PRESENTATION

JANUARY 2023

Graphenano
nanotechnologies

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1. GRAPHENE

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WHAT IS GRAPHENE

Description and characteristics

Although there was much theorising about the existence of this material, it was not until 2004 that A. Geim and K. Novaselov were able to isolate a sheet of this material and for this reason, they were awarded the Nobel Prize in Physics in 2010.

Graphene is a two-dimensional material with a single layer thickness, creating a hexagonal honeycomb lattice. It is this unique structure that gives it unique properties not present in other materials.

Graphene, in its allotropic form, has incredible mechanical, electrical, chemical, magnetic, and optical properties.

Two-dimensional graphene is a transparent and flexible material, it is a great electrical and thermal conductor and has incredible mechanical properties capable of surpassing even steel or diamond. Moreover, as a material composed only of carbon, it presents bacteriostatic properties and biocompatibility.

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WHAT IS GRAPHENE

Graphene based materials

Since its discovery in 2004, the scientific community has developed several materials based on the structure of graphene, known as “graphene materials”. These materials, which are easier to synthesise than crystalline graphene, possess very similar properties to those of crystalline graphene, and their range of applications is very close to that of two-dimensional materials. Some of them are:

- **Graphene nanofibres:** these are cylindrical graphene nanostructures, in which the layers of graphene can be oriented in different ways in space, giving rise to various types of nanofibres.
- **Carbon nanotubes:** these are tubular nanostructures of graphene sheets overlapped to form a tube of nanometric diameter. There are two types depending on the number of graphene sheets: one layer thick or SWCNT and many layers thick or MWCNT.
- **Graphene oxide:** functionalised graphene sheet, composed mainly of carbon, oxygen, and hydrogen atoms, introduced into its structure using strong oxidising agents in graphitic sheets and their separation by exfoliation.
- **Elastomers:** combination with silicon for heat management and carbon black replacement in tyres.
- **Graphene “nanoplatelets”:** they are nanoparticles consisting of small sheets of graphene bonded together with thicknesses of no more than 15 nm and diameters ranging from 100 microns to nanometre sizes.

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WHAT IS GRAPHENE?

NANOMATERIAL

Its dimension is less than or equal to one millionth of a millimetre.

0,142 nm

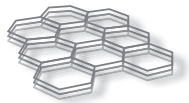
Carbon atoms are tightly bound together in a uniform, honeycomb-like surface

TWO-DIMENSIONAL

It has only two dimensions as it is only one atom wide (10^{-9} mm).

PURE COAL

Such as *graphite** and diamonds.



* *Graphite* is composed of many sheets of graphene stacked on top of each other

It is not surprising that graphene, as a substance with more electrical and thermal effects, conductivity, mechanical strength, and optical purity than any other, is being heralded as the "wonder material" of the 21st century, just as plastics were in the 20th century.

