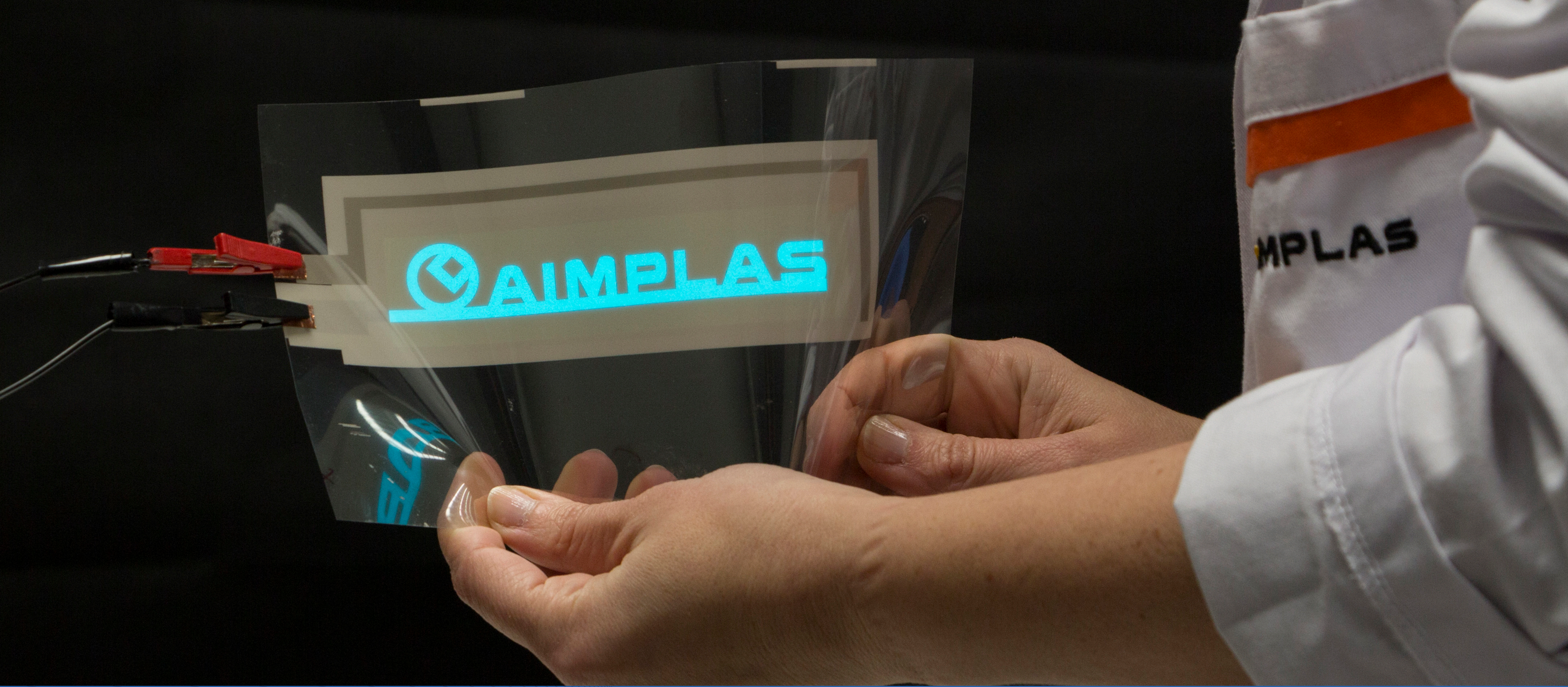
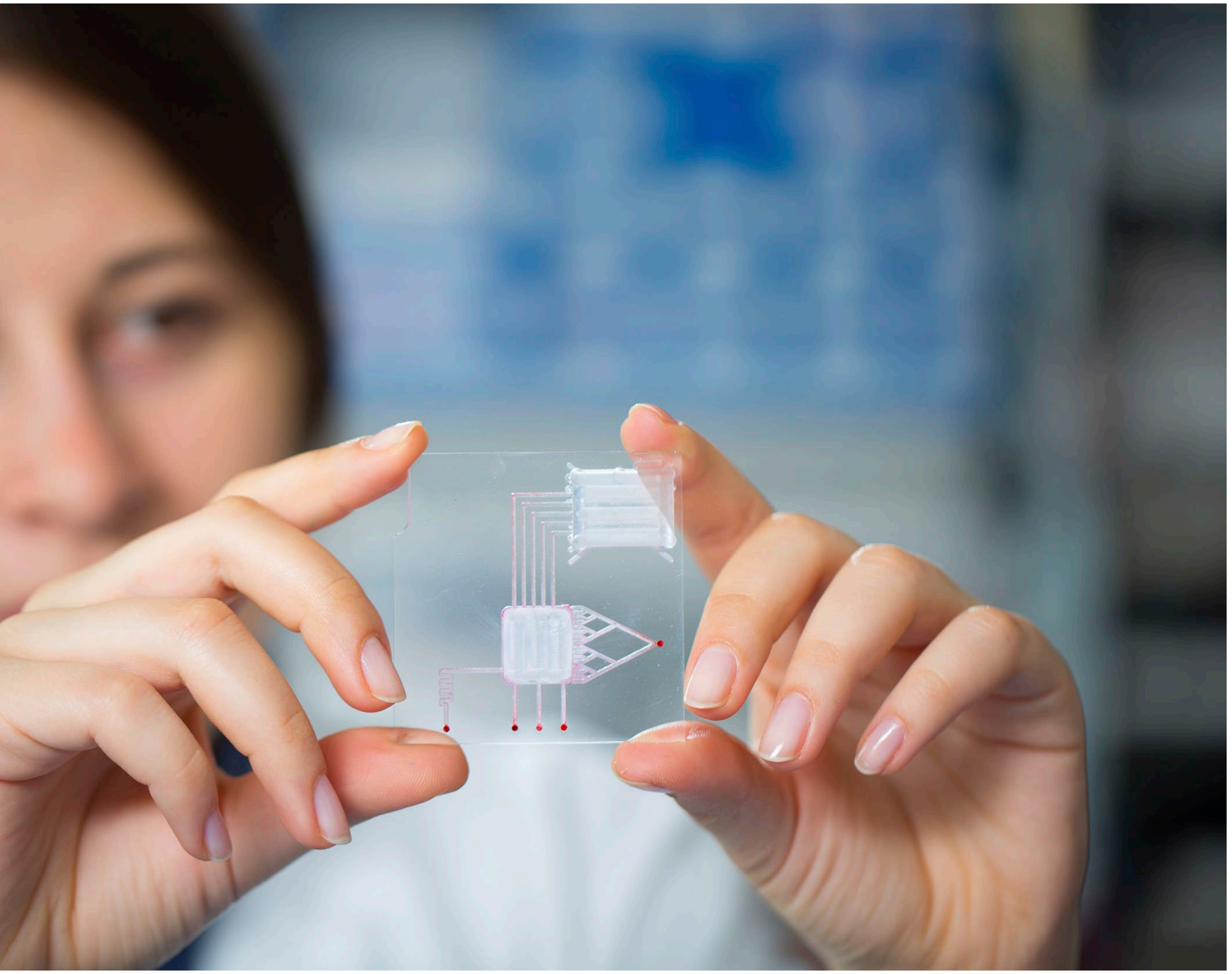


