

NAITEC



Jornada Técnica

DE LA TINTA AL PROCESO INDUSTRIAL

Jornada exclusiva para socios de Functional Print Cluster e invitados de
Cyclops Synergies

Jornada impartida por **Josh Morris**, de Cyclops
Synergies , con la colaboración de NAITEC



Salesianos Pamplona



7 MAYO



9:00 – 13:00

Organiza:

Colabora:

Actividad de INFINITE



cyclops
synergies



salesianos
PAMPLONA



NAITEC



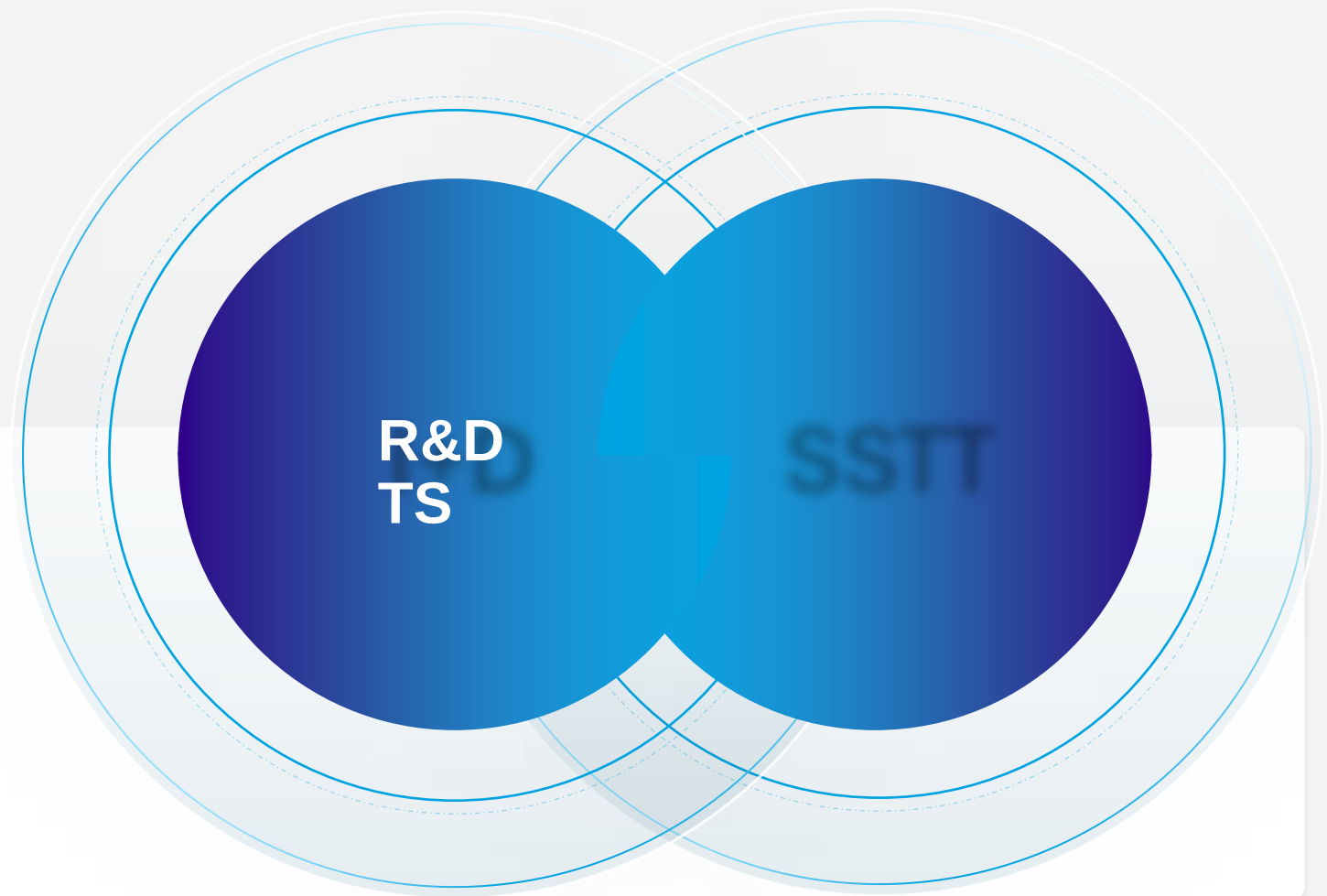
Co-funded by
the European Union



NAITEC Technology Centre Strengthening R&D and Technological Services

NAITEC is a private non-profit foundation created in 2018 at the initiative of the Government of Navarre.

It brings together in a single organisation the knowledge and experience of previous technology centres in Navarre and applies them in strategic sectors such as industry and mobility.



Knowledge areas

Validation Engineering and
Technology Consulting



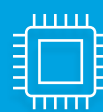
Artificial Intelligence and
Data Analytics