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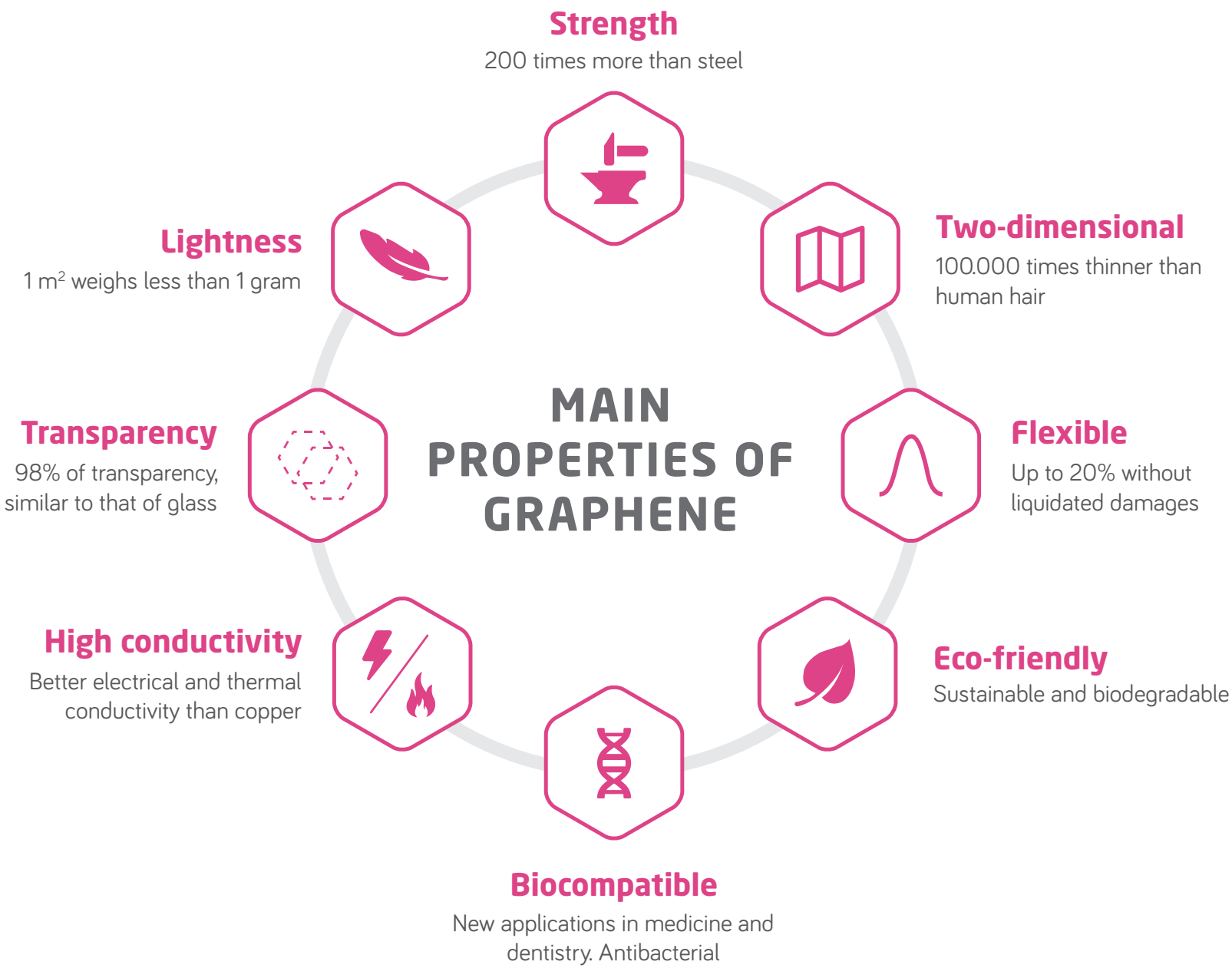
Strength
200 times more than steel
Two-dimensional
100.000 times thinner than human hair
Flexible
Up to 20% without liquidated damages
Eco-friendly
Sustainable and biodegradable
Biocompatible
New applications in medicine and dentistry. Antibacterial
High conductivity
Better electrical and thermal conductivity than copper
Transparency
98% of transparency, similar to that of glass
Lightness
1 m² weighs less than 1 gram
MAIN PROPERTIES OF GRAPHENE