AIMPLAS
PLASTICS TECHNOLOGY CENTRE

PLASTRONICS

The combination of plastics and electronics



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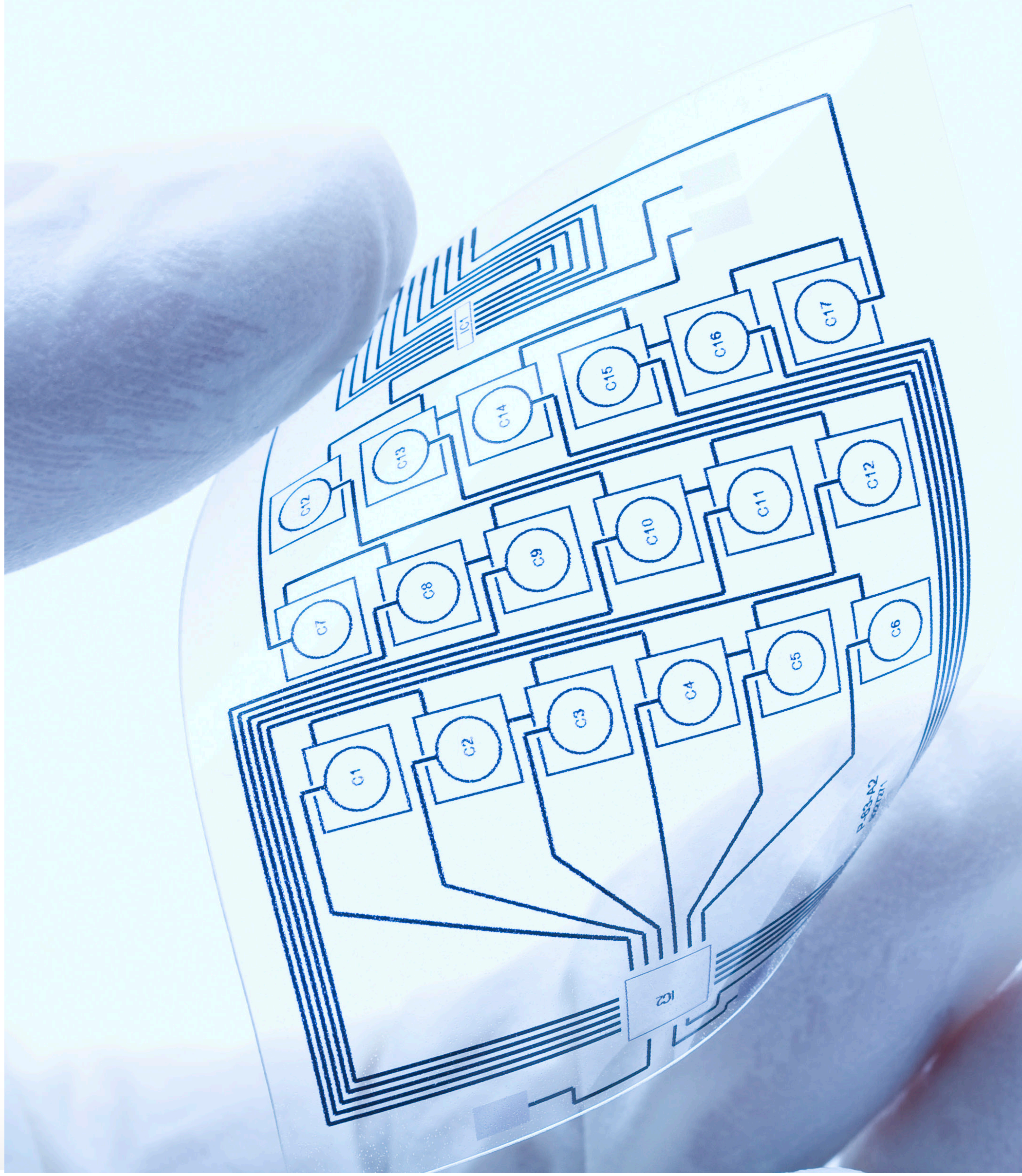
Plastronics: A new technology

Plastronics is a new line of research and development in the field of electronics that integrates electronic components to plastic materials, develops flexible electronics and uses polymer-based conductive materials from organic and hybrid materials.

According to Álvarez, R. et al., the term ‘plastic-electronic materials’ refers to the group of polymer-based materials applicable to macro and microelectronics.

It creates light and flexible devices that can be integrated into certain complex-shaped parts. Another advantage is that, unlike silicon electronics, it is an economical technology as it can be processed on a large scale.



Plastronics is an **emerging line of development** that shows **great growth potential** in industrial sectors such as the **automotive, aeronautical, aviation, consumer electronics and white goods industries.**

The materials and processing technologies that plastronics encompasses include the synthesis of conductive polymers, the integration of conductive materials in thermoplastics and thermoset resins, flexible electronics and In-Mould Electronics (IME), which consists of integrating electronics in complex-shaped and 3D parts by means of thermoforming and mould injection.