**New
Materials**



**Electronics -
Edge Computing**



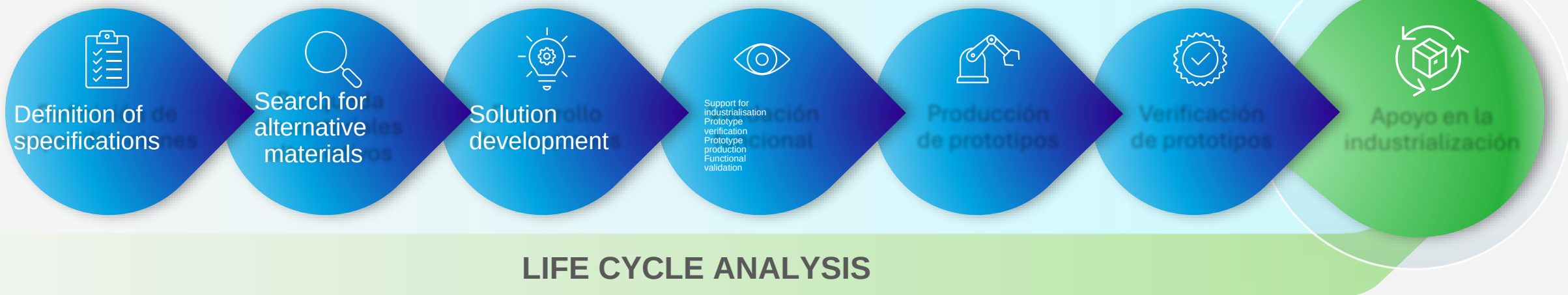
**Sustainable
Manufacturing**



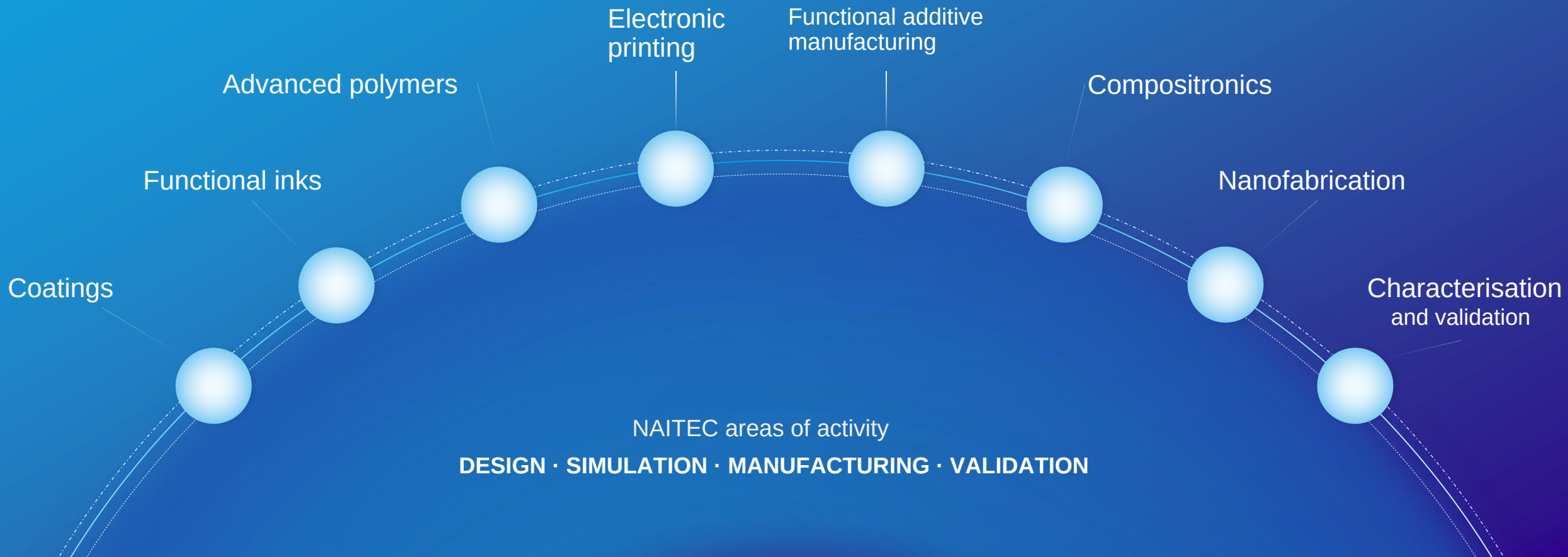
**Simulation and Advanced
Engineering**



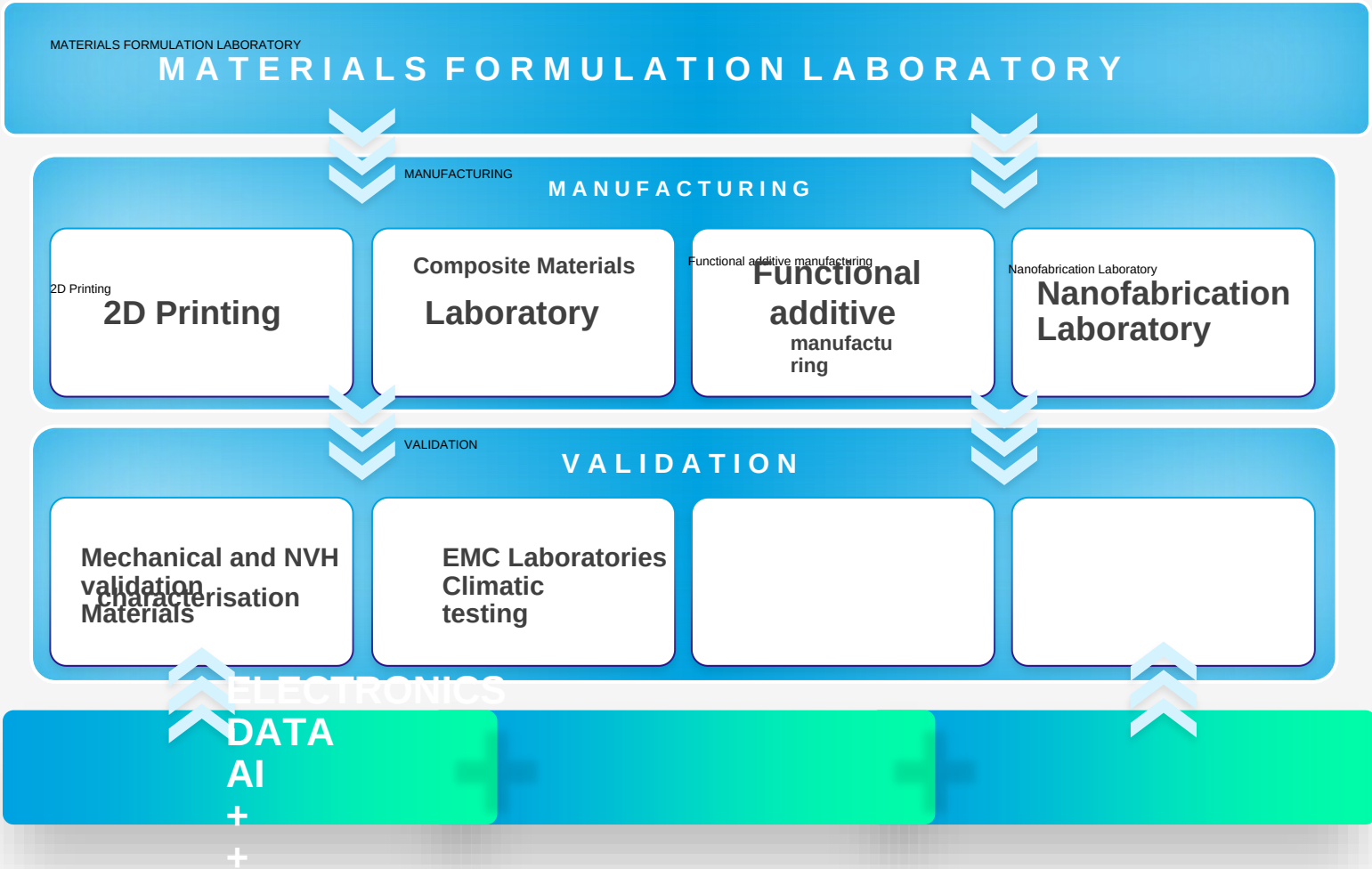
Comprehensive technological solutions



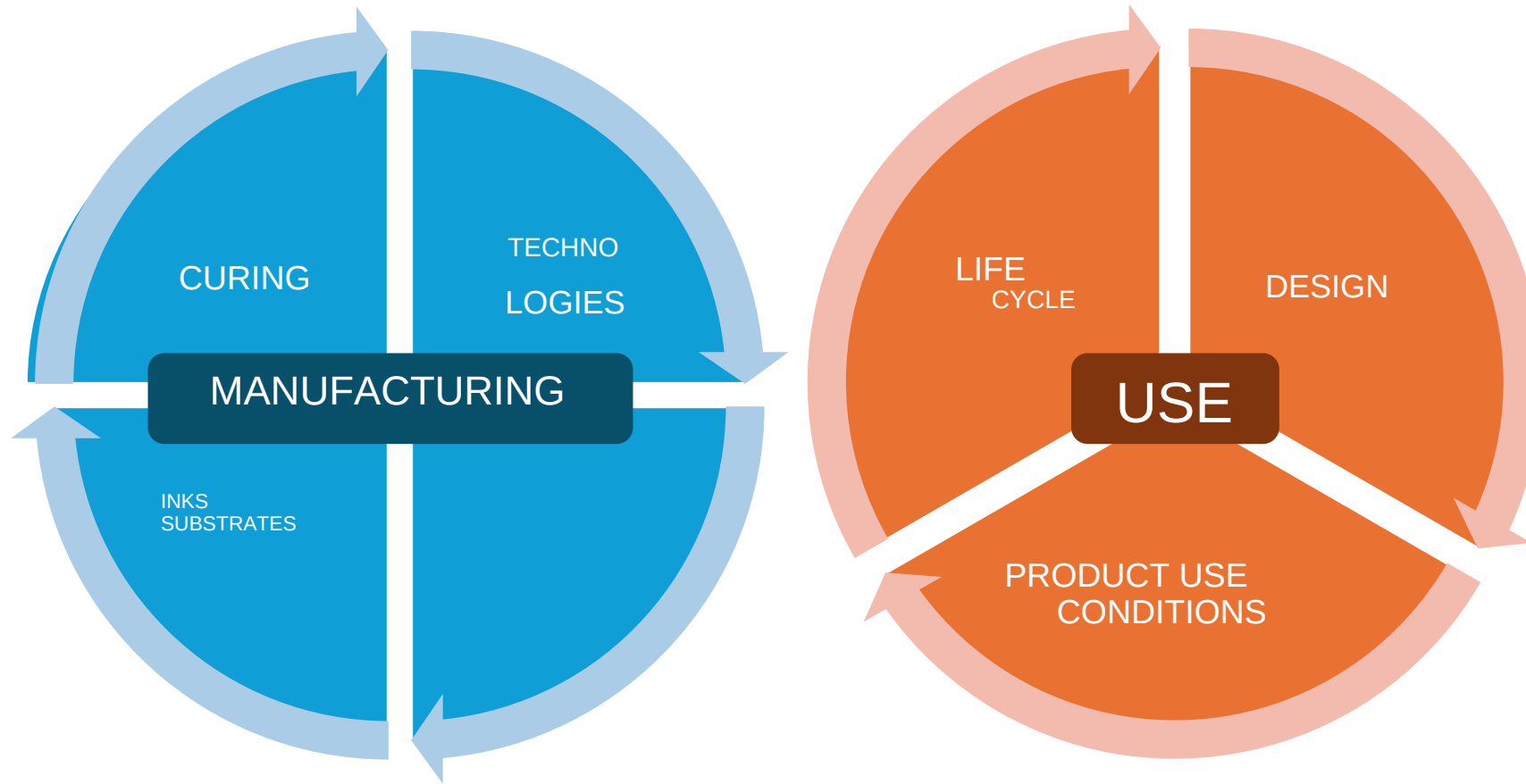
20 years of experience in Materials and Advanced Manufacturing for industry



We integrate complementary capabilities



Factors to consider in printed electronics



Factors to consider in printed electronics



TECHNOLOGIES

Speed

Deposition

Resolution



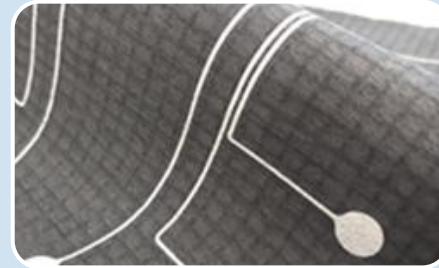
INKS

Price

Availability

Rheological properties

Nature



SUBSTRATES

Temperature
resistance

Ink
interaction

Porosity

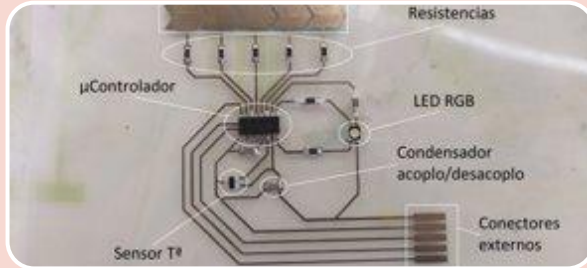


CURING

Thermal

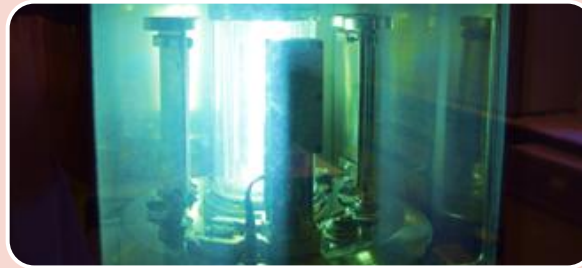
IR
UV

Factors to consider in printed electronics



ELECTRONIC DESIGN

Functionality
Conditions of use
Price



OPERATING CONDITIONS

Applicable standards
Application sectors

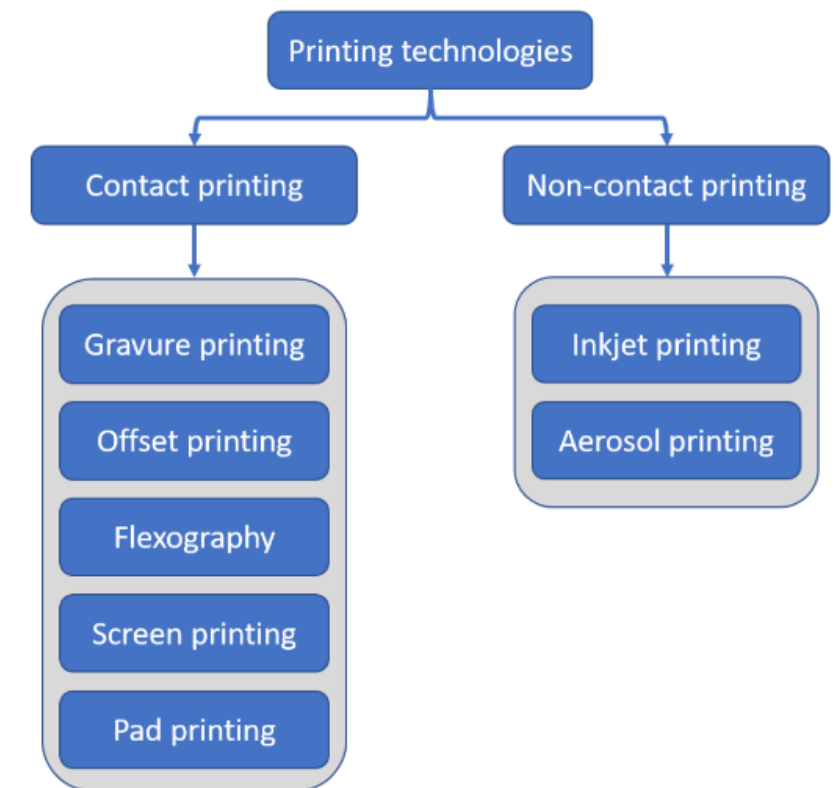
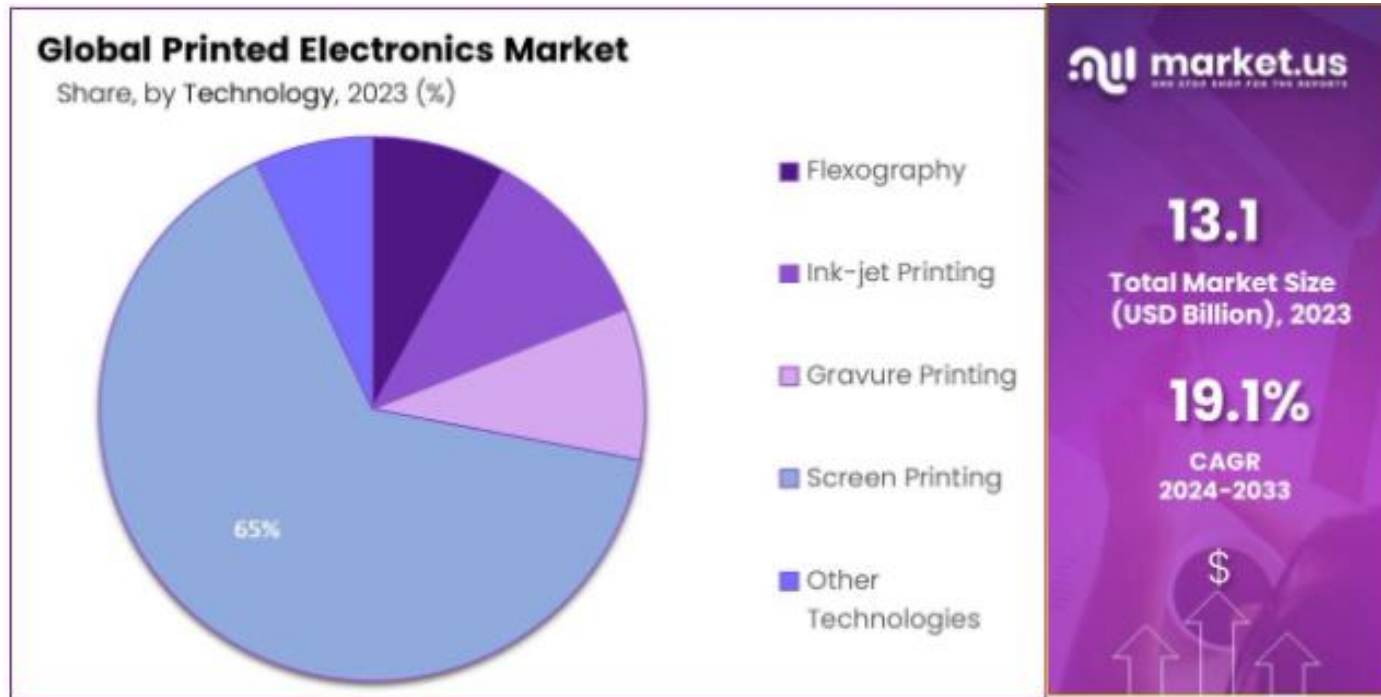


