



MGgrafeno
Project

Minas Gerais is known as the Brazilian mining state and holds a very strong position in this sector's international market. As a state-owned company dedicated to the development of the territory, Codemge is focused in Minas Gerais mining industry new endeavors, such as future-bearing materials and high technology research. Through strategic partnerships, and new business models, the Company is currently investing in a pioneering portfolio of enterprises.

The MGgrafeno Project is one of Codemge's main initiatives, in partnership with the Federal University of Minas Gerais (UFMG) and the Nuclear Technology Development Center (CDTN). The project aims to develop Brazil's 1st graphene production plant. A pilot plant is already in operation, with a production capacity of more than 100 kilograms per year of graphene.

In order to move forward, it is essential to know and control the properties of nanostructures. That is why Codemge is also financing NA@MO, an initiative for the characterization and manipulation of matter at a nanometric scale.

Other projects in motion are LabFabITR the 1st laboratory-factory of the Southern hemisphere for the production of rare-earth magnets, and the investments in the lithium chain, from extraction, to high technology applications, such as Lithium-Sulfur high technology Lithium-Sulfur battery cells.

Inspired by the future, Codemge invests and acts in the present.



MGgrafeno project pilot plant

MGgrafeno: transforming a commodity into a technological asset

Brazil has the second highest reserves and is the world's third largest producer of graphite. The Minas-Bahia Graphitic Province is the largest in the country, and other reserves can also be found in the state's central-south area.

CODEMGE, together with CDTN (Centro de Desenvolvimento da Tecnologia Nuclear) and UFMG (Universidade Federal de Minas Gerais), have established the **MGgrafeno Project** and implemented Brazil's first pilot plant for the production of graphene from natural graphite.

The facility is located in the state's capital and largest city, Belo Horizonte. The pilot plant has a capacity of up to 150 kg/year, and the industrial plant will be operational by 2022.

The **MGgrafeno Project** aims to add value to Minas Gerais' abundant graphite reserves, and to foster a business chain and a broad market for graphene-based products. By establishing partnerships with leading companies in strategic markets, the **MGgrafeno Project** will come up with innovative solutions in graphene and further advance the technology.

A unique combination of properties

- High Mechanical strength and High specific surface area (~2700 m²/g)
(Young's modulus 5x greater and yield strength 100x greater than martensitic aged steel)
- High electrical conductivity
- Able to sustain extremely high densities of electric current (a million times higher than copper)
- High thermal conductivity (compared to diamond)
- Ultra-impermeable (even to helium) and Chemically inert

MGgrafeno Project

MGgrafeno developed a liquid-phase exfoliation process that yields high-quality nanomaterials, each suitable to a variety of applications.

PRODUCT	PROPERTIES	MAIN APPLICATIONS	FORM
Few-layer graphene	Up to 5-layer, 3-layer centered graphene with average size of 120 nm and low defect density	Transparent conductive films, sensors and devices, conductive textiles, batteries, supercapacitors, 3D printing.	Water dispersion or powder
Graphene nanoplatelets	Up to 10-layer, 6-layer centered graphene nanoplatelets	Thermoplastics, composites (for added mechanical strength and conductivity), conductive ink, cements, refractories, coatings.	Powder or cake
Nanographite	Small graphite flakes, over 10 layers and high carbon percentage	Sintered metal parts, lubricants, plastics, lead acid batteries	Powder or cake