Conductive polymers and plastics

Flexible electronics

In-Mould Electronics

Conductive polymers and plastics

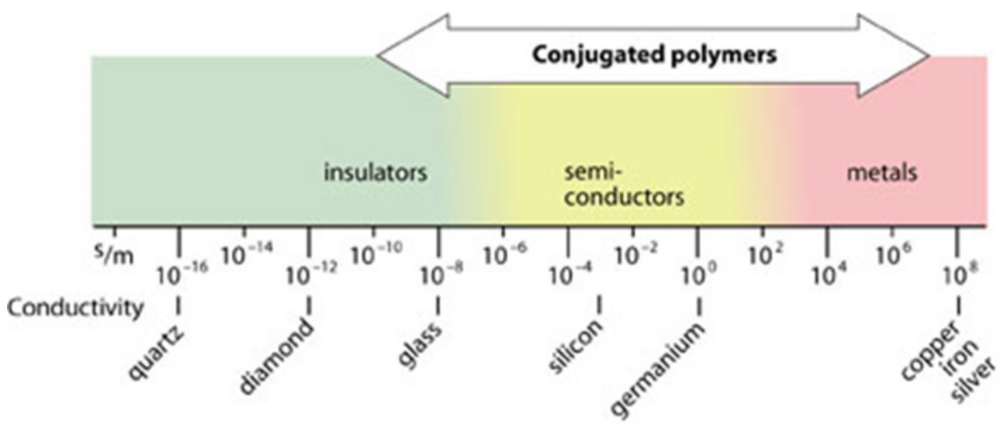
Conductive polymers are materials that are capable of conducting an electric current.

There are two types of conductive polymers:

- **Intrinsically conducting polymers:** Polymers whose electric conductivity is due to the extended conjugation of π electrons along the chain.
- **Extrinsically conducting polymers:** Conventional insulating polymers to which conductive fillers such as metals and graphite (among others) are added, making them conductive.

Intrinsically conducting polymers

Conductive polymers present a wide spectrum of conductivity, as shown in the image below:

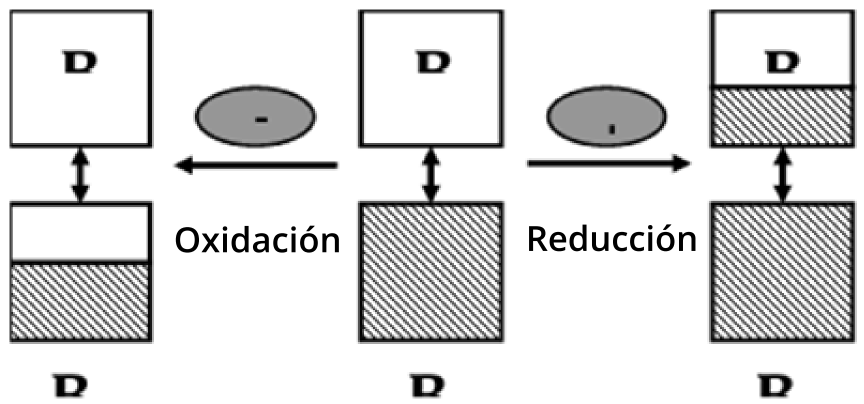


To increase their conductivity, different doping agents such as small ions (Cl, Br, NO_3...), molecules (I_2, Cl_2...) and larger molecules such as peptides, polymers and hyaluronic acid are used.

There are two types of doping, which are shown in the image below:

P-type or oxidation

N-type or reduction



In the end, it is a question of removing electrons from the valence shell, making the exchange of electrons easier or, conversely, adding electrons to the conduction band, enabling the exchange of electrons in that band.

Conductive plastics:
thermoplastics and thermosets

Polymers with conductive fillers combine the electrical conductivity of metals and carbonaceous fillers with the properties of polymer materials. In essence, these materials **tend to be light, easy to process, economical and resistant to chemical attack and corrosion.**

These properties have encouraged the introduction of these materials in consumer goods, as well as in advanced applications (aviation, electronics, non-linear optics, biomedicine...).

Conductive thermoplastics

Compounding is used to obtain thermoplastic composites with electrical or thermal conductivity. This consists of a co-rotating double-twin screw extruder adding conductive fillers to the chosen thermoplastics to obtain pellets with the required electrical conductivity.

Conductive plastics are light, easy to process, economical and resistant to chemical attack and corrosion

The most widely used materials are polymers. They can be used in almost all plastic materials; but the majority of them centre on injection processing, making injection plastics the logical candidates to be integrated in conductive fillers, as well as high-performance materials such as PSU, PEEK and PEI.

Conductive thermosets

Thermoset resins with electrical conductivity:

Doping resins for obtaining thermoset resins with electrical conductivity properties.

It affects the reactivity of the resin, so it requires knowledge of formulations to adapt the catalytic system used, if necessary.

Thermoset resins: polyester, vinylesters, epoxy, furan resins, polyurethanes...

Types of fillers used

Carbonaceous materials: Carbonaceous nanotubes, graphites, carbon black and graphenes.

Metallic materials: Metallic steel, nickel and copper fibres, and metallic powder, although metallic powder can explode due to oxidation at high temperatures.

The market for conductive fillers

According to research carried out by BBC Research on conductive polymers, the global market for electroactive polymers stood at £447.3 million in 2015 and by 2021, the figure is forecast to reach £726.8 million, i.e., a compound annual growth rate (CAGR) of 8.4% from 2016 to 2021. These are global data and encompass all kind of conductive polymers.

