstructure of a polymer or plastics, causing changes in properties in order to improve strength and hardness, to reduce internal stresses related to the polymer or plastics structure

3.6
annealing
<printed functional material> treatment that can be used to enhance the electrical performance (i.e., to reduce the electrical resistance) of a printed functional material

3.7
arc plasma heating
arc heating utilizing disposable graphite electrodes which generate an arc plasma between the material and electrode, thus transferring the energy to the material

Note 1 to entry: Arc plasma heating captures the arc plasma with a nozzle or gas flow. It can offer higher orientation and higher temperature than does normal arc heating.

3.8
area gain
area of the actual feature that lies outside the nominal feature contour

3.9
area loss
non-printed area of the nominal feature

3.10
basic pattern
set of two-dimensional figures for inspecting the reproducibility of printed patterns, consisting of the evaluation pattern and alignment marks used for accurate positioning of the substrate with respect to the printing apparatus

3.11
bending radius
radius of the curved area in the sample

3.12
bending test
deformation test by application of external stress perpendicular to the plane of a printed element

3.13
blade coating
use of a metal blade offset from the substrate to deposit a material onto the substrate

3.14
cell
basic functional unit, consisting of an assembly of electrodes, electrolyte, container, terminals and usually separators, that is a source of electric energy obtained by direct conversion of chemical energy

[SOURCE: IEC 60050-482:2004, 482-01-01, modified – Note omitted.]

3.15
chip
<glass substrates> form of damage in which a small piece of glass has come off the glass surface, for example as a result of impact from a hard object

3.16
conductive film
substrate (sheet or roll) coated with a conductive layer

3.17
conductive ink
fluid in which chemical precursors, polymers, or particles are dissolved or dispersed

Note 1 to entry: Conductive ink becomes an electrically conductive layer after post treatment.

3.18
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

3.19
conductive material
ingredient of a printing or coating material, which itself is electrically conductive or becomes electrically conductive by post treatment such as heating

3.20
contact heating
heating process during which a hot object comes in direct contact with materials

3.21
contact printing
printing process that transfers an image from a suitable medium to base materials

3.22
corner rounding
deviation of an actual feature corner from its nominal shape

3.23
crack
<glass substrates> line on the surface of a substrate (e.g. glass) along which it has split without breaking apart

3.24
critical dimension
dimension of a geometrical feature (width of interconnect line, contacts, trenches, etc.) which can be formed during electronic device/circuit manufacturing and can be of interest for further qualification

3.25
cross direction
direction at right angles to the machine direction of a substrate

3.26
cross-sectional qualification feature
feature which can be qualified by cross-sectional qualification parameters

3.27
curing
process during which volatile components evaporate and/or materials undergo chemical reactions to form a continuous bulk material

3.28
cylinder printing
image transfer process in which a substrate and silk screen are indexed across the surface of a rotating cylinder

Note 1 to entry: When printing sheet substrates, the sheet is fixed to the surface of a cylindrical suction roller, and the sheet is printed as the cylinder rotates. The screen mask is the same format as that used for flatbed printing.

3.29
dielectric heating
microwave heating
HF heating
electric heating in which the heat is generated in dielectric and semiconducting loads, under the action of high frequency electric field of a frequency range from 1 MHz to 300 MHz

[SOURCE: IEC 60050-841:2004, 841-28-01, modified – the two terms "microwave heating" and "HF heating" have been added.]

3.30
dielectric strength
maximum electric field an electrically insulating material can sustain without experiencing failure of its insulating properties

Note 1 to entry: Dielectric strength is determined by measuring the minimum applied voltage that results in breakdown (breakdown voltage) and dividing it by the electrode separation distance at the moment of breakdown. Due to possible changes in specimen thickness during the measurement of dielectric strength, alternatively the breakdown voltage and the initial thickness may be specified.

3.31
dispersion
<inks for printed electronics> system consisting of two or more phases one of which is continuous and at least one other is finely dispersed

[SOURCE: ISO 862:1984, 17]

3.32
double-flash mode
mode of inkjet drop analysis where LED or high-power light is quickly flashed twice per jetting event, thereby capturing the same individual drop in two different locations within the camera field of view

3.33
drop analysis
<inkjet printing> method of visualizing or quantifying the motion, trajectory or substrate impact of droplets ejected from an inkjet print head

3.34
drop analysis system
<inkjet printing> imaging-based equipment that can visualize or quantify the motion of inkjet droplets

3.35
drop delivery speed
total distance between the inkjet print-head nozzle plate and the substrate, divided by the time interval between jet triggering and drop arrival

3.36
drop repeatability
number specifying the repeatability of the drop dimensions of subsequent drops with the same target volume, for example standard deviation of drop volume or drop diameter

3.37
drop speed
distance divided by the time it takes the drop to traverse the distance