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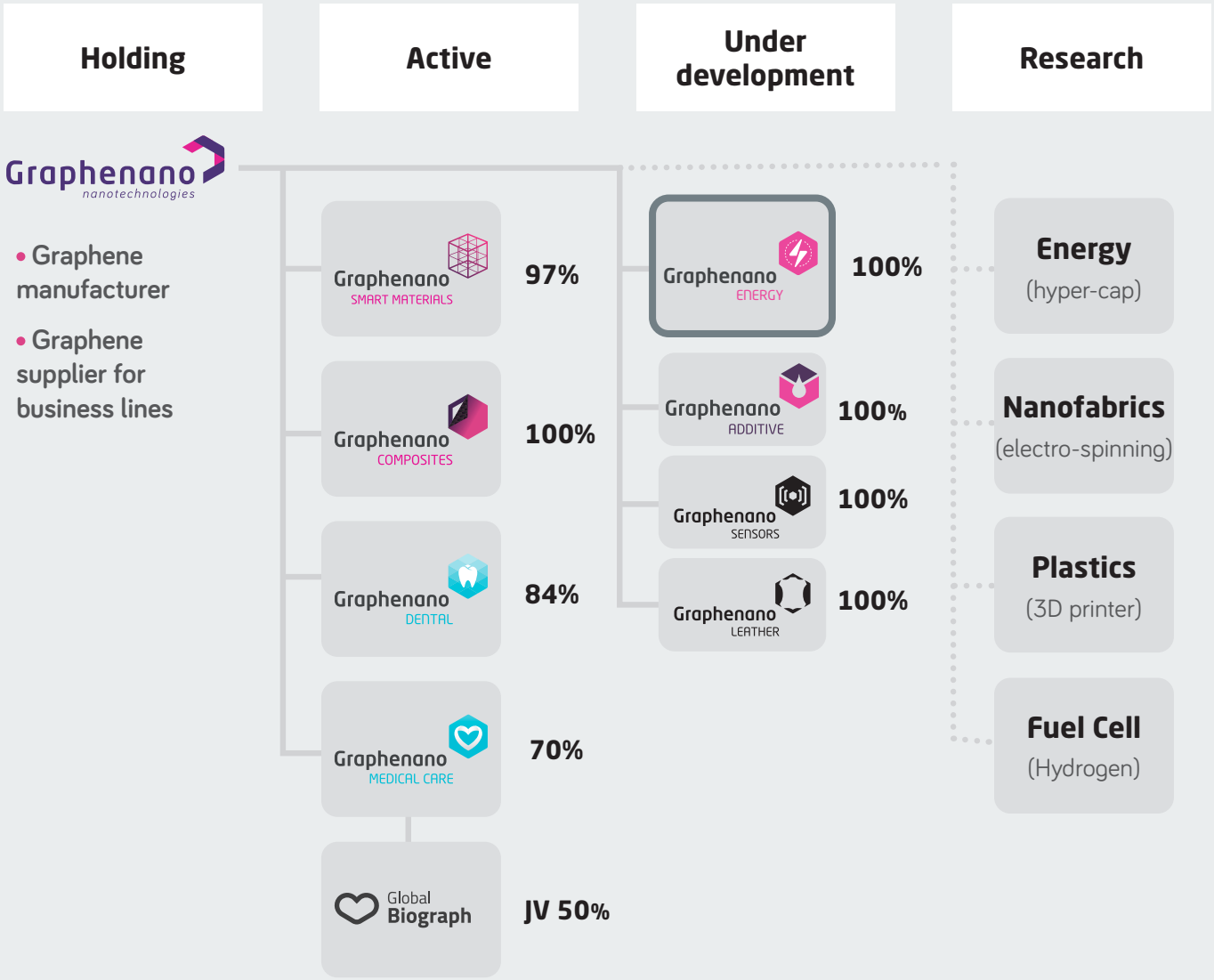