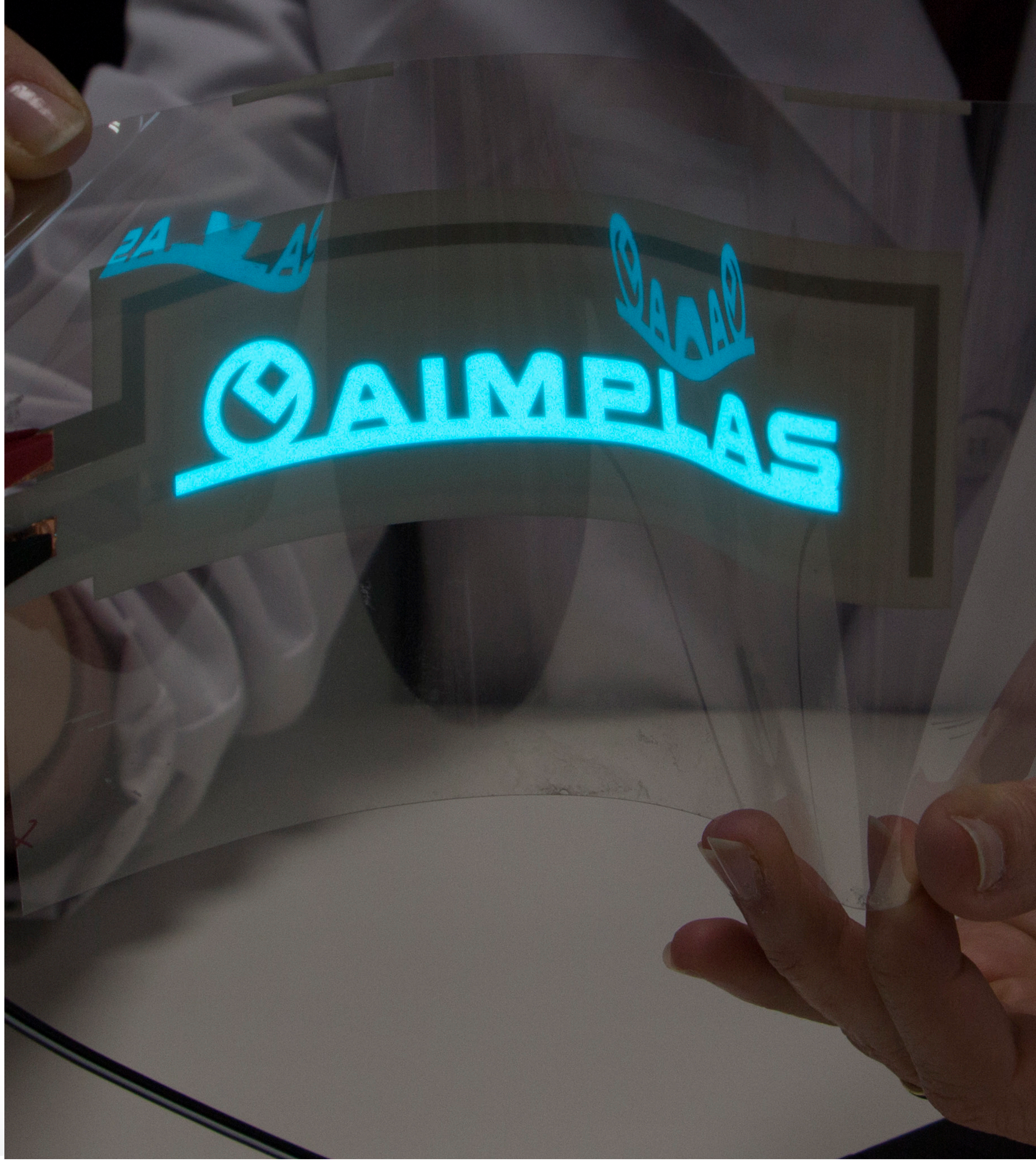
Flexible electronics

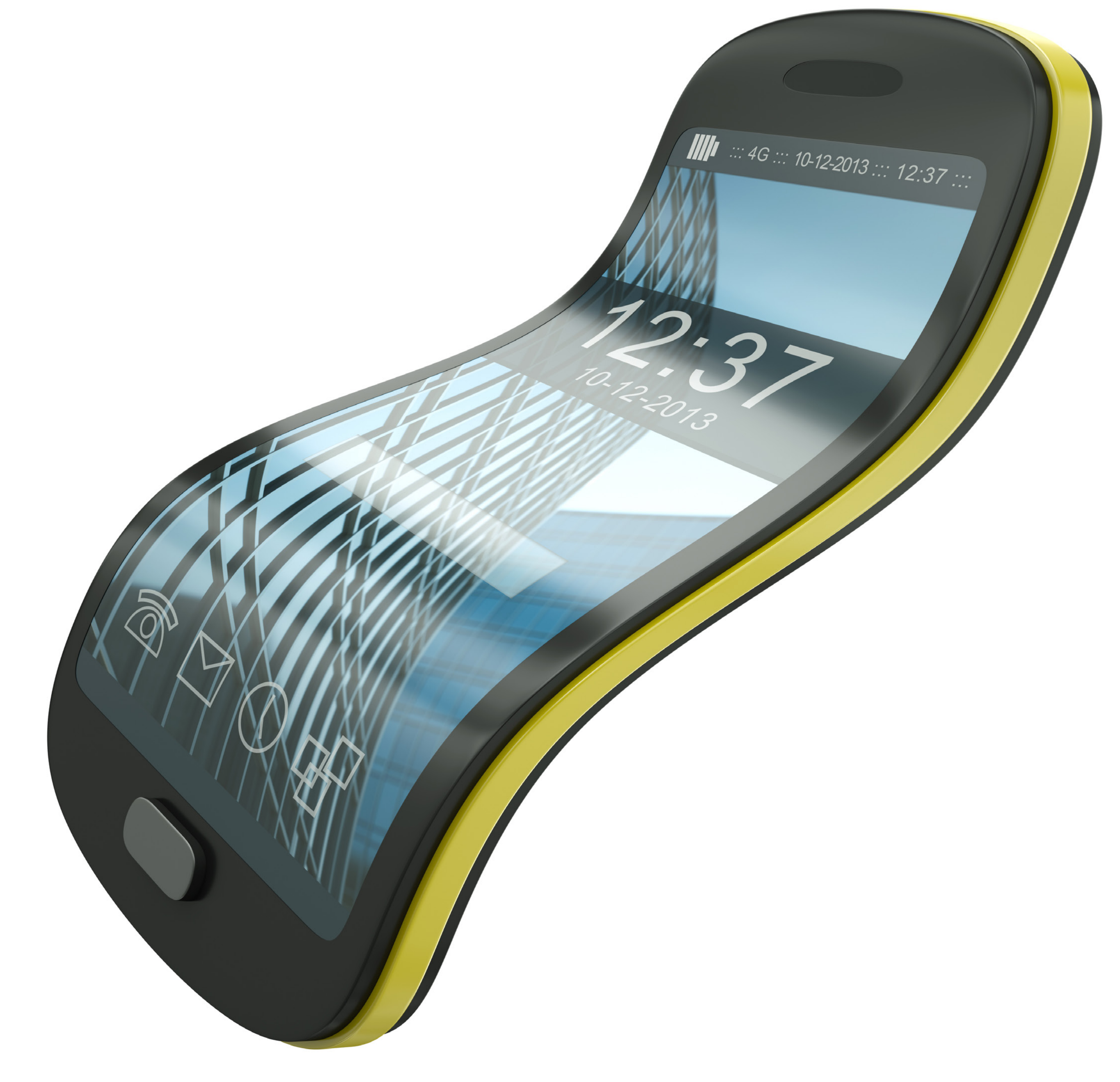
"Flexible electronics" refers to electronic devices that can blend, stretch or be given shape regardless of their material composition without losing their functionality.