LIFE CYCLE

Raw materials
Recycling
Energy consumption

PRINTING TECHNOLOGIES AND MATERIALS

PRINTING TECHNOLOGIES AND MATERIALS



GRAVURE PRINTING

Direct roll-to-roll printing system on flexible substrates.

Intaglio printing system.

Uses low-viscosity water-based, solvent-based or

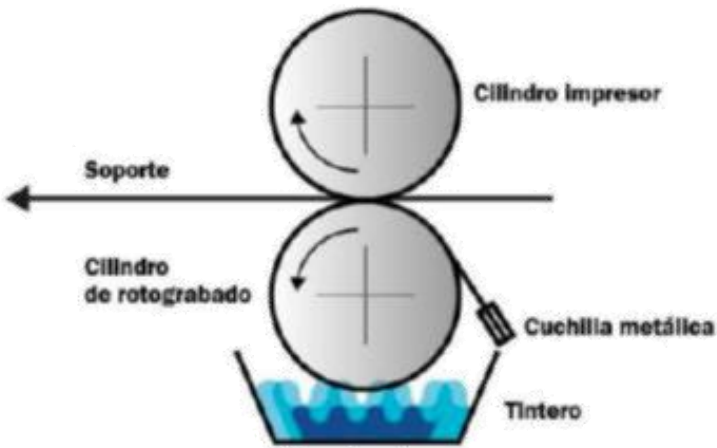
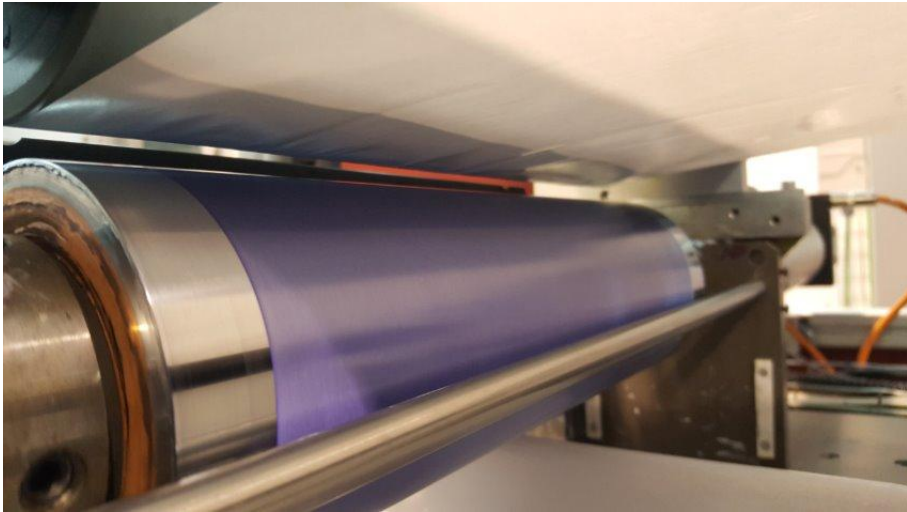
UV-curable
inks.

Process:

The anilox roller is immersed in the ink reservoir and the cylinder cells are filled with ink.

The doctor blade removes excess ink from the cells.

The impression or pressure cylinder presses the substrate against the gravure cylinder, transferring the ink from the cells.



GRAVURE PRINTING

Applications

Flexible food packaging: paper, aluminium, plastic, packaging.

Tobacco

Pharmaceutical industry

Decoration

Gift wrapping paper

Wood

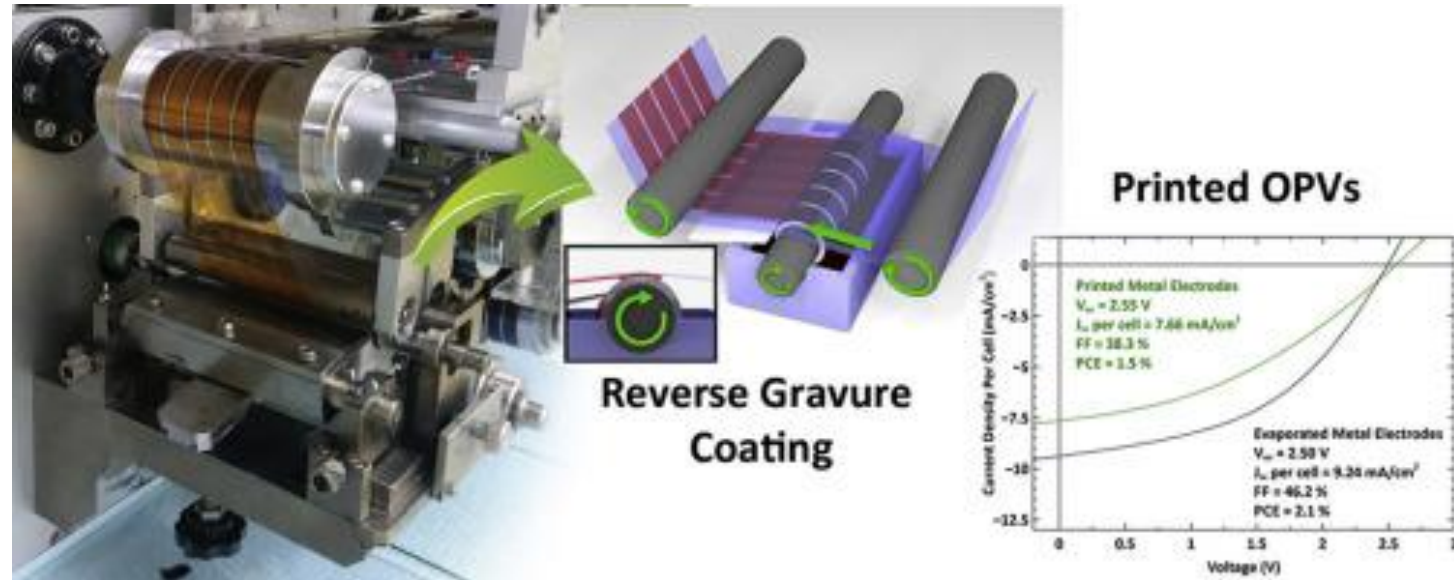
Rubber

Wallpaper

Textiles

Special applications: adhesives, lacquers.

Functional coatings

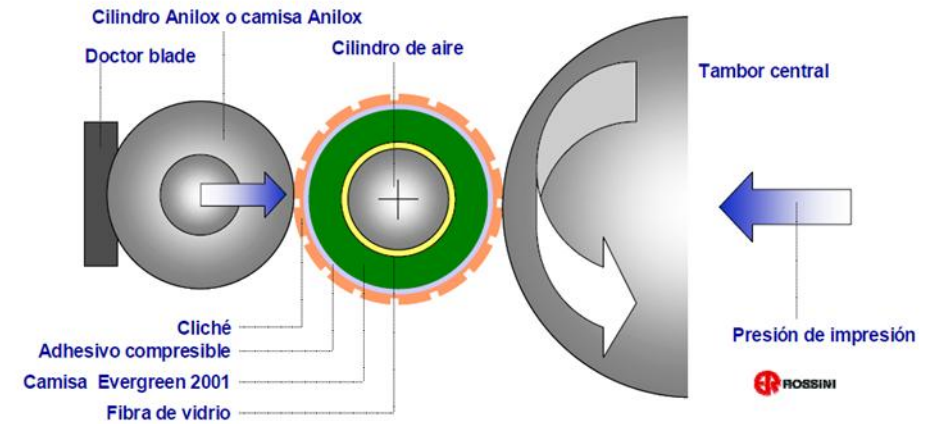


Source: Reverse gravure coating for roll-to-roll production of organic photovoltaics, Solar Energy Materials and Solar Cells

FLEXOGRAPHY

Process:

1. The anilox roller is immersed in the ink reservoir and the cells are filled with ink.
2. The doctor blade removes excess ink from the surface of the anilox roller.
3. The anilox roller contacts the raised areas of the **plate / sleeve, coating them with ink.**
4. The plate contacts the substrate and the ink is transferred. The substrate must be supported by a cylinder so that pressure can be controlled.



- Ink reservoir/tray: similar to gravure printing.
- Doctor blade: similar to gravure printing.
- Anilox roller: similar to gravure printing.
- Sleeve: a steel cylinder coated with rubber, located between the ink transfer roller (anilox) and the impression cylinder. It is very important that the inks used are chemically compatible with the rubber on this cylinder. Perforated metal rollers and compressed air are used to position the sleeves correctly.