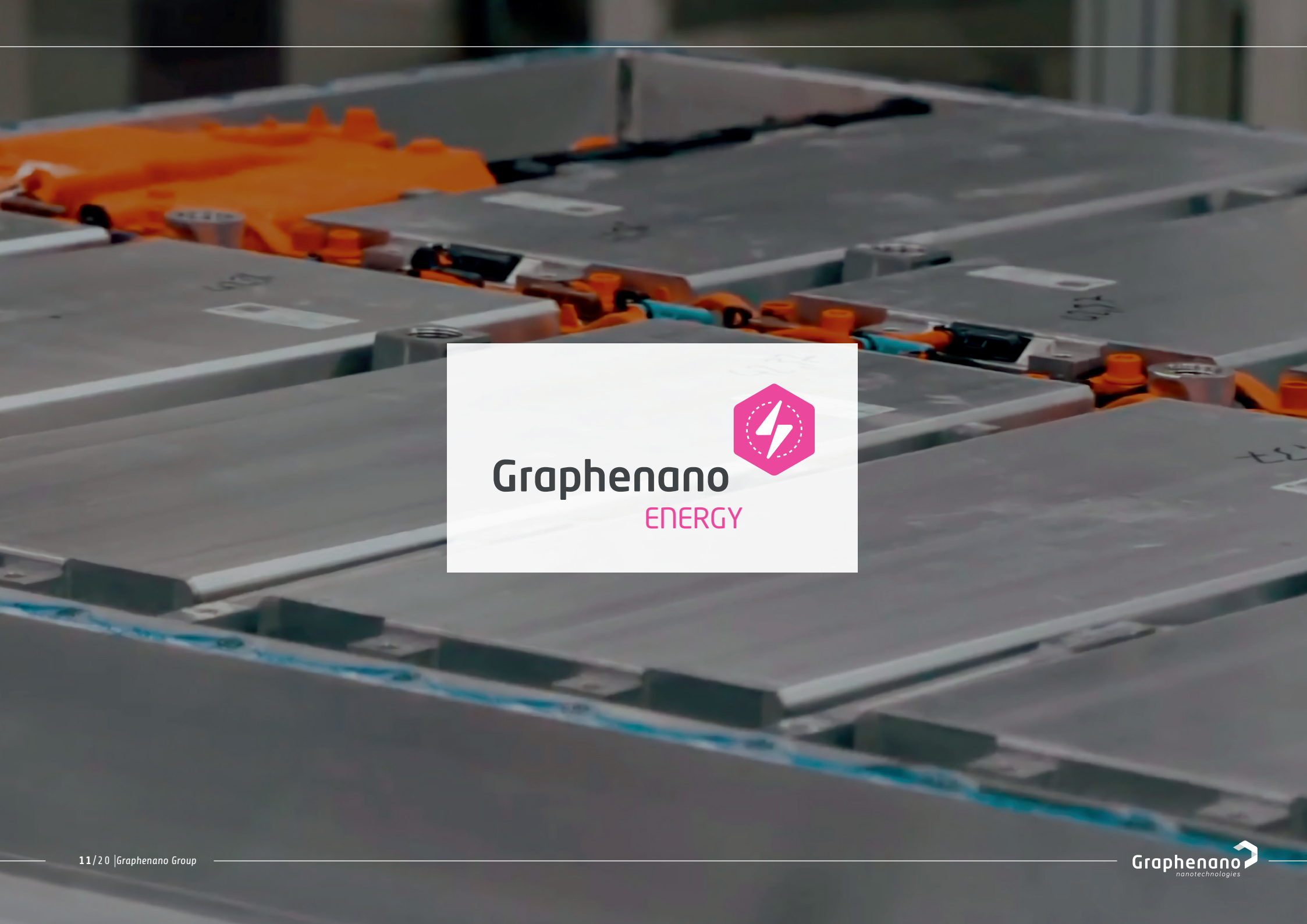
BUSINESS LINES AND CORPORATE STRUCTURE