Flexible electronics is based on the combination of **new materials** (conductive, semi-conductive and dielectric inks), their **cost-efficiency** ratio and large-scale **production processes** that open up new application fields.

The main properties and advantages of flexible printed electronics are **thinness, lightness and flexibility.**

They also enable the development of a **broad range of electronic components and applications** such as organic photovoltaic solar cells (OPV), organic light-emitting diodes (OLEDs), organic thin-film transistors (OTFT), RFID antennas and sensor electrodes, and they can be **incorporated into intelligent objects** that can be produced and directly integrated through coil winding technologies at low cost.





Intelligent packaging, OLED lighting, RFID low-cost converters, roll-up screens, flexible solar cells, disposable diagnosis devices, tactile flexible screens and printed batteries are just a few of the promising application fields for organic, printed and flexible electronics based on new large-scale processing options for conductive and semi-conductive materials.

Organic and Printed Electronics Association · Roadmap Application Clusters

Source: OE-A

The flexible electronics market

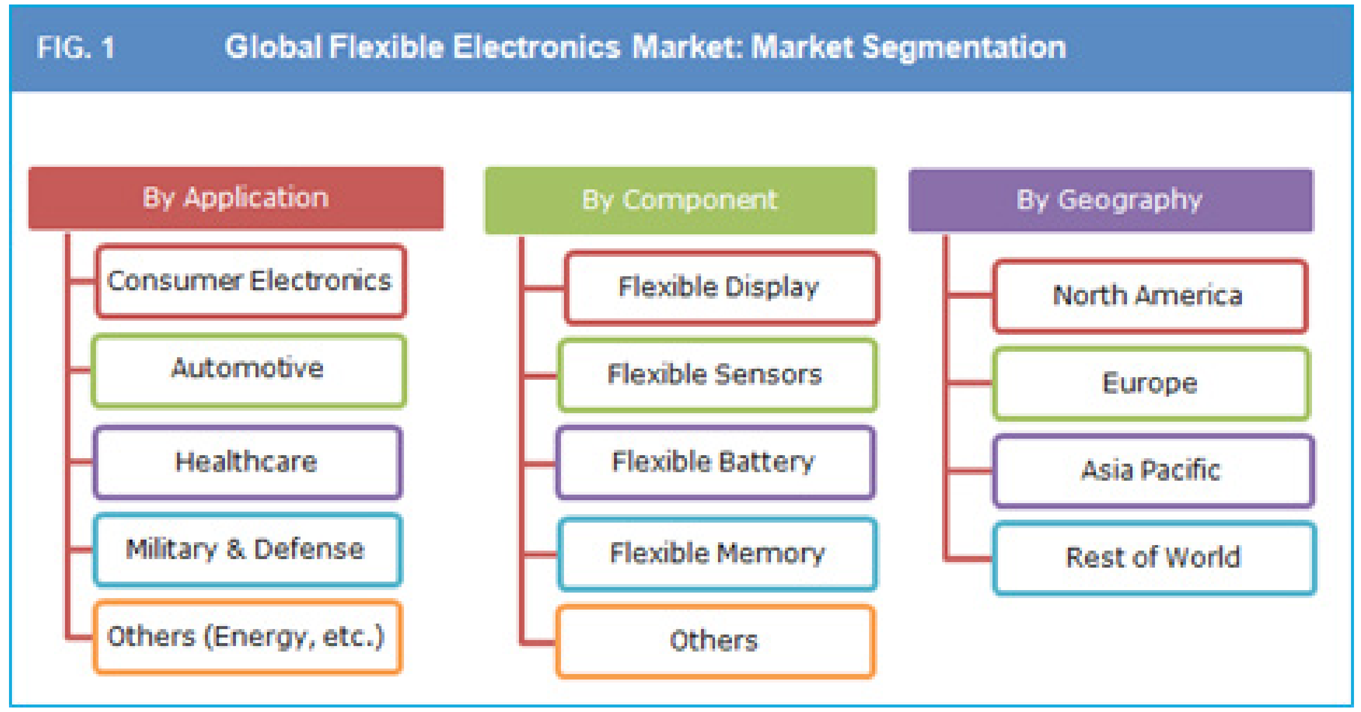
According to a market report by IDtechEx and the OE-A (Organic and Printed Electronics Association), the global market for printed and potentially-printed electronics is estimated to reach **$44.3 billion in 2021.**

In the majority of cases, organic and printed electronics cover a market segment that conventional electronics cannot cover.

By 2021, 56% of organic electronic components will be printed while 43% will be non-rigid or flexible (depending on the flexibility of their substrates).

Some of the main segments for flexible electronics include the automotive, white goods, consumer electronics and health-care industries. Consumer electronics led the flexible electronics market in 2015, accounting for 52% of total market share. This market is expected to grow significantly over the next few years. The health service, automotive and industrial segments are also set to grow sharply in the near future.