3.38
drop trajectory
direction of travel of a drop, often characterized as an angle relative to the nozzle plate

3.39
drop visualization system
<inkjet printing> equipment that can be used to observe or visualize droplets at a specified jetting frequency by means of a strobe flash light which is synchronized with the jetting frequency

3.40
droplet volume
amount of jetted droplet from a nozzle per trigger pulse

3.41
edge squareness
angular difference between the machine direction reference edge of the plate master relative to straight lines drawn between the ends of, and perpendicular to, the nominally orthogonal reference edge

3.42
edge straightness
deviation of an edge relative to a straight line

3.43
edge waviness
degree to which a pattern edge conforms to a measurement plane

[SOURCE: ISO 12635:2008, 2.5, modified – The word "plate" in the original definition has been replaced by "pattern".]

3.44
elastic region
interval of tensile or compressive strain within which a material deforms reversibly under mechanical stress

3.45
electric photolithography
method of electrically modifying the surface energy of a target material to accept or repel applied materials

3.46
electrical test
functional inspection process of printed electronics, especially for short and open circuits

3.47
electron beam curing
curing of material by exposure to an electron beam

3.48
equilibrium thermal processing
thermal processing in which little or no temperature gradient occurs in a material while it is being heated

3.49
evaluation pattern
set of fundamental geometrical shapes and structures with systematically varied size and orientation used to evaluate printability for printing machines in printed electronics

3.50
feature
region within a single continuous boundary that is distinct from the region outside the boundary

3.51
feature area deviation
sum of the values of the feature area gain and feature area loss

3.52
feature area difference
feature area gain minus feature area loss

3.53
feature area gain
absolute value of the difference of the measured surface area of an individual feature and the nominal feature area in case the measured surface area of an individual feature is greater than the nominal feature area

3.54
feature area loss
absolute value of the difference of the measured surface area of an individual feature and the nominal feature area in case the measured surface area of an individual feature is smaller than the nominal feature area

3.55
feature depth
feature height
dimension of a feature perpendicular to the reference plane

3.56
feature model
solid geometrical shape, with well-defined parameters (e.g. length, width, height, centroid, etc.), meant to approximate the actual shape of a feature boundary

3.57
flash lamp processing
intense pulsed light
transient, radiative heating process using broadband, incoherent radiation from a flash lamp

3.58
flatness parameter
parameter for evaluating the flatness in all profiles

3.59
flexibility
propensity of a sheet-like object (printed electronics substrate, component or device) to be bent or creased upon application of mechanical stress

3.60
flexible substrate
substrate showing reversible (i.e. elastic) mechanical behaviour within a certain range of applied mechanical stress

EXAMPLE: Examples of flexible substrates include but are not limited to: paper, plastic films, metal foil, and fabrics.

3.61
flexographic printing
printing process which uses a soft positive master plate or cylinder made from photopolymer or rubber and an anilox to transfer material from a dispenser or pan to a substrate

Note 1 to entry: The key to the deposition process is that the ink transfer is controlled by an inking system using anilox rolls which are patterned with wells of uniform volume. The anilox picks up ink from a source, is doctored (scraped) and then transfers controlled amounts of ink from the anilox wells to the features of the positive plate. The plate is then impressed, under pressure, onto the substrate.

Note 2 to entry: An anilox roll is a cylinder that is machined or etched, creating a uniform pattern of wells. The anilox roll is continuously inked, and then excess ink is scraped off (doctored). The doctored anilox is then impressed upon the printing plate. The ink volume delivered to the plate is controlled by the volume and shape of the anilox.

Note 3 to entry: Flexographic printing is typically a roll-to-roll process and has been, historically, used for printing on packaging and other modestly rough surfaces.

3.62
functional printing
achievement of capabilities beyond graphics and visual information using adapted standard printing methods

3.63
gravure printing
printed electronics process in which an image is applied to a substrate by use of a master image carrier in which the reverse of the image to be transferred is engraved and/or etched

Note 1 to entry: The negative master can consist of small wells or engraved lines and areas.

Note 2 to entry: The master is engraved typically onto a cylinder (or plates attached to cylinders) via mechanical or laser techniques.

Note 3 to entry: Ink transfer is direct to the master, and ink is doctored from the master cylinder. Very precise ink transfers to a substrate are possible with this technique, as control of inking is the relationship between the volume of the image and the viscosity of the ink. Gravure printing is typically confined to long-run products due to engraving costs.