GRAPHENANO GROUP STRUCTURE

- Graphenano Production Plant 1 (Yecla)
  Graphenano Office (Yecla)
- Graphenano Composites (Yecla)
- Graphenano Additive (Yecla)
- Graphenano Smart Materials R&D (Yecla)
- Graphenano Dental (Paterna)
- Medical Care R&D (Alcalá de Henares)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ENERGY

Graphenano
ENERGY

New electrode printing system for any energy storage system on the separator on both sides, thus avoiding the use of metallic collectors, such as copper, aluminium, steel, etc.

By treating the electrode inks with graphene carbonaceous materials, an optimum electrode conductivity is achieved for the chemical and electrochemical reactions to take place during the charging and discharging processes, without the need to use a metal collector as a support.

This new technology offers numerous advantages for energy storage systems, such as increased energy density, lower cost, higher cell voltage, etc.

DEVELOPMENT POTENTIAL

ELIMINATION OF THE USE OF COLLECTORS

Metal current collectors are one of the heaviest components of energy storage systems and are hence involved in the reduction of energy density (Wh/Kg).

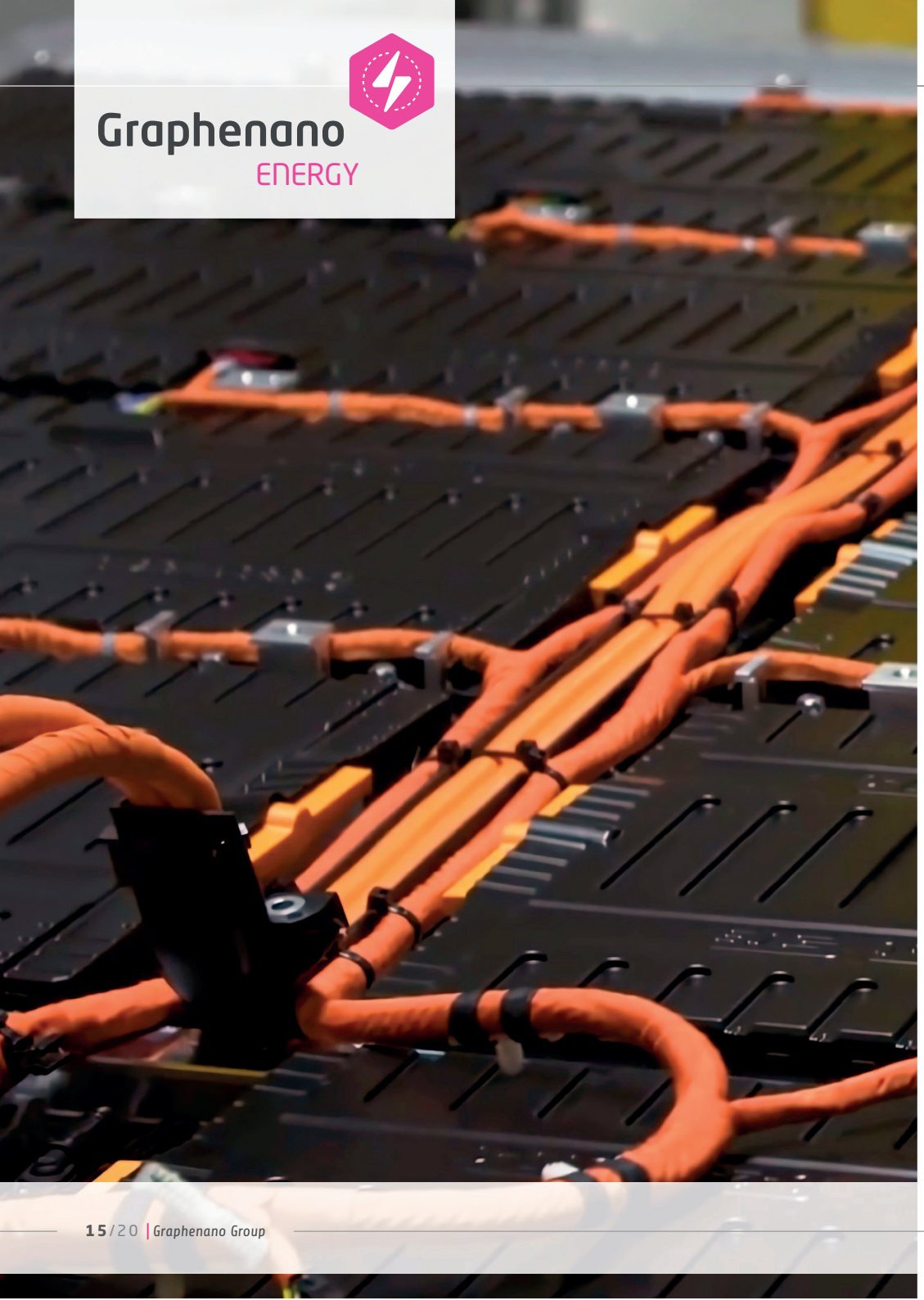
Collectors are one of the most expensive components of a battery, especially nowadays with the problem of material supply and geolocation. Up to now, the solutions that have been proposed have been to reduce the thickness of the collector as much as possible in order to reduce its weight and price, however, no one has ever done away with it.