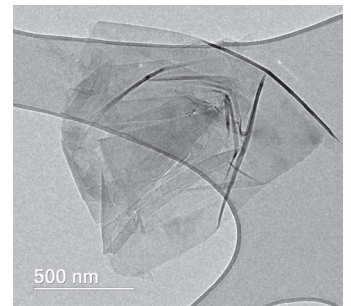
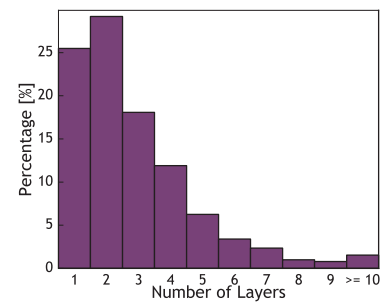
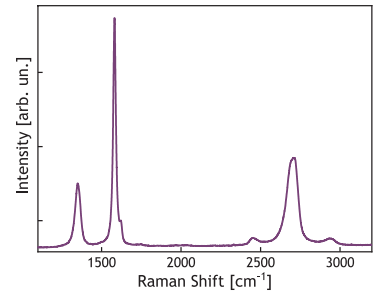
The process

- Environmentally friendly (no pollution and 100% water reuse)
- Highly scalable
- Customizable for each application
- Reproducible (reliable datasheet for each batch)

Applications

- Batteries
- Supercapacitors
- Polymer composites
- Membranes
- Conductive inks
- Anti-corrosion coatings
- Sensors and devices
- Smart textiles

Few-layer graphene



Business model

MGgrafeno will not focus on selling graphene. Rather, it will set up partnerships to provide companies with customized graphene products at cost, and share in any profits from the applications.

- Technical-scientific assistance and co-development of new products and processes
- Graphene customization (graphene = many graphenes)
- Guaranteed supply in volume, price, reproducibility, reliability and certified sheet of information on characterization processes and specifications



LITHIUM



Oxis's Ultra Light Li-S cells

Lithium-Sulfur battery

Codemge is investing in the lithium chain, from its extraction (Companhia Brasileira de Lítio - CBL) up until the production of new lithium-sulfur batteries with UK's Oxis Energy.

The main result of Codemge and Oxis Energy partnership will be the world's first plant for the mass production of Lithium-Sulfur cells. Scheduled to be operational in 2022. The plant will be able to produce up to one million cells each year.

In a promising synergy, another Codemge project, MGgrafeno, is developing applications of graphene in LiS cells. The goal is to advance the technology even further, by improving the batteries' performance and extending its cycle life.

LITHIUM

The LiS technology is innovative, and essential for the future of transport. LiS cells are lightweight, extremely high in energy density, safe, and much more environmentally friendly than current batteries. These unique characteristics make LiS batteries ideal for the aviation and heavy electric vehicles, as well as power, heavy electric vehicles, and power generation and distribution.

The alignment of different initiatives within Codemge will create a robust and integrated industrial platform, capable of supporting the development of the most advanced solutions in energy storage.

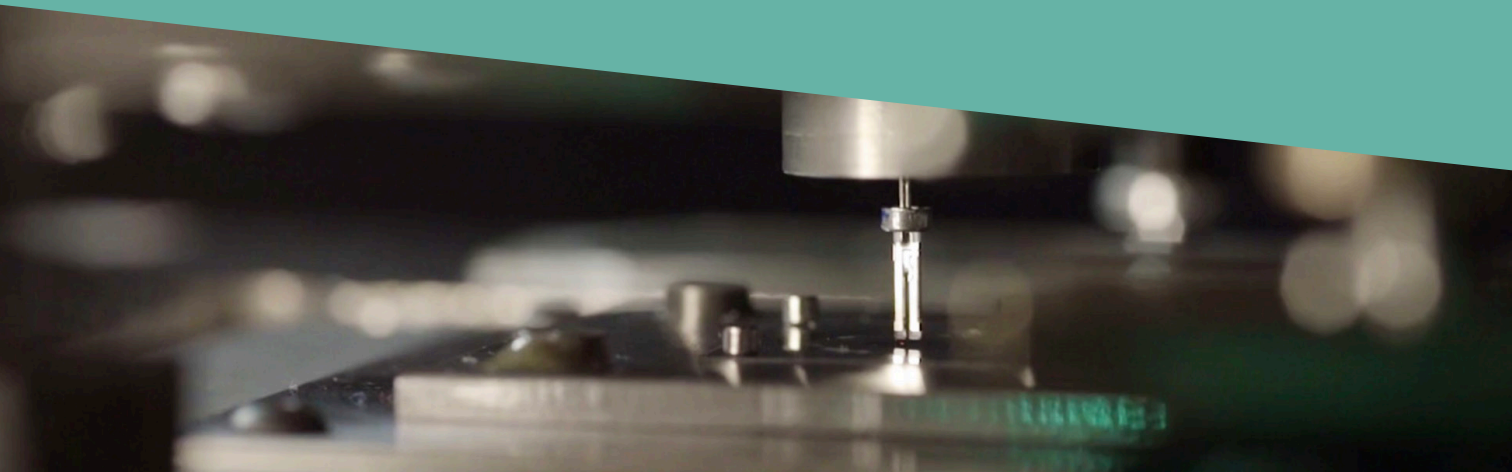
Codemge's investments in Lithium-Sulfur technology aim to foster businesses and add value to the lithium and graphene supply chains.