3.64
heat-medium heating
heating process utilizing a medium such as oil or melted inorganic salt

3.65
height of point
distance in height between any point in the profile and a reference plane

3.66
hybrid printed electronics
printed electronics incorporating, or incorporated with, non-printed electronic devices

3.67
hybrid printing
printing using more than one printed electronics process for multilayer functional products

3.68
inclusion
object embedded or trapped in a substance

3.69
induction heating
electric heating using the Joule effect produced by induced currents

[SOURCE: IEC 60050-841:2004, 841-27-04]

3.70
infrared heating
electric heating consisting in absorbing of thermal and optical radiation, emitted by especially constructed source of radiation, mostly infrared radiation

Note 1 to entry: Infrared heating is categorized by radiation wavelength as: short/near: 0,7 µm to ≤ 2 µm; medium/mid: 2 µm to ≤ 4 µm; long/far: 4 µm to ≤ 1 000 µm.

[SOURCE: IEC 60050-841:2004, 841-24-05, modified – the note has been added.]

3.71
ink
processable material for printing that contains a functional material as well as fillers, binders, dispersants, and a dispersion medium or solvent

3.72
inkjet printing
noncontact printing method that creates an image or pattern by propelling droplets of ink onto a substrate

3.73
instantaneous jetting curve
speed of droplets measured relative to the imaging field of view in the region of interest

3.74
jetting speed curve
plot of the jetting speed as a function of time calculated from the drop trajectory

3.75
joule heating
direct resistance heating
heating caused by an electric current through a resistive material

Note 1 to entry: The amount of heat produced is proportional to the square of the current.

[SOURCE: IEC 60050-815:2015, 815-15-41, modified – the note has been added.]

3.76
line edge roughness
perpendicular point-to-point deviation of the feature's edge from the linear fitted feature edge

3.77
line width roughness
deviation of the point-to-point line width from the average width of the specified line width

3.78
line-end shortening
deviation of the actual feature from the nominal feature at the nominal line-end

3.79
lithography
printing process in which an image is rendered onto a plate that has oleophobic areas which repel ink as well as oleophilic areas which retain ink, and that is used to transfer the image onto a substrate

Note 1 to entry: Traditional offset lithographic printing uses a complex inking system, which smoothly inks the plate. The plate then transfers the image onto rubber blankets or rollers; these blankets or rollers then impress the inks onto a substrate using mild pressure.

3.80
machine direction
direction in which the substrate or stock moves during printing

3.81
machine direction reference edge
reference edge parallel with machine direction

3.82
margin area
blank border around the printing area on a page or substrate

3.83
mean surface roughness
average difference in height between the peaks and valleys of an irregular surface

3.84
minimum bending radius
smallest bending radius at which a printed electronic device or material is not adversely affected

3.85
nanotransfer printing
printing technique using lithography to make a nanoscale master pattern or stamp

Note 1 to entry: The stamp is then used to mechanically emboss the desired pattern into a resist. Subsequent fabrication steps are usually subtractive.

3.86
nominal feature
intended or designed feature

3.87
nominal value
value of a quantity used to designate and identify a component, device, equipment, or system

Note 1 to entry: The nominal value is generally a rounded value.

[SOURCE: IEC 60050-151:2001, 151-16-09]

3.88
non-contact printing
method of adding a material to a substrate without contacting the substrate

3.89
non-thermal curing
chemical reaction that hardens organic substances such as adhesives and coating materials without the use of heat energy

3.90
OLED element
light-emitting element formed with at least one light emitting organic semiconductor film layered between the anode and cathode electrodes, having an application in lighting or display

3.91
organic electronics
branch of electronics which uses organic materials for the fabrication of passive and active electronic components

[SOURCE: IEC 60050-511:2018, 511-02-03]

3.92
orientation corner
point specified for mechanical orientation and visual confirmation of object alignment

3.93
pad
<in pad printing> flexible polymer surface used to transfer an image from the source to the target

3.94
pad printing
tampography
deposition process which uses an offset positive plate and a pad to transfer an image from the plate to a substrate

Note 1 to entry: Pad printing is, by definition, an offset process, as the ink is split before delivery. In graphic arts and some forms of printed electronics, the target substrate can be a non-planar substrate and the stamp (or plate) is typically made of a flexible material. In other forms of printed electronics, the stamp is a non-master transfer receiver of organized semiconductor devices. These devices are then impressed upon a receiving substrate in the picked-up form.

3.95
pattern center line
center line of two edges obtained from the centers of the stroke widths

3.96
pattern edge detection method
method for determining the edge position of a given pattern by using a computer algorithm

3.97
pattern width
overall width of the printed image

3.98
pitch
centroid-to-centroid distance between two repeatedly placed features

3.99
plate master
device that carries the image to be printed

3.100
printability
interrelationship of inks, other functional materials and substrates in conjunction with printing equipment in order to achieve the desired electrotechnical function

3.101
printed functional component process
process of using printed methods for functional components, such as organic semiconductors

Note 1 to entry: See also IPC/JPCA-6901.