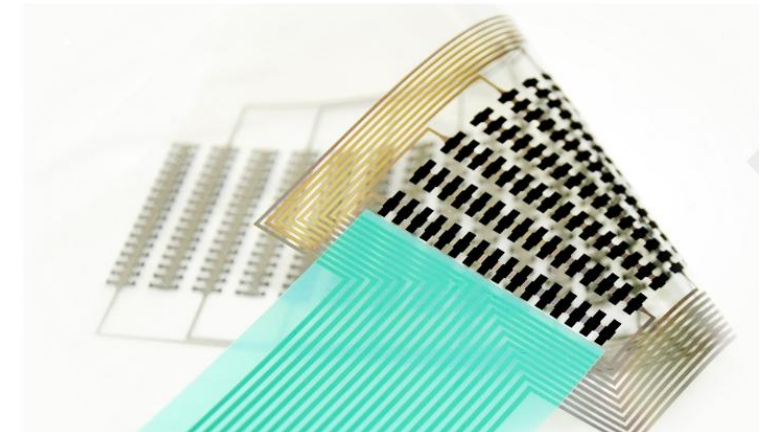
APPLICATIONS FLEXOGRAPHY

- Labelling: self-adhesive labels in rolls on paper or polymer films.
- Packaging: corrugated cardboard containers, plastic films (polyethylene, polypropylene, polyester, etc.), paper and plastic bags.
- Printing of napkins, toilet paper, folding cartons, newspapers, etc.
- Printed electronics: antennas, sensors, conductive tracks

Flexography is one of the most cost-effective printing methods for the final product because it enables a greater number of reproductions at lower cost.



Printed electronics – printelectric®



SCREEN PRINTING OPERATION

It is a highly versatile technique, as it can achieve high resolutions with very fine lines or high deposition levels, depending on the mesh.

It is a direct printing technique because the image passes directly from a screen to the substrate. The system transfers ink through a mesh stretched on a frame and coated with a photosensitive emulsion, which blocks the ink in the non-image areas.

Most widely used printing technology in functional printing: 80%

The inks used have medium-to-high viscosities: from 3,000 cP to more than 1 million.

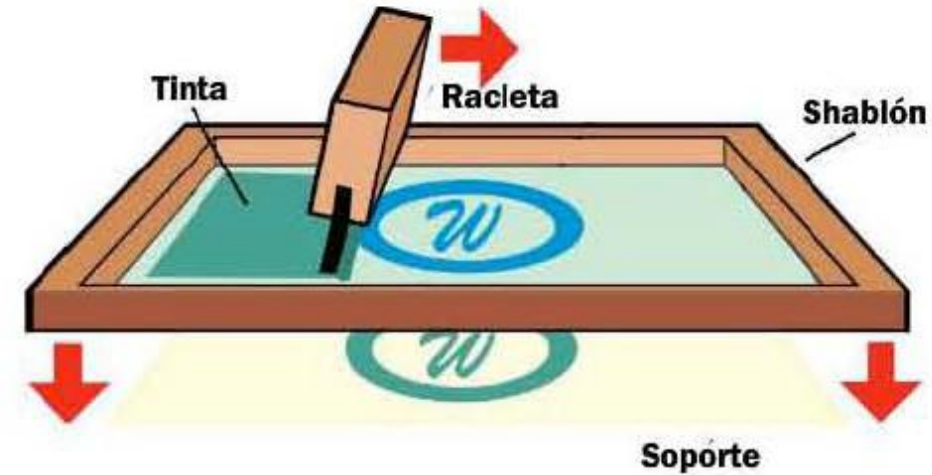


SCREEN PRINTING OPERATION

- Direct printing system that works by permeability or screening.
- The matrix, known as the screen-printing screen, consists of a metal frame over which an ink-permeable synthetic fabric is stretched.
- The mesh characteristics determine the quality and amount of printing.

The printing process is based on:

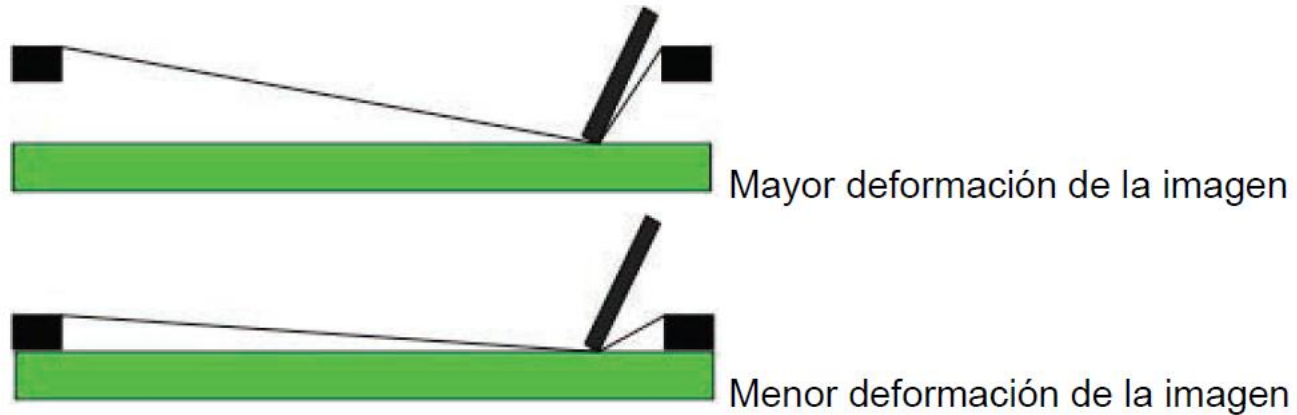
1. Positioning the screen on a flat base: a small gap remains between the mesh and the substrate.
2. Flooding: ink is applied to the screen and spread with a longitudinal movement of the flood bar.
3. Printing: the squeegee passes again under pressure so that the mesh contacts the printing substrate and the ink passes through the mesh openings in the permeable areas.
4. When the pressure is released, the mesh separates from the printing substrate and it can be removed.



SCREEN PRINTING OPERATION

The variables controlled in the printing process are:

1. Squeegee pressure and angle: affect the amount deposited.
2. Screen height: affects image deformation.
3. Printing speed: affects deposition and finish. Ink rheology is closely related to this variable.



SCREEN PRINTING TOOLS

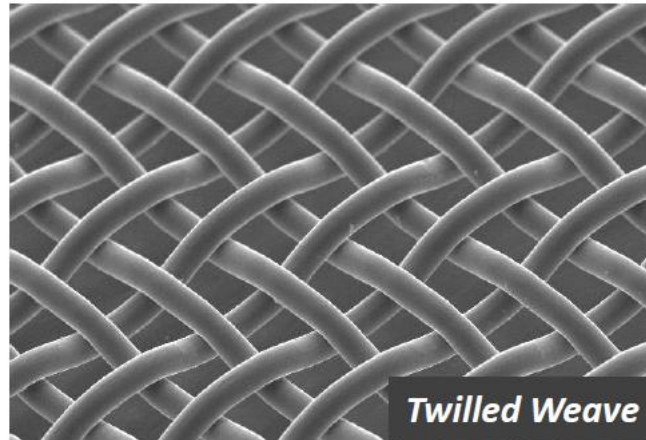
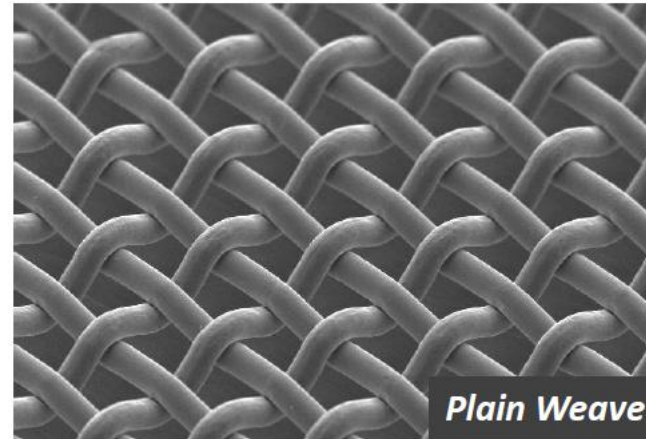
SCREEN-PRINTING SCREENS

FRAME: may be metal (aluminium, iron), interchangeable or self-tensioning.

Screen tension is an important parameter that can be controlled with specific equipment.

MESH: usually metal (fine lines) or synthetic nylon or polyester (more versatile and cheaper). It is defined by mesh count:

- Number of threads per cm
- Thread diameter



SCREEN PRINTING TOOLS

It is a highly versatile technique, as it can achieve high resolutions with very fine lines or high deposition levels, depending on the mesh.

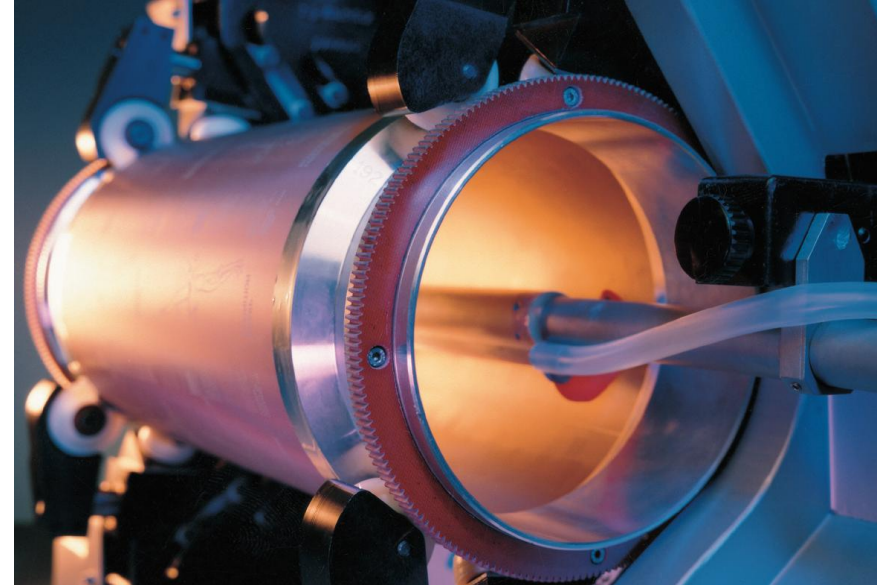
There is always a trade-off between resolution and deposition:

- If coarse meshes are used to deposit a large volume of ink, resolution will be low.
- If fine meshes are used to achieve high resolution, deposition will be low.

The inks used have medium-to-high viscosities: from 3,000 cP to more than 1 million.