Thanks to our new technology, the electrodes of the energy storage systems can be printed directly onto the separator, which significantly improves their weight, price, and energy density.

ADVANTAGES

Advantages of using our development.

- Higher energy density: by avoiding the use of metallic collectors, considerably reducing the total mass of the device. As a consequence, the energy density per kg (W·h/kg) will be improved.
- Reduction of the final price: one of the most expensive components of energy storage devices are the metallic collectors (e.g. Cu, Al, Ni, steel), even more so today with the material crisis due to the war in Ukraine among other factors. This new technology makes these collectors unnecessary, and since they are replaced by cellulose-based inks (paper) and graphene fibres, the price will only depend on the cost of other materials such as electrolyte and electrode material.
- No collector oxidation/reduction problems: when the solvent in the electrolyte is organic, this does not usually cause oxidation problems in the collectors. Nevertheless, if water-based electrolytes are used (much more ecological and economical), the degradation of the collectors affects the stability of the storage devices (as it has been confirmed in the ICMol-Graphenano project for supercapacitors or alkaline batteries). Without metal collectors, we can overcome this problem.
- Increased cell potential: the use of metallic collectors leads to a very high localised conductivity on their surface, increasing the conductivity of the device, and thus its capacity. On the other hand, this high conductivity results in high localised potentials, which lead to the decomposition (oxidation or reduction) of the solvent in the electrolyte. Due to the graphene fibres hybridised with the electrode materials, we obtain an optimal conductivity (i.e. exceeding the percolation limit) for its correct behaviour without the metallic collectors. Hence, the high localised conductivity is avoided, and therefore, the cell potential can be increased by around 0.5V. In addition, this also improves the energy density, as the power is directly proportional to the voltage (P=V·I).

