

GRAPHENE MATERIALS: A KEY ROLE IN UPCOMING INDUSTRIAL HIGH VALUE PRODUCTS

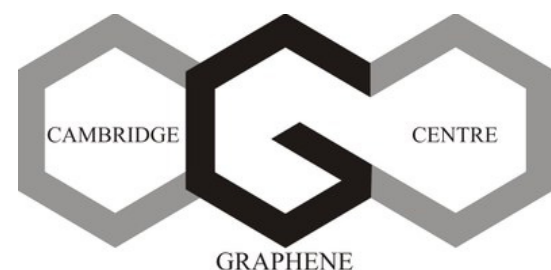
Dr Siva Bohm

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(Subsidiary of **Talga Resources Ltd**)

**15TH ANNIVERSARY HVM CONFERENCE AND
4TH GRAPHENE & NEW MATERIALS 2017 SUMMIT CONFERENCE**

**SESSION: ENERGY STORAGE, ENERGY & HEAT TRANSFER
CAMBRIDGE UK, 3RD NOVEMBER 2017**



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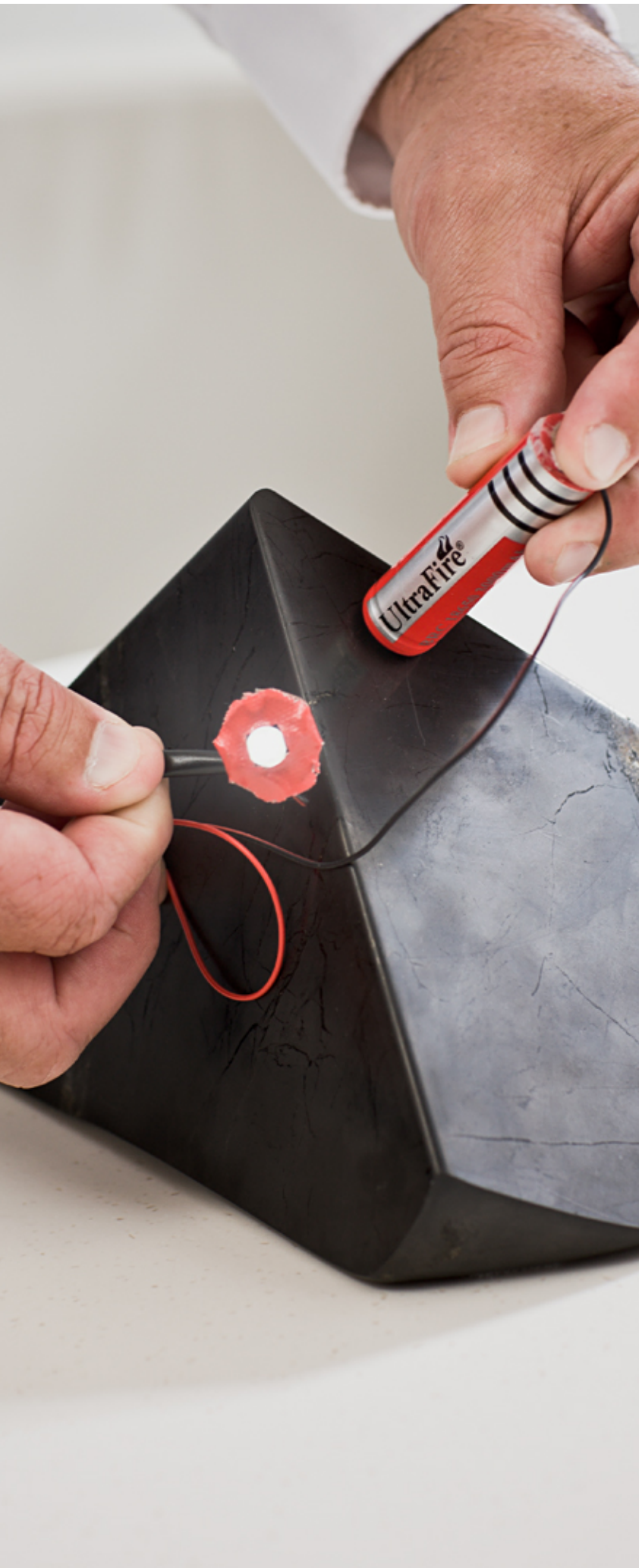
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WHAT WE DO