Global Flexible Electronics Market: Market segmentation



Source: Credence Research

In-Mould Electronics

In-Mould Electronics refers to film-printed electronic circuits that have undergone a thermoforming or injection moulding process. The circuit remains functional, since the conductive tracks go around the 3D shape.

This technology is an extension of IMD (In-Mould Decoration) / FIM (Film Insert Moulding) which appeared in the 1990s, and essentially combines film, graphics and electronics in one, forming a fully-integrated functional 3D electronic device.

Main characteristics and advantages

Lighter components and parts with reduced volume

Lower manufacturing costs.

As In-Mould Electronics technology uses fewer parts and requires fewer manufacturing steps production is easier and more efficient than before.

Reduction of assembly times by around 40%.

Assembly is a unique, "instant connection" process that significantly reduces assembly time while increasing reliability and improving serviceability.

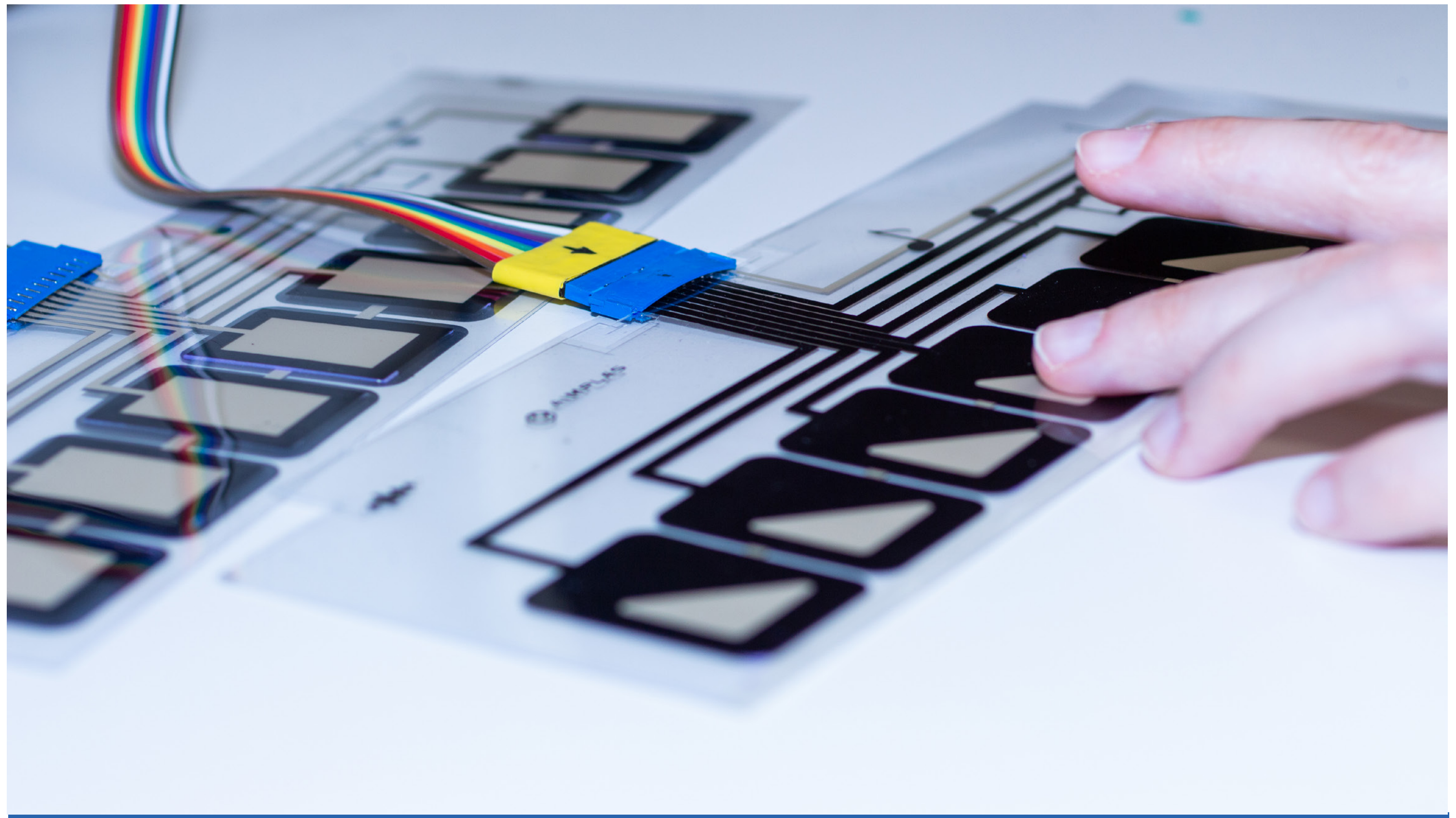
Adaptation to complex-shape geometries and 3D parts

Even though the electronics and automotive industry have pioneered the application of IME, other sectors such as the electrical household appliance, health-care and packaging sectors are also starting to use this technology.