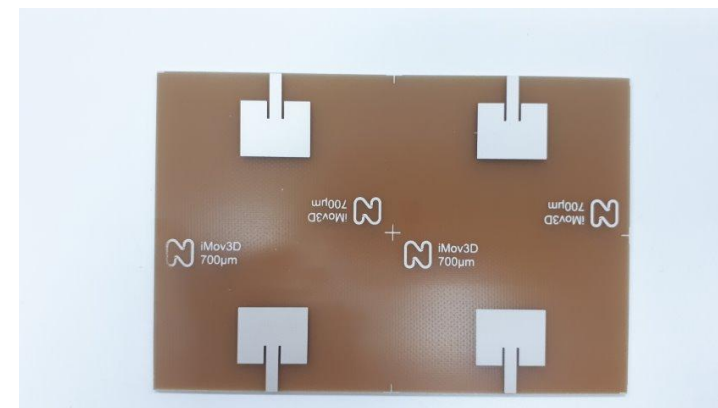
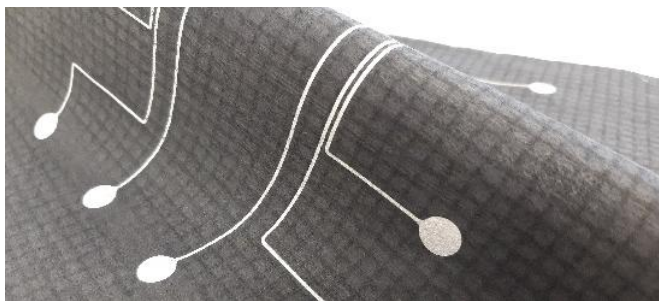
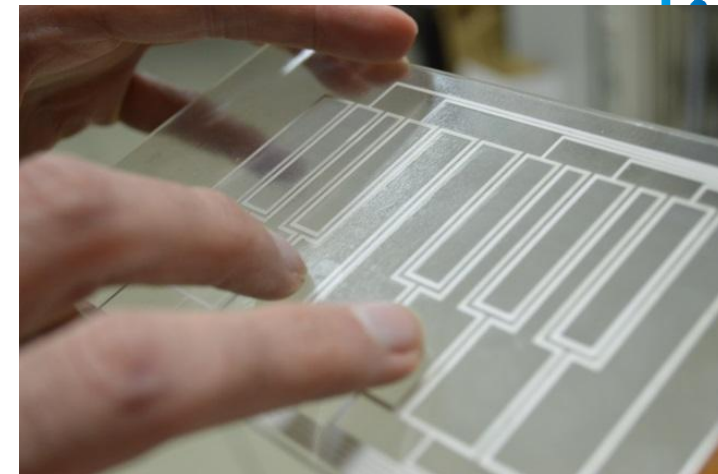
ROTARY SCREEN PRINTING TOOLS

- In this case, the screen is cylindrical and works in rotary mode with roll-fed substrates.
- The difference in application is that the ink is distributed inside the rotating screen cylinder. The squeegee is fixed inside.
- The screens are metallic and are not made from woven fabrics, although the general mesh concepts are maintained.
- The process is more expensive because of the screens and is justified for long production runs where production speed is very high.
- The inks must be specifically designed for rotary application



SCREEN PRINTING APPLICATIONS

- Labels and packaging: applications of varnishes and inks with high thicknesses.
- Embossed labels for high-quality products, widely used for wine labels.
- Printing Braille graphics (high thicknesses)
- Functional printing: printed electronics



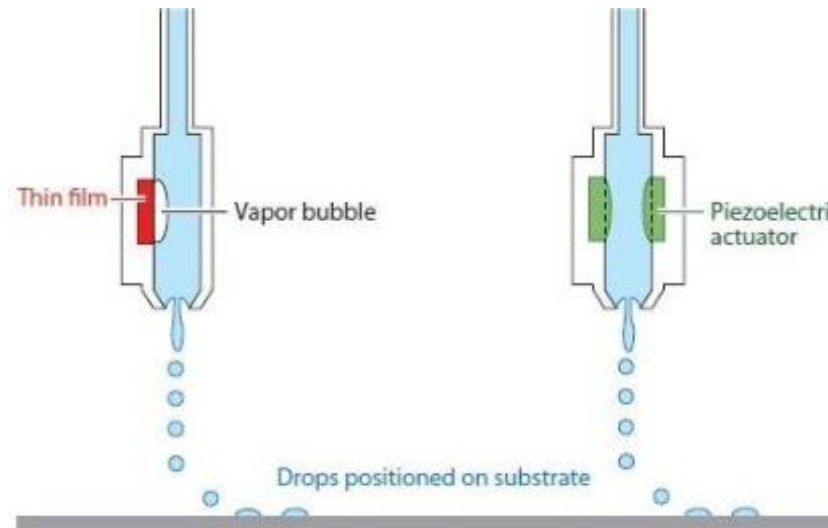
SCREEN PRINTING APPLICATIONS



INKJET OPERATION

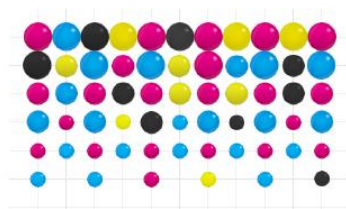
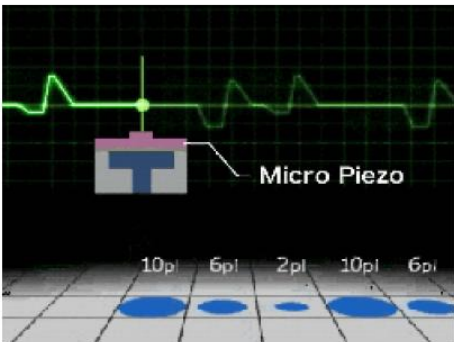
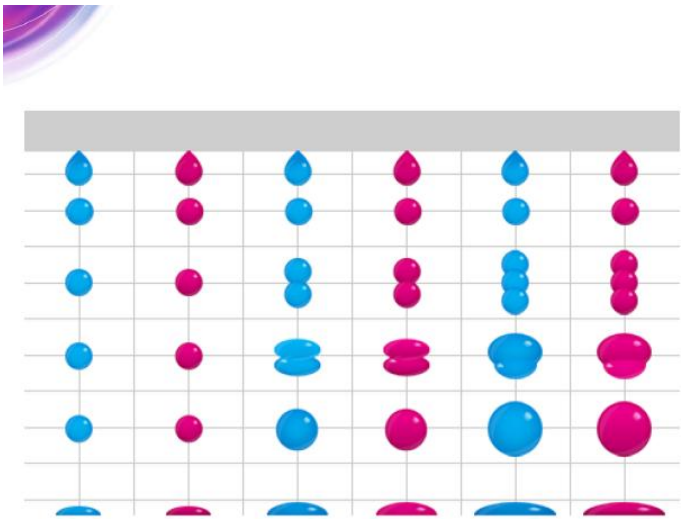
- Formation of an image by digitally controlled deposition of ink droplets from a printhead onto a substrate, with no contact between printhead and substrate.
- **No intermediate tooling (screens, anilox rollers) is required, so each printed image can be unique. This gives it unique versatility among commercial printing systems.**
- Drop-On-Demand (DOD) technology: ink droplets are expelled from the printhead by a pressure pulse generated:

1. Thermally (desktop printers):
ink vaporisation by local heating.
2. By piezoelectric crystals that
deform when an electric current is
applied.



INKJET OPERATION

- Resolution is determined by the number of nozzles per printhead.
- One printhead is usually used for each colour or type of functional ink (conductive, dielectric).
- Droplet density increases with resolution.
- Very high speeds can be achieved with roll-fed or flat materials, provided the printing surface is in a flat area.
- A robot with an inkjet printhead can be used for non-flat surfaces.
- Droplet volume is very small (measured in picolitres), and waveforms are generated to optimise the process for each ink and printhead.



Resolution	Gap between Drops
300 dpi	84.7 μm
360 dpi	70.6 μm
600 dpi	42.3 μm
720 dpi	35.3 μm
1200 dpi	21.2 μm
1440 dpi	17.6 μm

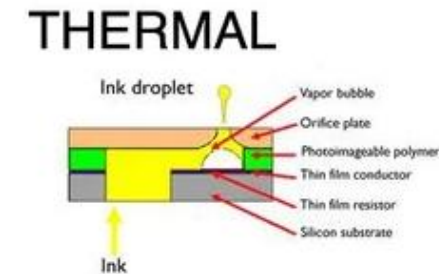
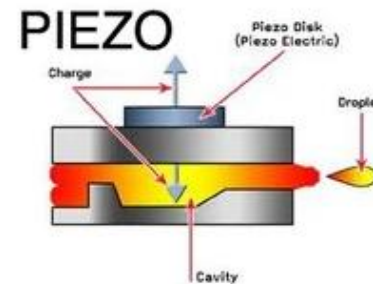
INKJET TOOLS

Printhead: _____

It consists of several hundred nozzles which, when a high-voltage pulse is applied, selectively eject the ink contained in each one.

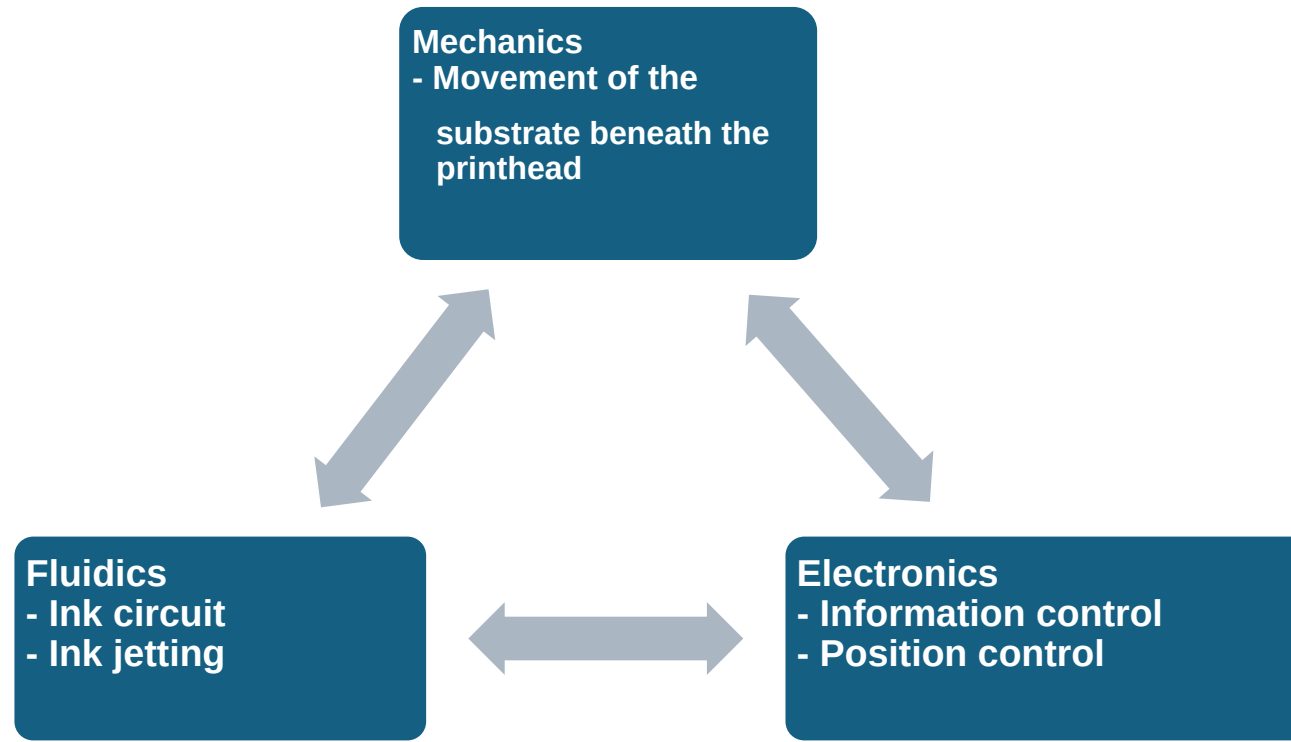
Printhead selection is a critical factor in defining the printing process.
The following must be considered:

- ink compatibility
- required deposition volume
- particle size of the ink to be used (in functional printing)
- required process speed
- required resolution



INKJET OPERATION

- The development and optimisation of a complete inkjet process must include these three major aspects.
- Materials must also be optimised: substrate, ink, primer, coating.
- Images require pre-processing before printing.