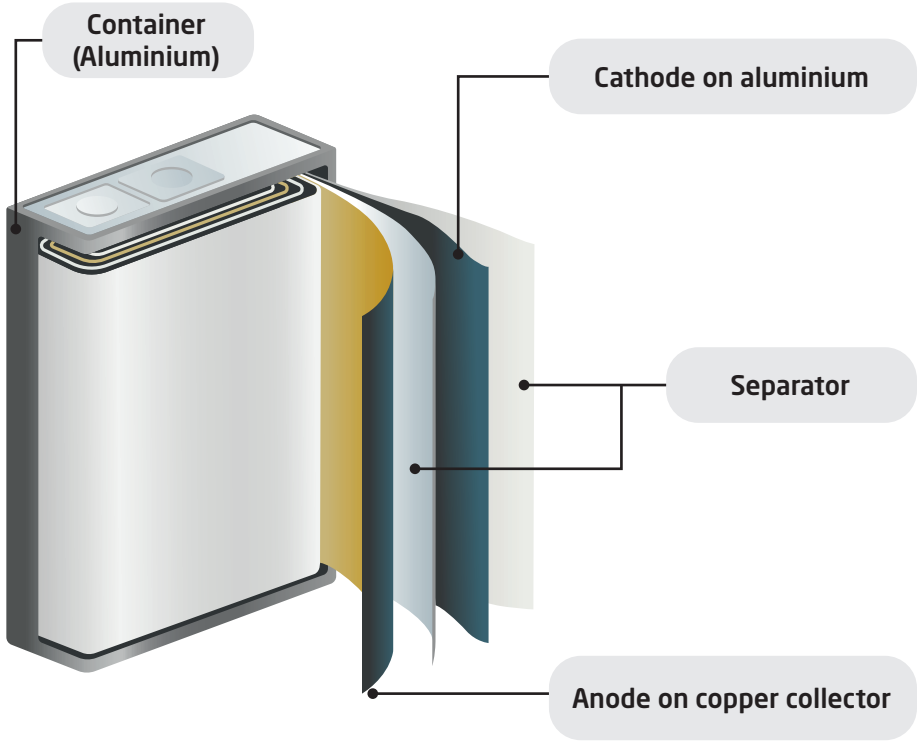


APPLICATIONS UNDER DEVELOPMENT

It is of interest to any company involved in the manufacture of energy storage systems, whether lithium batteries, sodium batteries, capacitors, supercapacitors, hydrogen cells, etc. As it is a very versatile technology for any storage system, the producer company could be able to market its products with the same (or sometimes better) performance, but at a much cheaper cost and better energy density per kg.