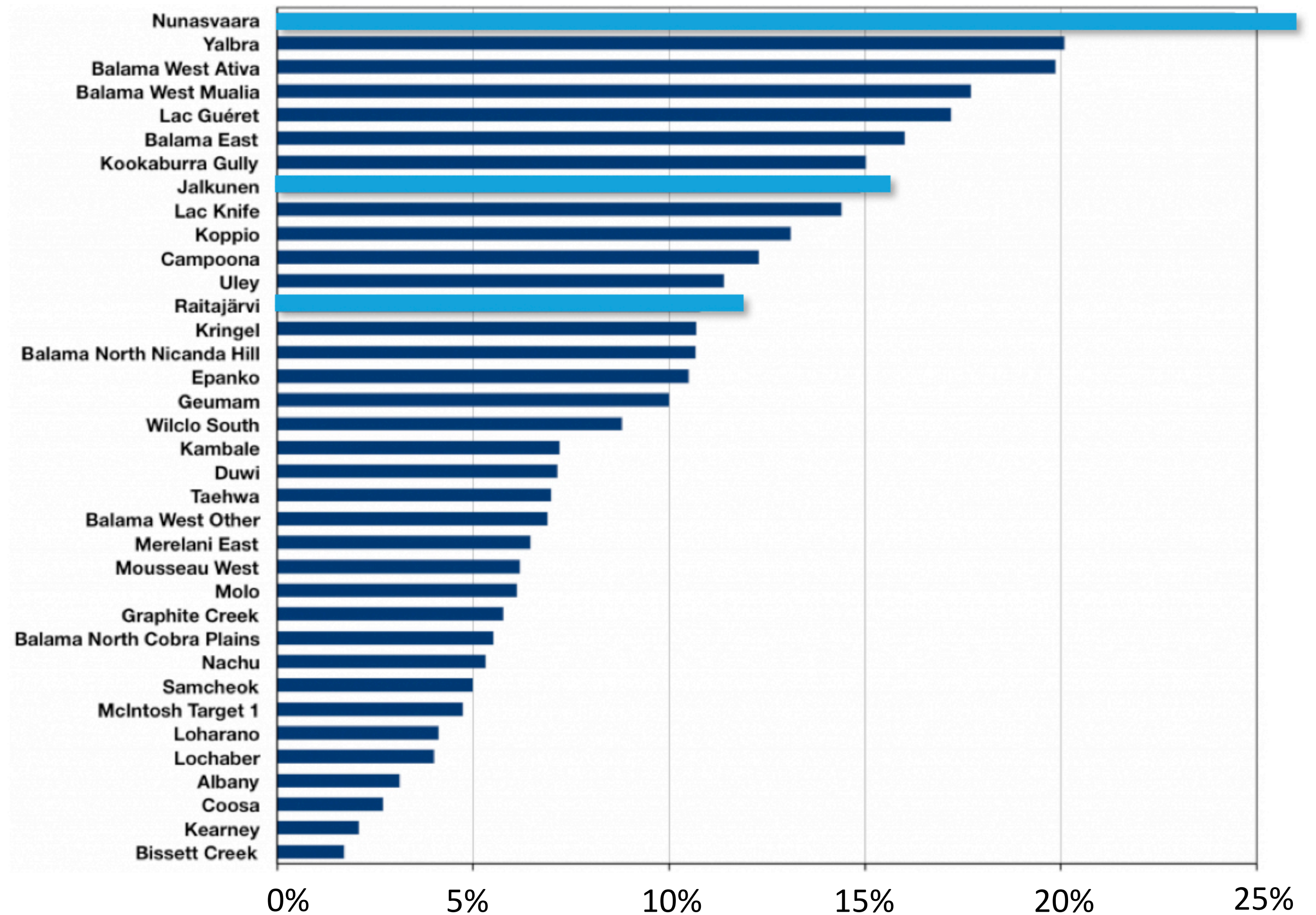
- ▶ Talga is a vertically integrated technology minerals company with a focus on its scalable and cost effective process to liberate graphene from large high quality graphite ore deposits in Sweden.
- ▶ Talga is a listed public company on the Australian Stock Exchange (ASX code TLG) with subsidiary operations in Sweden, Germany and the United Kingdom.
- ▶ Potential to be worlds largest volume supplier of graphene products, ultrathin micro/nano graphite, few layer graphene (TalphenTM) raw and formulated products, as well as conductive carbon/silicate filler for industrial applications
- ▶ Talga **tuning Graphene technology** for our industrial partners, B2B.