Cathode production of Li-S cells in Oxis Energy pilot plant

CBL's lithium mining plant



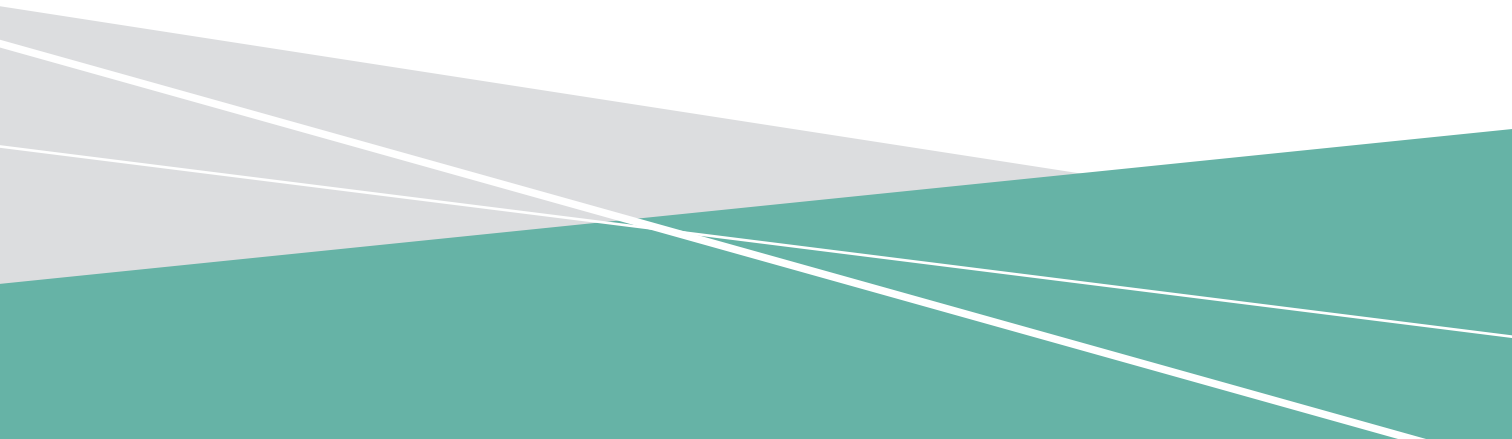


The use of nanotechnology is rapidly increasing. The field will be one of the main drivers of the next technological revolution, with a strong impact in major industries, such as medical and pharmaceutical, semiconductors and defense.

In order to move forward, whether in the development of new materials, such as graphene, or in biotechnology, it is essential to know and control the properties of nanostructures. That is the goal of **NA@MO** project.

Under development for the past ten years at UFMG's LabNS, the **NA@MO** allows the characterization and manipulation of matter at a nanometric scale.

It uses tip-enhanced Raman spectroscopy (TERS), which consists of an optical microscope coupled with a system for the control and monitoring of a nanoantenna.