INKJET APPLICATIONS

Inkjet printers (plotters) make it possible to customise products for individualised manufacturing. They are the only option for individual products or short runs, as well as when ?non-contact? printing is required, meaning that no printing element touches the substrate.

However, they also have interesting applications in mass production:

- Ceramics
- Bottles and containers
- Packaging
- Mobile phones and digital cards
- Promotional products
- Control panels
- Labels
- Protective coatings and adhesives.



CONDUCTIVE INKS

Conductive ink types

Silver flake

Silver nanoparticle

Particle free

Copper

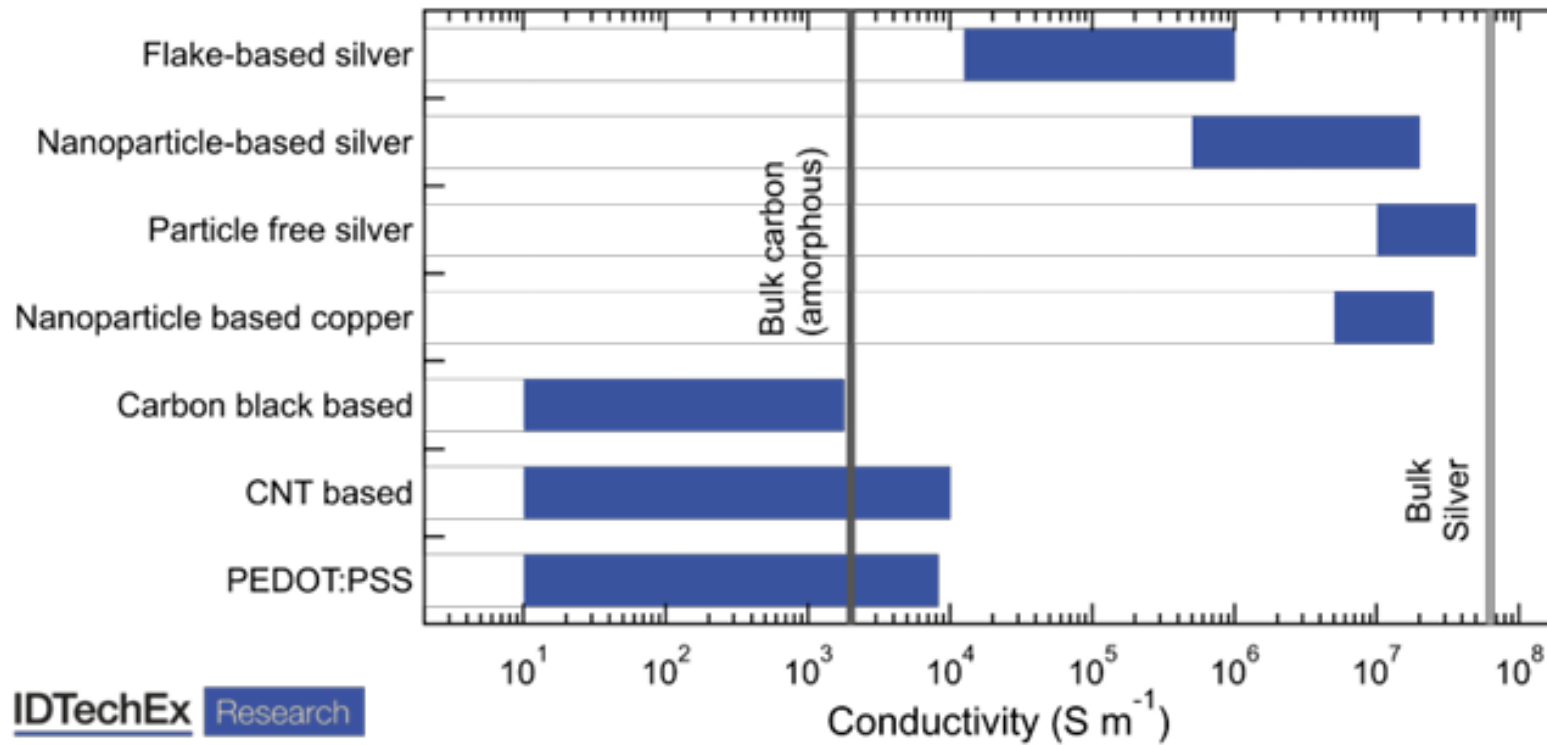
Carbon (incl. CNT)

Stretchable

Thermoformable

Silver nanowire

Conductive polymer



INKJET INK REQUIREMENTS



Typical low viscosity
Controlled surface tension



Sub-micron particles

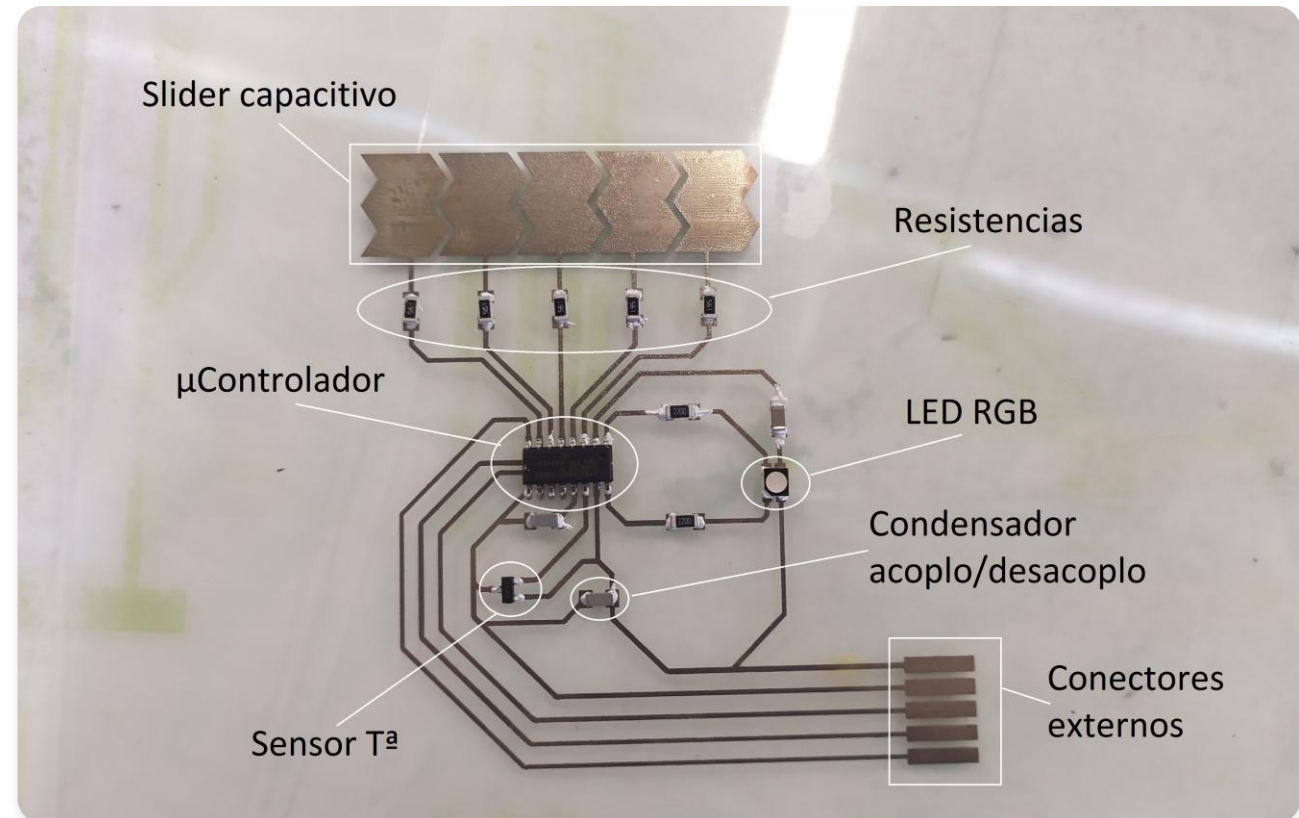


Stability

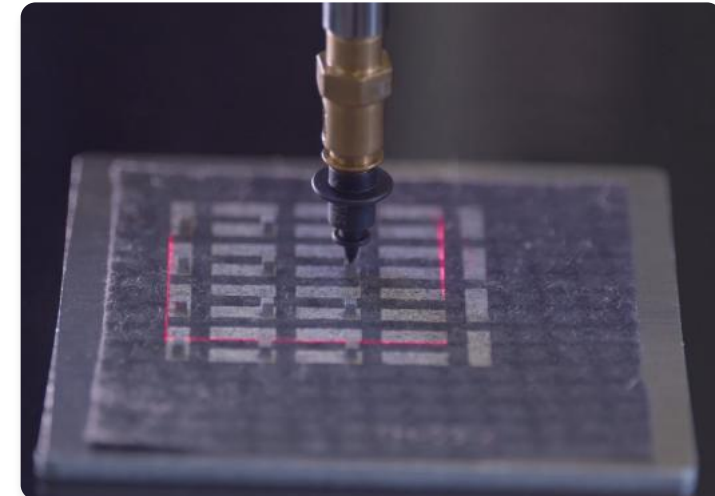
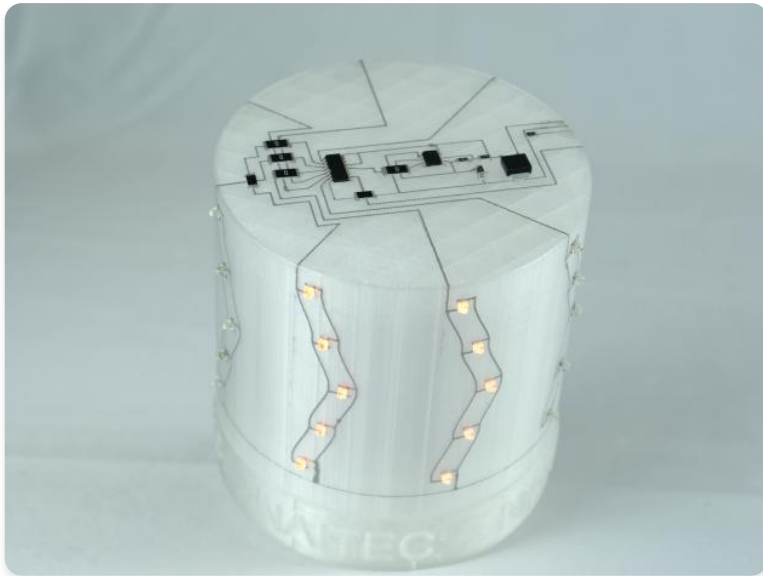
HYBRIDISATION OF ELECTRONIC COMPONENTS AND INTERCONNECTIONS

HYBRIDISATION OF ELECTRONIC COMPONENTS

This refers to the integration of electronic components into flexible devices. These may include integrated circuits, sensors, resistors and capacitors. This makes it possible to combine printed-circuit manufacturing with surface-mount technology (SMT) and other assembly methods to achieve thinner, lighter electronic devices that can adapt to different surfaces.