GLOBAL GRAPHITE RESOURCES BY GRADE



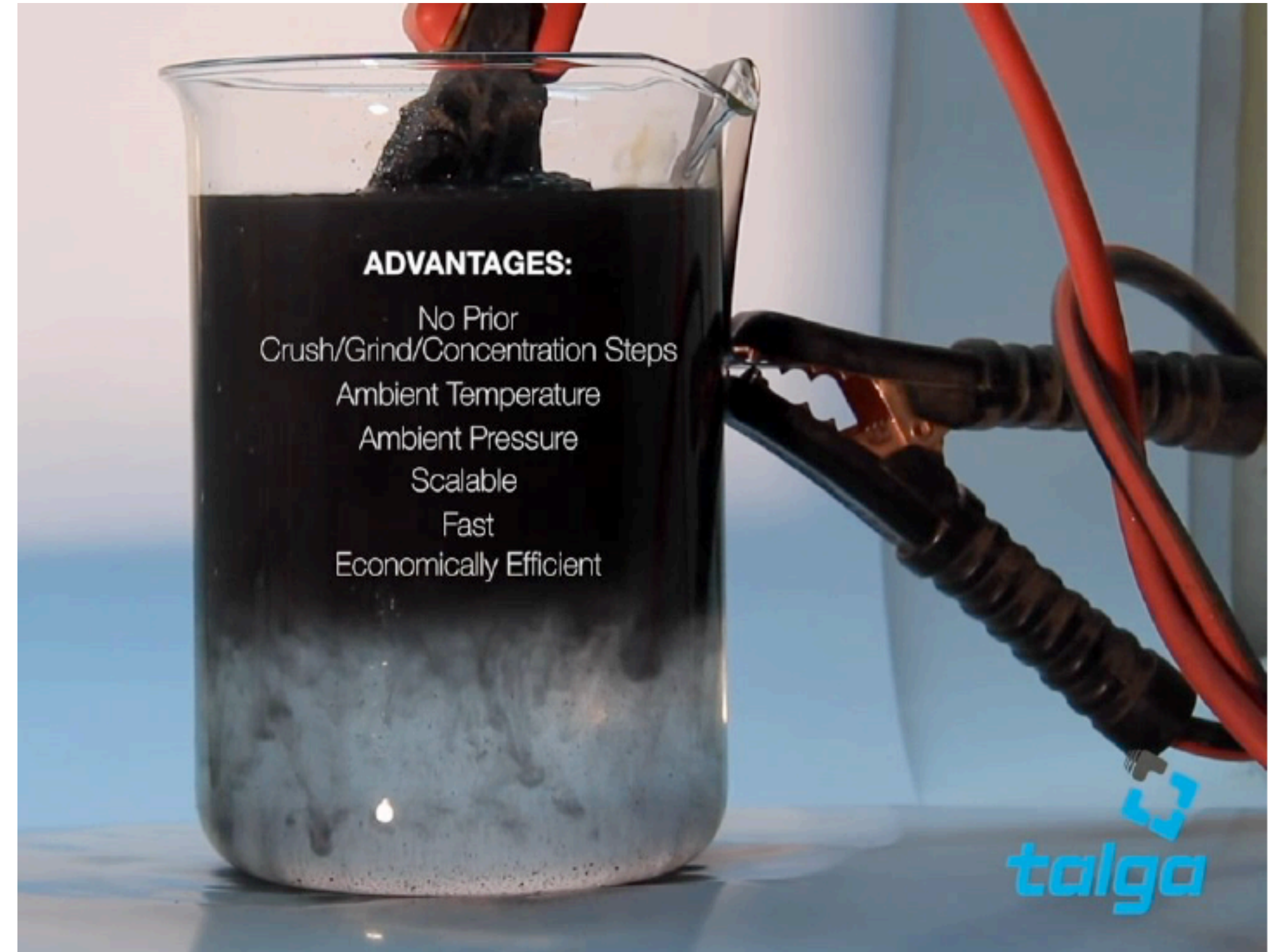
- ▶ Talga owns 3 of Top 10 grade graphite resources in world
- ▶ Pipeline of development to deliver into market
- ▶ Focus is on margins and volume of market applications, not resource tonnes for tonnes sake

Average Grade of Graphite Resource (graphitic carbon C%)



Source: <http://www.techmetalsresearch.com/metrics-indices/tmr-advanced-graphite-projects-index/>

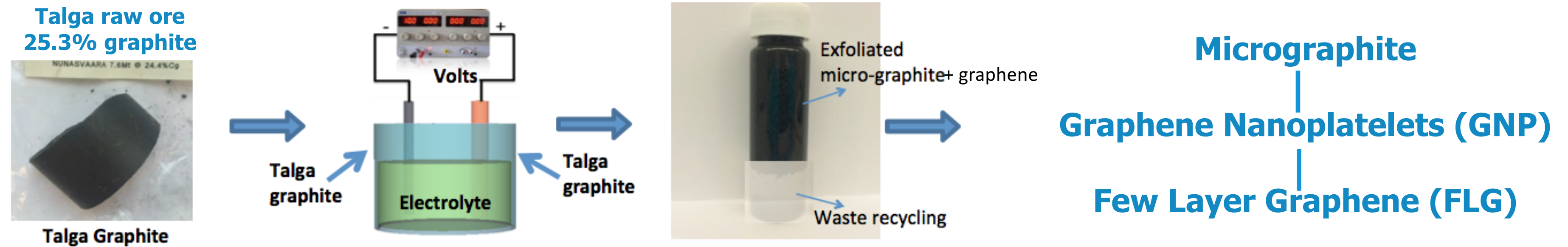
SWEDISH ORE – GEOLOGY ADVANTAGE & TALGA PROCESS



- ▶ Ore blocks are naturally conductive
- ▶ Able to be used directly as electrode
- ▶ Large volume