CURRENT SYSTEM

Components of a lithium-ion (li-ion) battery

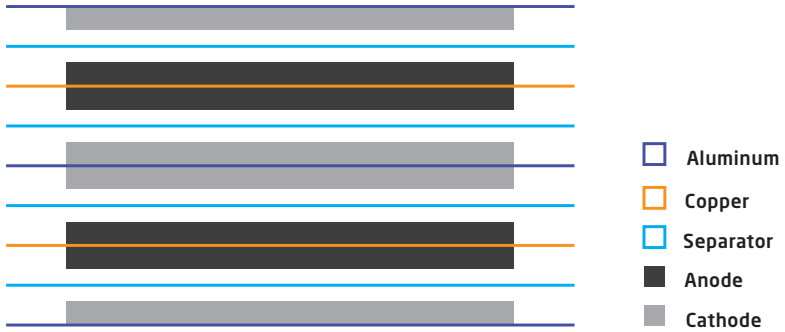


GRAPHENANO SYSTEM

Components of a Graphenano battery

CURRENT SYSTEM

Components of a (li-ion) battery



2 Copper sheets (Cu)

4 Anode sheets

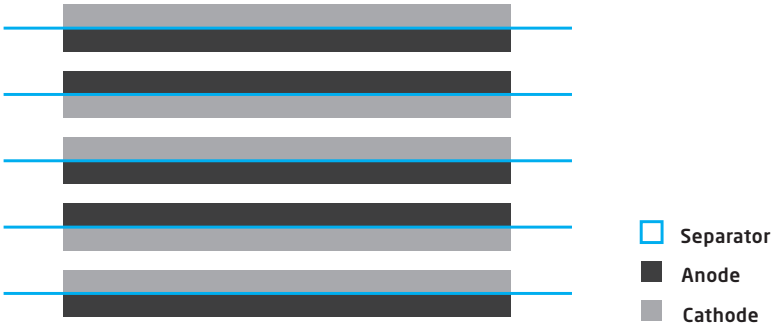
4 Cathode sheets

4 Separator sheets

3 Aluminum sheets

GRAPHENANO SYSTEM

Components of a Graphenano battery



0 Copper sheets (Cu)

5 Anode Sheets

5 Cathode sheets

5 Separator Sheets

0 Aluminum sheets

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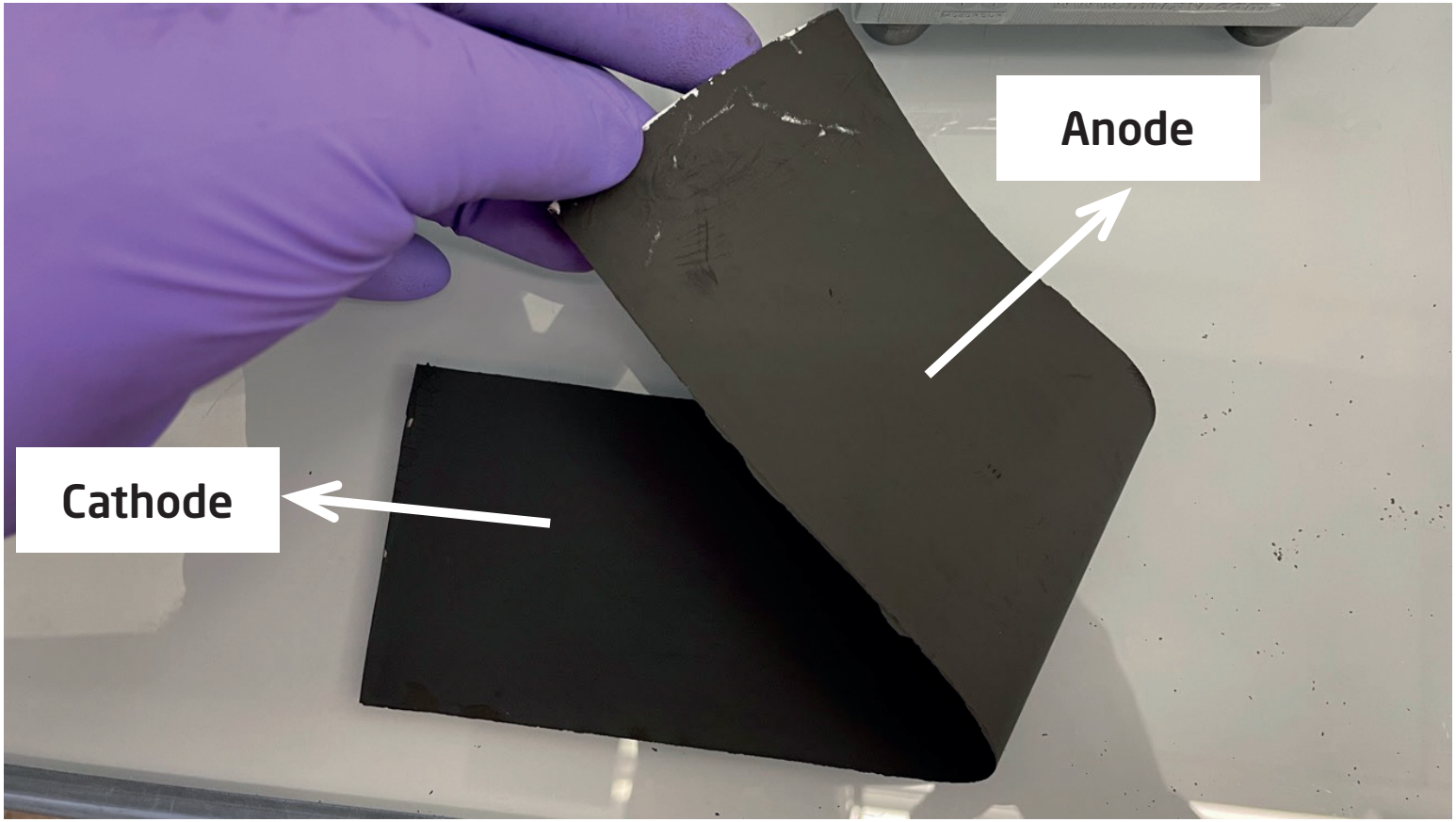
GRAPHENANO SYSTEM



Graphenano ENERGY

COMPETITIVE ADVANTAGES

WEIGHT REDUCTION POUCH = INCREASE DENSITY 30%

- The elimination of the collectors for the cathode and anode reduces weight considerably, increasing the density proportionally.

COST REDUCTION

- Fewer material, less weight, more density = direct product cost reduction due to the materials employed.

MUCH MORE ECO-FRIENDLY AND SAFE

- **NO FIRE**
- **NO EXPLOSION**
- By renouncing the commonly used metals such as copper and aluminium, it is much more eco-friendly.
- It improves thermal conductivity which helps to be safer and more efficient.

LESS COMPLEX PRODUCTS

- It simplifies and increases the productive capacity of the electrodes, making it possible to use higher depositing speeds.
- Anode and cathode drying energy reduction.
- Simplified anode and cathode manufacturing machinery and processes.

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GRAPHENE
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INSIDE