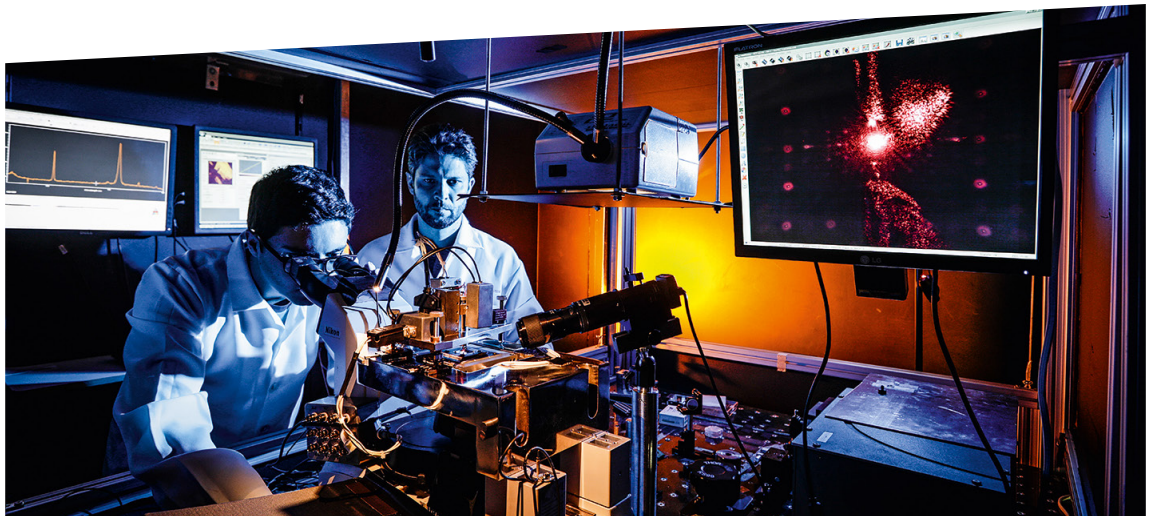


Combining optical spectroscopy, which provides physical-chemical information, and scanning electron microscopy, which provides topological information and allows the manipulation of the sample, the **NA@MO** produces images using optical microscopy with molecular resolution, far beyond the limits of conventional optical microscopy.

Investments by Codemge will allow the translation of **NA@MO**'s state-of-the-art technology into a commercial equipment that will transform nanotechnology research. It will be capable of performing:

- Confocal Raman Spectroscopy
- Atomic Force Microscopy (AFM)
- Scan Tunneling Microscopy (STM)
- Tip Enhanced Raman Spectroscopy (TERS)

NA@MO project is a crucial step in the creation of a national technological ecosystem for the advance of nanoscience and nanotechnology, and in fostering businesses and institutions throughout the nanotech value chain.



LABFABITR

The first laboratory-factory of the Southern hemisphere for the production of rare-earth magnets is under construction in the city of Lagoa Santa, Minas Gerais, Brazil.

The magnets have a wide range of applications, notably in electrical engines, wind turbines, hybrid and electrical cars, elevators, sensors and and magnetic separators.

LabFabITR will develop innovative solutions in rare-earth magnets, including different compositions for the alloys, new production processes, as well as instruments and equipments tailored to its clients' needs.



The project aims to add value to our abundant rare-earth reserves (Brazilian reserves are the world's second largest, accounting for 17% of the worldwide total), and to foster businesses throughout the supply chains of the various products that employ the magnets.

- Sintered NdFeB magnets and rare-earth alloys
- Launching in March/2020
- Capacity of 23 t/year, reaching 100 t/year in 10 years
- Four state-of-the-art labs: Metallography, Corrosion, Chemical Analyses and Magnetism
- Pilot plant, allowing the production of prototypes and small series without interfering with the main facility

Business Model

- The model is focused on providing alloys or magnets, free of cost or cost for the development of products and share the economic benefits of the applications enabled by this supply
- Technical-scientific assistance and co-development for the applications with regard to the customization of alloys and magnets
- Guarantee of supply in volume, price, reproducibility and reliability



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