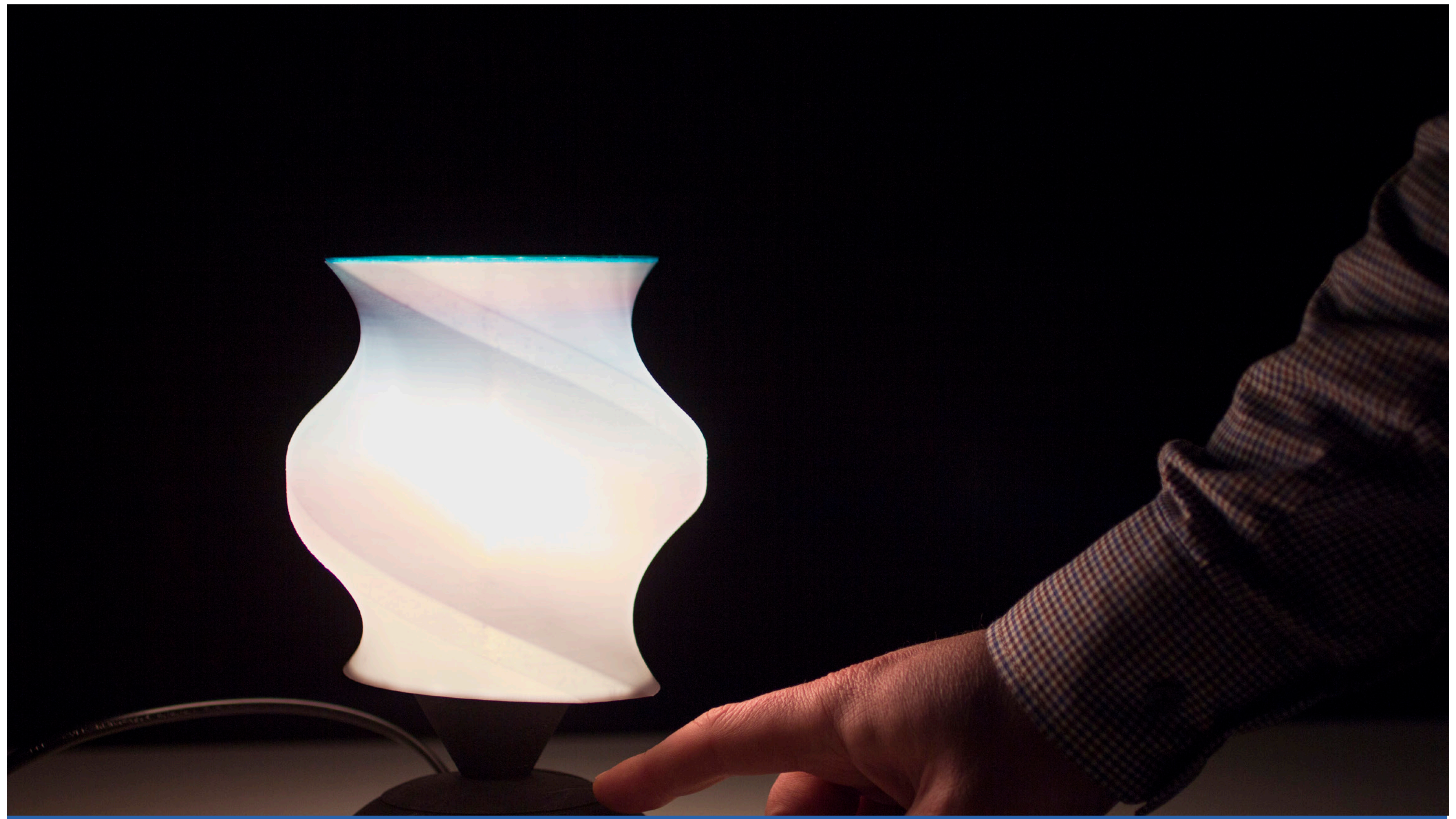
Success stories

Projects and developments carried out by AIMPLAS

Success stories: **Printed electronics and 3D printing demonstrators for conductive plastics**

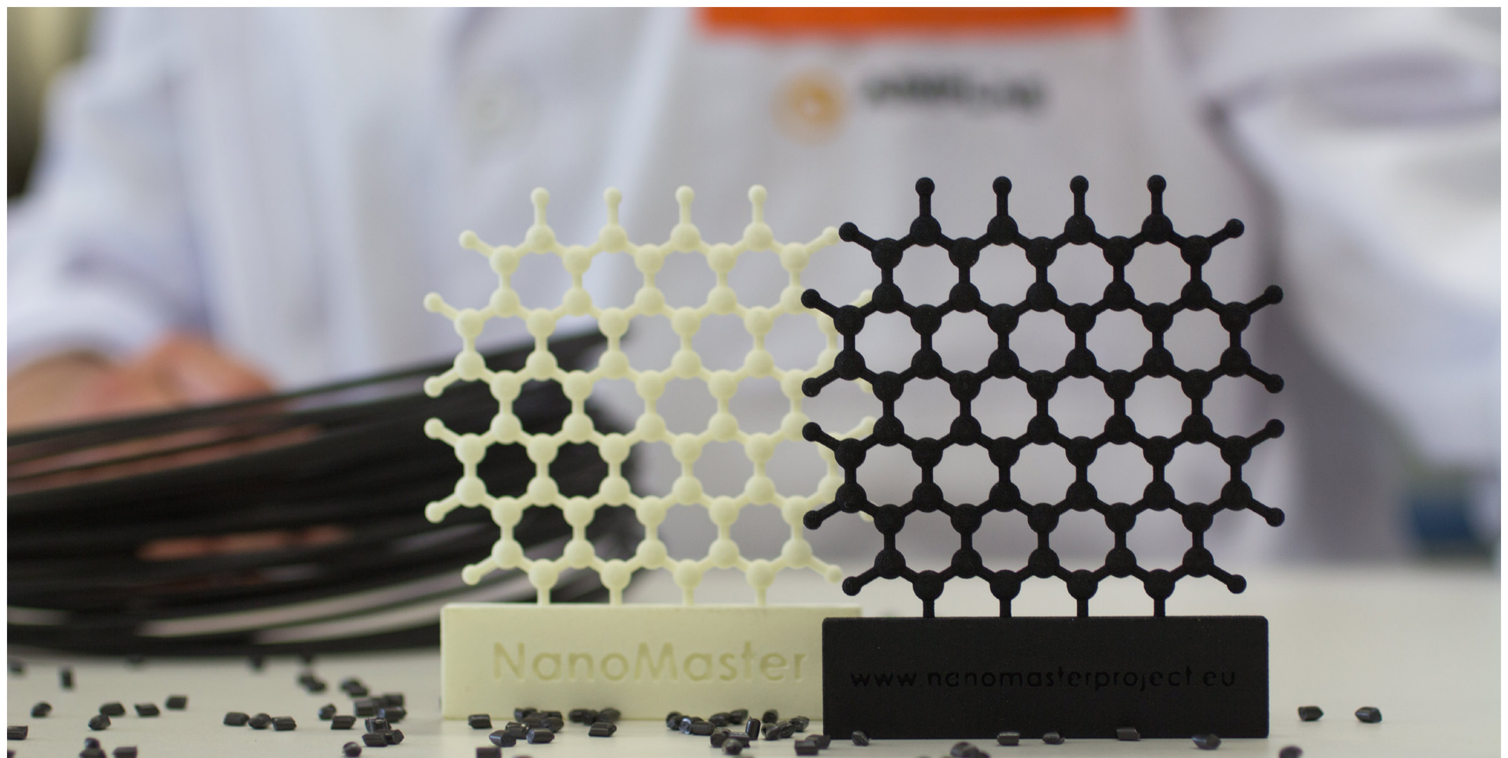


Capacitive-pressure sensor-based piano keyboard printed on PET



Conductive plastic-based lamp with tactile-switch manufactured by 3D printing

Successful cases: **New generation of plastic materials with electrical conductivity**