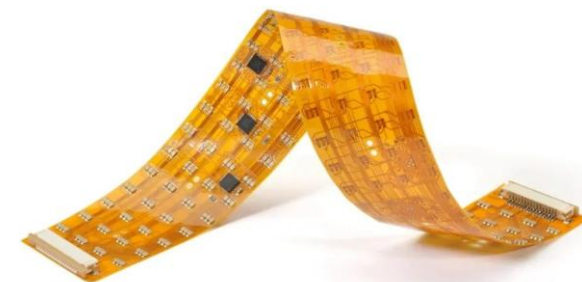
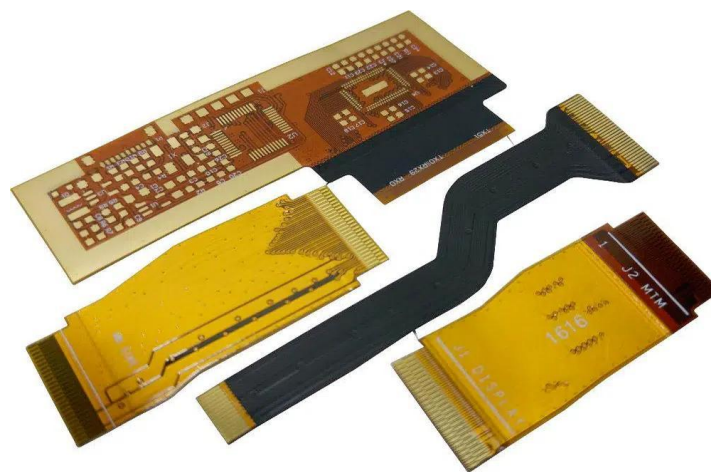
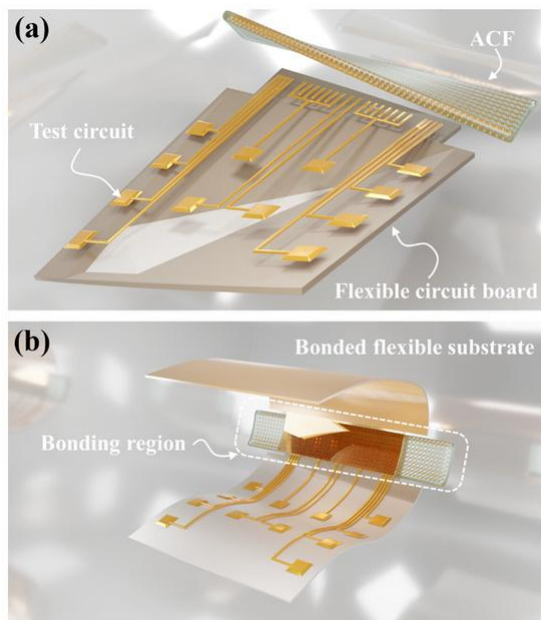
HYBRIDISATION OF ELECTRONIC COMPONENTS



PRINTED-CONVENTIONAL ELECTRONICS INTERCONNECTION

Interconnection using ACF
(Anisotropic Conductive Film)

Flexible FPC/Flex PCB circuits
connected to conventional electronics



PRINTED-CONVENTIONAL ELECTRONICS INTERCONNECTION

Snap/button-type connectors
in textiles
Connectors in textiles



PRINTED-CONVENTIONAL ELECTRONICS INTERCONNECTION





NAITEC

WHERE ARE WE HEADING?

SUSTAINABLE MATERIALS

Recycled silver

Bio-based substrates

Water-based inks

Composites:

Natural fibres

Bio-based resins

Recyclable resins

Bio-based resins

Inks based on
non-metallic precursors

Manufacturing process

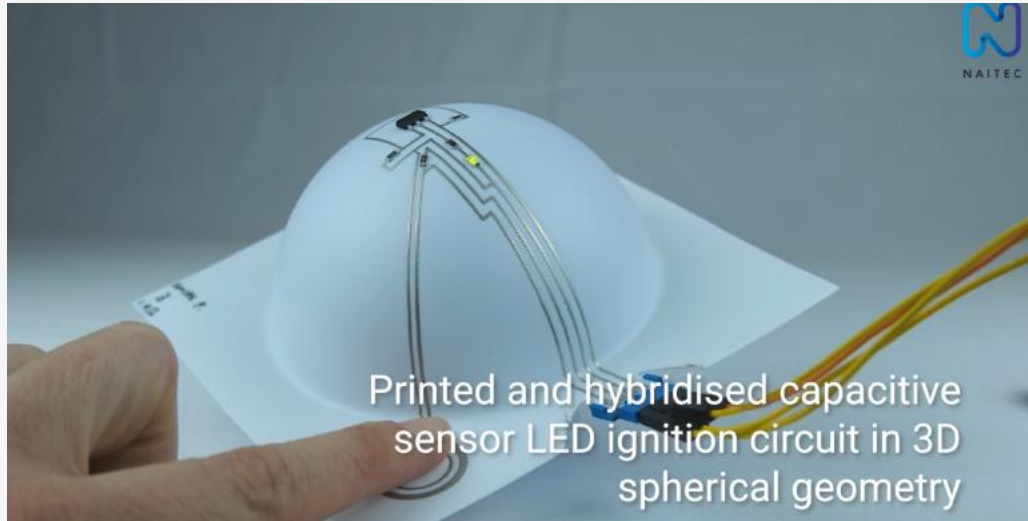
Functional additive manufacturing

Printing solutions to create high-value functional products

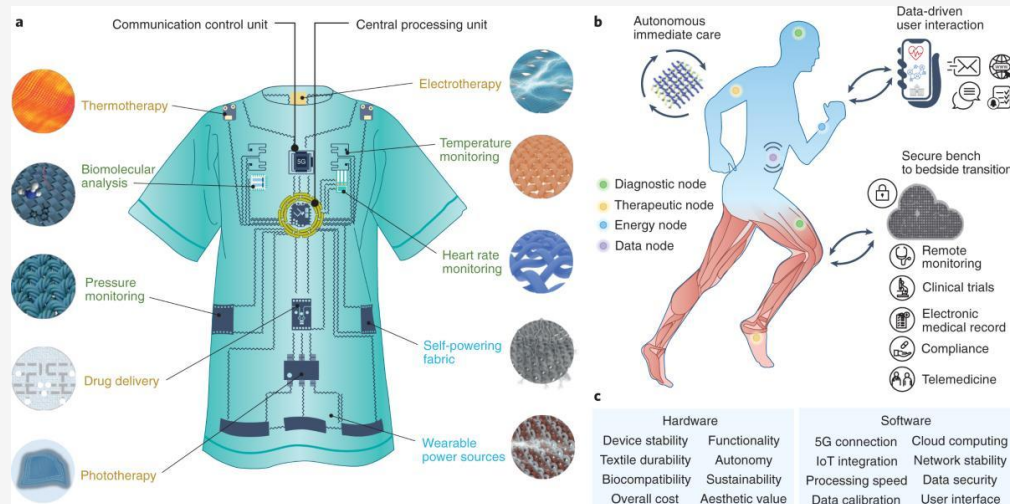
3D Electronic Printing with Hybridisation

Printing on curved surfaces

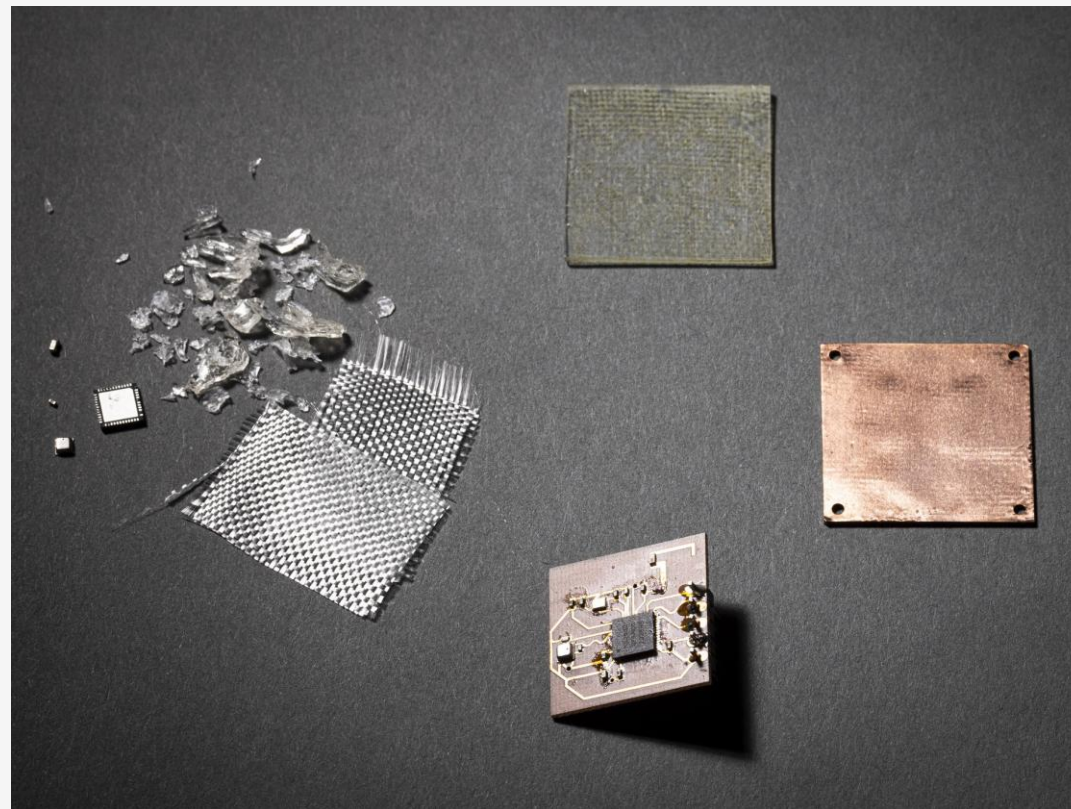
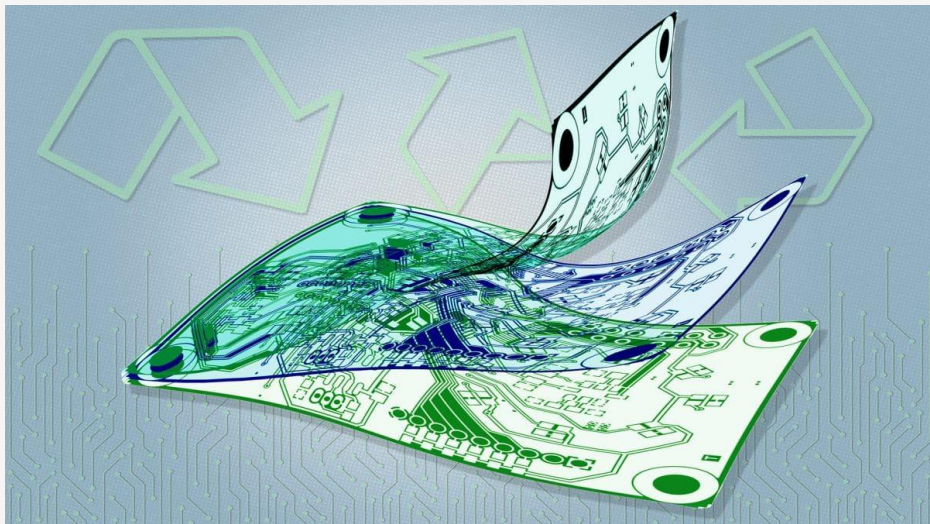
Conformable and flexible electronics



