

MINAS GERAIS: TECHNOLOGY DEVELOPMENT

Graphene



Minas Gerais Investment
and Trade Promotion Agency

For nearly 50 years INDI is a key player in the economic development of Minas Gerais. Over 3000 companies were supported, which brought jobs and income to the state. They saw their business grow, along with the state economy.

Our Services:

INVESTMENT PROMOTION: INDI supports companies that want to invest in Minas Gerais. We offer a complete guidance through all the investment phases.

TRADE PROMOTION: We encourage companies from Minas Gerais to export. Training courses, hosted buyers projects and export missions are some of our activities.

INTELLIGENCE: DataViva is an open research platform of socioeconomic data. INDI develops analyses from its database in order to support economic development policies.

indi.mg.gov.br



The Economic Development Company of Minas Gerais is a public company created in 2003 and controlled by the state. Its focus is on promoting sustainable economic development in the state, attracting businesses and therefore increasing the competitiveness of the state. To this end, Codemig works in partnership with public and private sector institutions in many enterprises. CODEMIG is aligned with the state's directives, acting efficiently based on three strategic axis: Mining Industry, Energy and Infrastructure; Creative and High Tech Industries.

codemig.com.br

portaldageologia.com.br

TECHNOLOGICAL OPPORTUNITIES

Minas Gerais is internationally known as the Brazilian mining state and its main source of income comes from the extraction of minerals. The State current holds a very strong position in the mining world scenario and is focused in the 4.0 industry and new applications in the mining industry. CODEMIG as a state owned company responsible for the development of the State has identified the necessity to diversify the economic activities within the state and in doing so has determined as one of its strategic goals the support for the high technology industry. In the high technology industry, the strategic sectors selected for investments are advanced materials, aerospace & defense, biotechnology & life sciences and internet of things. CODEMIG is implementing projects with high technology and innovation through strategic partnerships, new business models, institutional support, incubation of companies and equity investments. As examples of the potential projects, CODEMIG is currently investing (a) to build a pilot plant for the production of graphene in an industrial scale; (b) in the implementation of the first rare-earth magnet laboratory-plant in the country; and (c) in the development of the lithium battery.

All of these actions are aimed at the development of the entirety of the supply and industrial chain in the State, going from mineral extraction to the manufacturing of a range of high technology products adding value to the production within the state, boosting the development of expertise to the local industry and consolidating Minas Gerais as a national reference in high technology development.

GRAPHENE

GRAPHITE / GRAPHENE

The Minas-Bahia Graphitic Province, located in the northeast of Minas Gerais and in the south of Bahia, is the largest graphite province in Brazil. The country is the 3rd largest producer of graphite in the world and it is the 2nd largest holder of reserves of this substance. Graphite reserves can also be found in the central-south area of the state, in the city of Itapeçerica. CODEMIG is working with partners to implement Brazil's first pilot plant of graphene production from natural graphite on industrial scale, whose operations are scheduled to start in 2017. Graphene, a revolutionary nanomaterial of carbon, has diverse applications, and its production integrates Minas Gerais Government strategy, whose objective is technological innovation and diversification of the state's industrial production.

TECHNOLOGICAL ASSET

Transformation of Graphite, a commodity, to Graphene - a Technological Asset

Development of graphene production by chemical exfoliation of Brazilian Natural Graphite and develop a business chain and a broad market for graphene based products. This will be done from the production of graphene and the development of technologies of application and use of it in partnership with leading companies in strategic markets.