3.102
printed electronics
type of electrical or electronic devices or systems manufactured using printing processes

3.103
printed electronics process
additive printing or coating method used to generate electrical or electronic circuitry or devices

3.104
printed OLED element
OLED element formed by using at least one printed electronic process during its fabrication, where the printed layer(s) can be the anode electrode, hole injection layer, hole transport layer, light emitting layer, electron transport layer, electron injection layer, charge generation layer, cathode electrode, passivation layer, or smoothing layer

3.105
printed passive component process
process of using printed methods for passive components, such as resistor, capacitor and inductor

Note 1 to entry: See also IPC/JPCA-6901.

3.106
printing area
imaging or drawing area on a page or substrate made by a printing machine

3.107
raster scan
repetitive scanning in one direction while moving stepwise in the orthogonal direction

3.108
reference accuracy
deviation of the measured feature position from the nominal feature position

3.109
reference edges, pl
two edges adjacent to the orientation corner which are used for referencing the position of the plate master

3.110
reference plane
<printing> user-defined flat plane approximating the front surface of a plate master and containing a coordinate system

3.111
region of interest
ROI
area (inside defined boundaries) that the user wants to analyse

[SOURCE: ISO 19262:2015, 3.211]

3.112
reproducibility of printed patterns
fidelity of individual qualities of a printed pattern to that of the design data

3.113
reverse offset printing
process for transferring a substrate to a semi-dried ink of the positive pattern remaining in a cylinder

Note 1 to entry: This process is performed after removing the ink in the negative pattern using relief printing.

3.114
rolling test
test for measuring the endurance of a flexible printed electronics system while or after rolling and unrolling it onto and from a cylindrical roller with a specified radius

Note 1 to entry: A rolling test can be used to determine the suitability of a flexible printed device for roll-to-roll processing.

3.115
roll-to-roll process
process performed on a flexible substrate supplied in roll shape and producing an output roll by re-reeling after the process

3.116
roll-to-sheet process
process performed on a flexible substrate supplied in roll shape and producing individual sheets as output

3.117
rotary screen printing
printing using a cylindrical screen mask which has a printing image formed on its surface

Note 1 to entry: A squeegee installed inside the cylindrical mask presses against its outside surface from inside to contact the substrate.

Note 2 to entry: The cylinders' unidirectional rotation allows for continuous printing and easy roll-to-roll printing.

3.118
screen printing
transfer of an image to a surface by forcing a suitable ink with a squeegee through an imaged screen mesh

3.119
semiconductive layer
film-like semiconductive body of material made of semiconductor ink, which is printed or coated on a substrate, and then subject to (as necessary) a post treatment such as UV, photonic, or thermal processing

3.120
semiconductor film
substrate (sheet or roll) with a semiconductive layer

3.121
semiconductor ink
liquid in which one or more of particles, small molecules, chemical precursors, or polymers are dissolved or dispersed, and which becomes an electrically semiconductive layer by solvent removal and/or post treatment such as UV, photonic, or thermal processing

3.122
sheet resistance
electrical resistance of a thin film of nominally uniform thickness, measured across the opposite ends of a square area

Note 1 to entry: The unit of sheet resistance is Ohm (Ω). However, in order not to confuse sheet resistance with bulk resistance, the use of Ohm per square (Ω/□) is recommended.

Note 2 to entry: If film thickness is known, the average bulk resistivity of the thin film material can be calculated as the product of sheet resistance and film thickness.

3.123
sheet-to-sheet process
process performed on a substrate supplied in sheet shape and producing sheets as output

3.124
sintering
<printed electronics> heat treatment during which discrete solid particles (e.g., within a printed film) form an interconnected bulk material

Note 1 to entry: Typically, sintering occurs through processes such as solid-state diffusion, neck growth, and grain boundary movement.

Note 2 to entry: See also IEC 60050-815:2015, 815-13-27.

3.125
slot-die coating
method of coating a substrate by dispensing a fluid through a small slot die onto a moving substrate that is closely spaced to the extrusion point

Note 1 to entry: In slot die coating, film thickness can be adjusted precisely by controlling the dispensing rate of the fluid and the velocity of the substrate relative to the slot die.

3.126
spin coating
method of uniformly coating a substrate that is fed to the center of a rotating disc, which is rotating at a speed relative to the viscosity of the coating material

Note 1 to entry: The liquid is typically fed to the center of the rotating substrate.

3.127
spray coating
atomization of material into a stream of air, allowing it to be deposited onto the substrate

3.128
stencil printing
formation of an image on a substrate by bringing a stencil into contact with the substrate, filling (by means of a squeegee) a suitable medium into apertures within the stencil that define the image, and finally separating the stencil from the substrate

3.129
stretchable conductor
electric conductor that exhibits a decrease in conductivity of less than 10 % during mechanical deformation up to at least 10 % tensile strain

3.130
stretchable cover lay film
electrically insulating film made from a stretchable insulator and used as cover layer for stretchable conductors