Textile integration: smart clothing, healthcare, occupational protection



Sustainable, biodegradable and recyclable materials



Defence and aerospace

DEFENSA



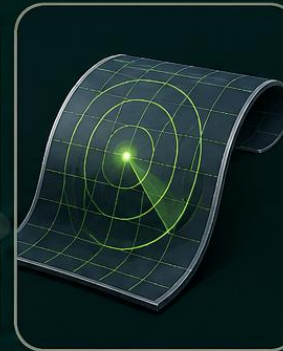
Soldado con
uniforme inteligente



Casco con
sensores



Dron con
antena impresa



Radar flexible



Wearable
táctico

AEROESPACIAL



Ala con sensores
impresos



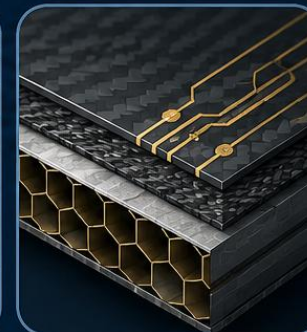
Satélite flexible



Antena
conformable



Revestimiento inteligente
de aeronave

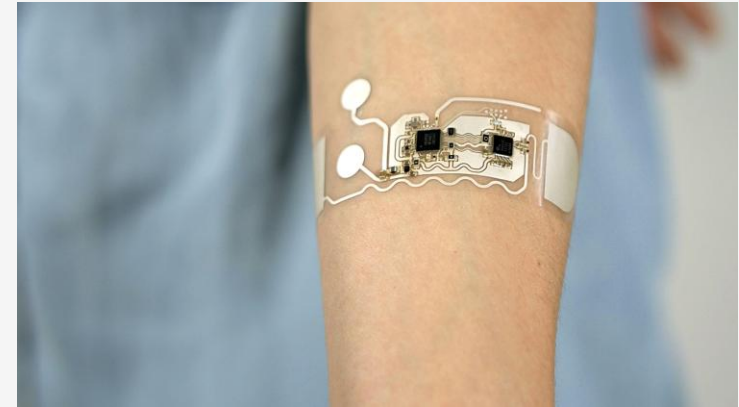


Compuesto
inteligente

Medium term: 3-5 years

The technology will move towards:

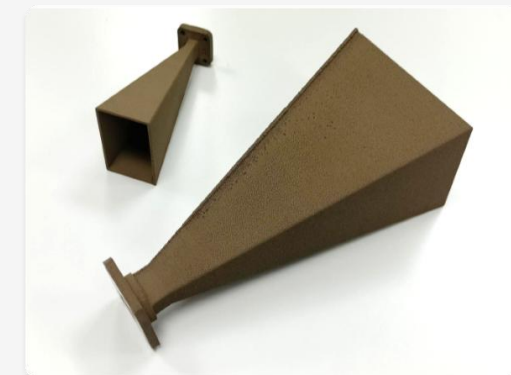
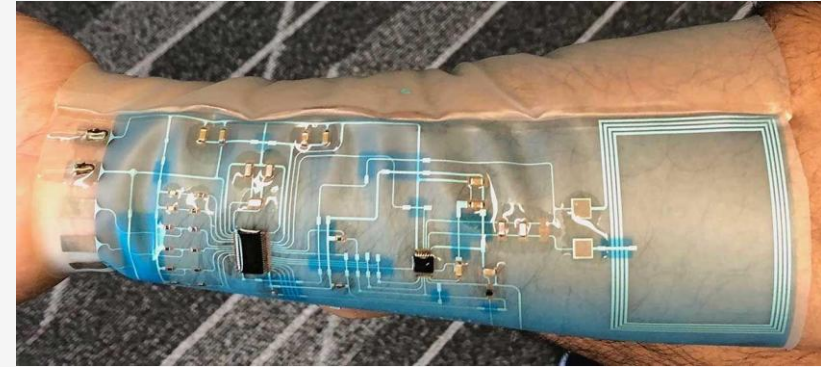
- printed sensors integrated into real products
- more robust medical patches and wearables
- smart packaging with RFID/NFC and sensors
- automotive interiors with integrated lighting, heating and touch controls
- rapid prototyping of circuits on complex geometries



Long term: 5-10+ years

The most ambitious evolution will be:

- structural electronics integrated into 3D parts
- smart components with no visible PCB
- textiles with integrated sensing, communication and energy
- flexible and conformable medical devices
- multimaterial additive manufacturing: conductor + dielectric + semiconductor + encapsulation
- distributed smart surfaces in vehicles, buildings, clothing and IoT devices



STANDARDISATION IN MATERIALS

IEC-TC 119



TC 119 Printed Electronics

[Scope](#) [Structure](#) [Projects / Publications](#) [Documents](#) [Votes](#) [Meetings](#) [Collaboration Platform](#)

TC 119 Scope

Standardization of terminology, materials, processes, equipment, products and health / safety / sustainability in the field of printed electronics

Further information

Secretariat Korea, Republic of

Contact [TC 119 Officers](#)

Strategic Business Plan



Strategic Business Plan

https://assets.iec.ch/further_informations/8679/SMB_8591e_SBP.pdf?0506T20

TC 119 Subgroups

Label	Title
Working Groups	
WG 1	Terminology and Roadmap
WG 2	Materials
WG 3	Equipment
WG 4	Printability
WG 5	Quality assessment
WG 6	Sustainability

Title & Task

WG 2

Materials

To develop measuring methods and evaluation methods for materials such as substrates, inks, composite substrates and related materials for printed electronics.

To analyze the effectiveness of the existing methods specific to the materials of printed electronics.

To define specific terms and to determine assessments, requirements, specifications and reliability of materials for printed electronics.

NOTE: Composite substrates include laminated substrates having multi-layer structure.

STANDARDS IN PREPARATION

Title
Printed electronics - Part 202-7: Materials - Printed film - Measurement of peel strength for printed layer on flexible substrate by 90° peel method
Printed electronics - Part 202-12: Materials - Rheological property measurement methods of inkjet ink for printed electronics
Printed electronics - Part 202-13: Materials - Sheet resistance measurement method for conductive layer in printed and in-mould electronics
Printed electronics - Part 202-14: Materials - Measurement methods for conductive ink properties specific to screen printing
IEC 62899-302-8 ED1: Printed electronics - Part 302-8: Equipment - Inkjet- Drop Weight Measurement for Drop Size Estimation
Printed electronics - Part 304-2: Equipment - Sintering - Temperature measurement method for thermal treatment system
Printed electronics - Part 305-1: Equipment - Aerosol Printing - Significant Parameters
Printed electronics - Part 402-2: Printability - Measurement of qualities - Edge waviness of printed pattern using a two-dimensional optical image
Printed electronics - Part 402-8: Printability - Measurement of qualities - Shape pattern dimension
Printed electronics - Part 525-1: Quality Assessment - R2R printed NFC QR code label for anticounterfeiting

PUBLISHED STANDARDS - MATERIALS WG

Reference	n	Date	Title
IEC 62899-201:2016	1.0	2016-02-25	Printed electronics - Part 201: Materials - Substrates
201:2016/AMD1:2018	1.0	2018-11-15	Amendment 1 - Printed electronics - Part 201: Materials - Substrates
IEC 62899-201-2:2021	1.0	2021-10-14	Printed electronics - Part 201-2: Materials - Substrates - Measurement methods for properties of stretchable substrates
IEC 62899-202:2023	2.0	2023-05-02	Printed electronics - Part 202: Materials - Conductive ink
IEC 62899-202-3:2019	1.0	2019-01-16	Printed electronics - Part 202-3: Materials - Conductive ink - Measurement of sheet resistance of conductive films - Contactless method
IEC 62899-202-4:2021	1.0	2021-10-22	Printed electronics - Part 202-4: Materials - Conductive ink - Measurement methods for properties of stretchable printed layers (conductive and insulating)
IEC 62899-202-5:2018	1.0	2018-09-28	Printed electronics - Part 202-5: Materials - Conductive ink - Mechanical bending test of a printed conductive layer on an insulating substrate
IEC 62899-202-6:2020	1.0	2020-12-04	Printed electronics - Part 202-6: Materials - Conductive ink - Measurement method for resistance changes under high temperature and humidity - Printed conductive layer on a flexible substrate
IEC 62899-202-7:2021	1.0	2021-03-03	Printed electronics - Part 202-7: Materials - Printed film - Measurement of peel strength for printed layer on flexible substrate by 90° peel method
IEC 62899-202-8:2024	1.0	2024-03-15	Printed electronics - Part 202-8: Materials - Conductive ink - Measurement of difference in resistance of printing direction of conductive film fabricated with wire-shaped materials
IEC 62899-202-9:2023	1.0	2023-08-03	Printed electronics - Part 202-9: Materials - Conductive ink - Printed patterns for mechanical test
IEC 62899-202-10:2023	1.0	2023-08-16	Printed electronics - Part 202-10: Materials - Resistance measurement method for thermoformable conducting layer
IEC 62899-202-11:2025	1.0	2025-04-23	Printed electronics - Part 202-11: Materials - Conductive ink - Measurement method of electrical resistance uniformity for large area printed conductive layer
IEC 62899-203:2024	2.0	2024-05-28	Printed electronics - Part 203: Materials - Semiconductor ink
IEC 62899-203-2:2025	1.0	2025-06-19	Printed electronics - Part 203-2: Materials - Semiconductor ink - Space charge limited mobility measurement in printed organic semiconductive layers
IEC 62899-204:2019	1.0	2019-05-20	Printed electronics - Part 204: Materials - Insulator ink - Measurement methods of properties of insulator inks and printed insulating layers
IEC TR 62899-250:2025	2.0	2025-03-05	Printed electronics - Part 250: Material technologies required in printed electronics for wearable smart devices

Thank you - Eskerrik asko



NAITEC Technology Centre

Rakel Herrero
rherrero@naitec.es
(+34) 948 29 29 00
naitec.es