FOCUS ON APPLICATIONS

Li-ion batteries

Polymer composites

Conductive thin films

Sensors / devices

MINAS GERAIS

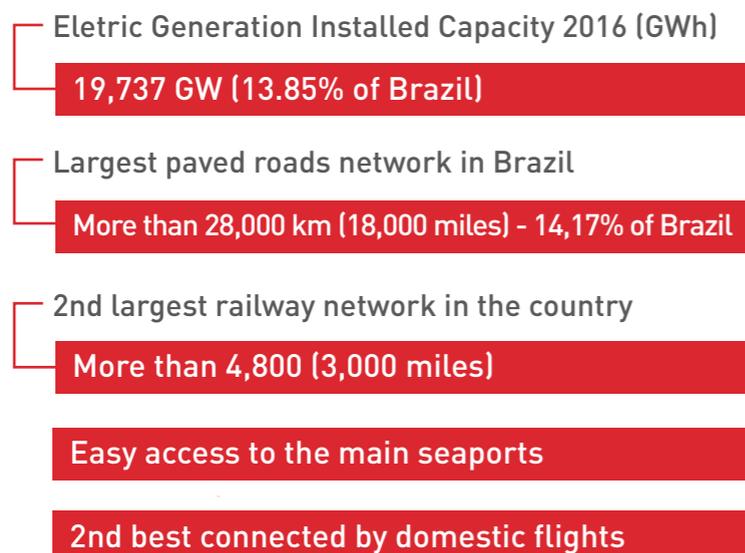
Minas Gerais is a Brazilian state, located in the southeast of the country. Its name is derived from the vast variety of mining spots such as iron ore, gold, bauxite, manganese, tin ore, among others.



It is a **large** Brazilian state...

- ▶ **587,000 km²** (Larger than France and Spain)
- ▶ **21 million people** (2nd largest in Brazil)
- ▶ **Brazil's third largest economy** (US\$ 200 billion = 9.3% of GDP)

INFRASTRUCTURE AND LOGISTICS



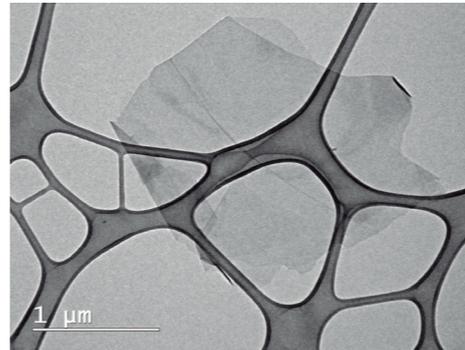
Sources: ANEEL; EPE; FJP; CEI-FJP/IBGE/UBM/OAG; SETOP-MG

ABOUT THE GRAPHENE

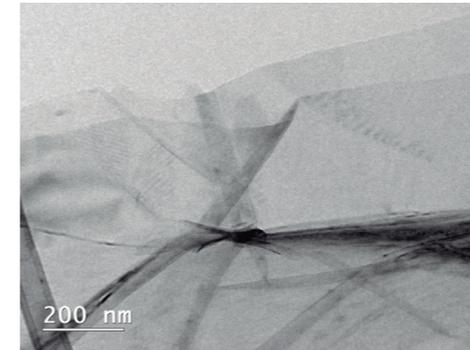
Quality of graphene produced

Process developed produces high quality graphene:

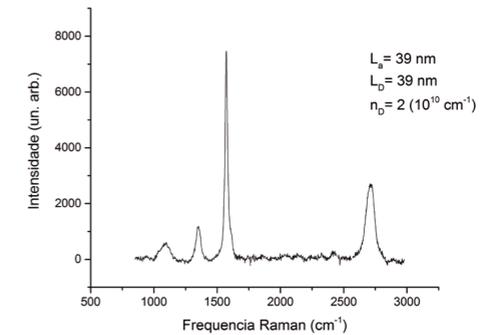
- ▶ Low defect density
- ▶ Average area of sheets: 54 μm^2
- ▶ A few layers, typically below 5



Transmission electronic microscopy



Transmission electronic microscopy



Raman Spectroscopy

Graphene production - Partners



First development of graphene applications

- Polymer composites
- Sensors / devices
- 3D Printing
- Anti corrosive coatings
- Aditive for mining

Business Model

- ▶ It is not focused on selling graphene
- ▶ The model is focused on providing graphene, 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 incorporation of graphene into products and processes
- ▶ Graphene customization (graphene = many graphene)
- ▶ Guarantee of supply in volume, price, reproducibility, reliability and certified sheet containing information on characterization processes and specifications
- ▶ Transverse billing throughout the economic chain around the production and application of graphene

Graphene Production from chemical exfoliation of natural

Initial investment

US\$ 7 million

Graphene characteristics

< 10 layers (centered in 4)

Average lateral size 1200 nm

Inicial production

30 kg / year