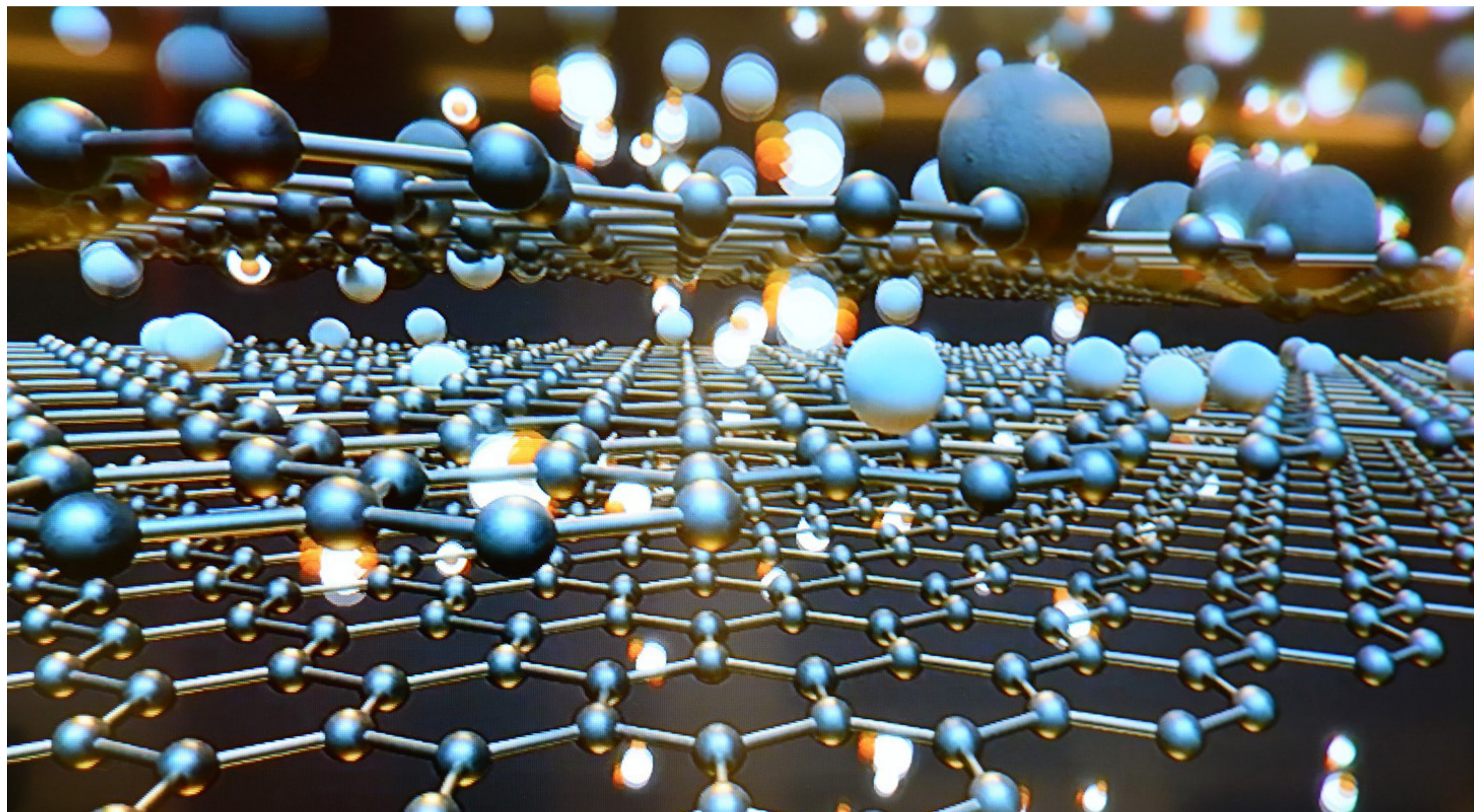
NANOMASTER Project
Graphene-based thermoplastic masterbatch development

JOSPEL Project
Novel energy efficient climate system for electric vehicles

Successful cases: **New generation of plastic materials with electrical conductivity**

POLYCOND Project

New generation of plastic materials with electrical conductivity



NANOCOND Project

Development of high-electrical conductive materials through the addition of nanofillers

AIMPLAS can help you develop high-added value products

PLASTRONICS by AIMPLAS

Conductive polymers and plastics

Selection of a conductive filler

Analysis of the compatibility of thermoplastics and thermosets

Optimization of mixing parameters

Development of masterbatches of conductive plastics for thermal and electrical conductivity

Development of electrical and thermal conductive resins.

Flexible electronics

Selection and development of the best conductive, semi-conductive and dielectric inks to develop printed electronic components

Selection and treatment of the substrate

Determination of optimal printing parameters

Design and printing of electronic components to develop demonstrators and small batches: electroluminescent, sensors, RFID antennas, heaters and printed circuits.

In-Mould Electronics

Analysis of the compatibility of flexible electronic materials and the parts to be injected

Determination of the correct placing of the electronics in the mould to avoid any quality defects in the product.

Do you want to use plastronics in your products?

Contact us

AIMPLAS
PLASTICS TECHNOLOGY CENTRE

REFERENCES

1. Credence Research "Global Flexible Electronics Market- Growth, Share, Opportunities and Competitive Analysis, 2016 – 2023".