- ▶ Fast & industrial scalable
- ▶ Ambient T, P conditions
- ▶ Electrochemical process

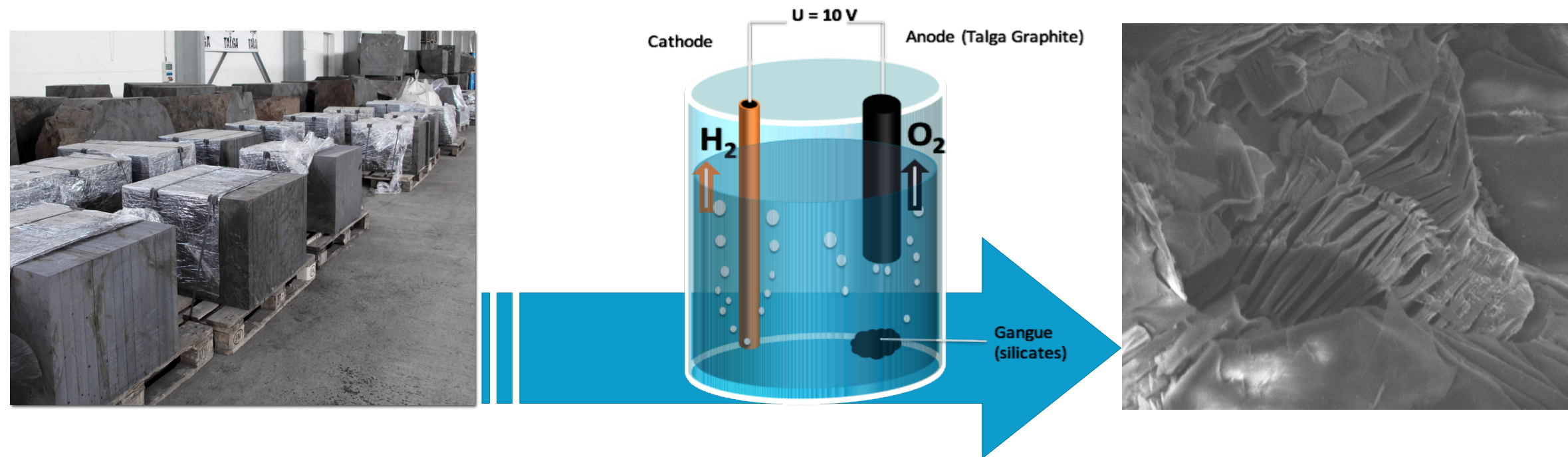
ELECTROCHEMICAL EXFOLIATION PROCESS - ADVANTAGES



- ▶ Process liberates graphene and micrographite directly from raw ore
- ▶ Makes ultrafine and ultrathin size particles without milling, a type of material not previously available economically at this scale
- ▶ Lowers energy, costs and emissions of graphene production
- ▶ Higher performance in some applications – pristine platelets, no oxide-reduction damage, larger size particles, increased edge site availability
- ▶ Talga owned technologies spans large volume FLG, MLG, GNP and 99.9% Graphitic Carbon

Technology minerals company with 100% owned resources, processing & product technology

Talga Electrochemical Exfoliation - Eco friendly and cost-effective process



- ▶ UK product development team focus on four key market sectors: Energy storage, Coatings, Composites and Construction materials
- ▶ Within Energy storage, the key product application is anode material development for batteries.

DEFINED GRAPHITE MINERAL

Project	Volume / Mt	% Graphite
Vittangi Resource	12.3	25.5
Jalkunen Resource	31.5	14.9
Raitajarvi Resource	4.3	7.1
Additional Targets	136 - 250	18 - 25

Talga Mining Pty Ltd Filial, Sweden

Graphite Exploration

Talga Advanced Materials GmbH, Germany

Talga Technologies Limited, UK

OPERATIONS - PILOT PLANT



- ▶ **Process scale-up and test-work well advanced**
- ▶ **4 phases** to upscaling process – Phase 2 commissioned and Phase 3 in progress
- ▶ High quality graphene output confirmed, via Key Academic & industrial partners
- ▶ ~76% of input carbon converted to graphene
- ▶ Capacity scale up continues towards Phase 4
- ▶ Product inputs form inventory for customer samples
- ▶ Plant capacity = 30T of ore from single modular platform, potential to be duplicated

Phase 2 pilot test platform



Portion of graphene coating product for customer test program, Talga Advanced Materials GmbH



DEVELOPMENT OF PRODUCT APPLICATIONS

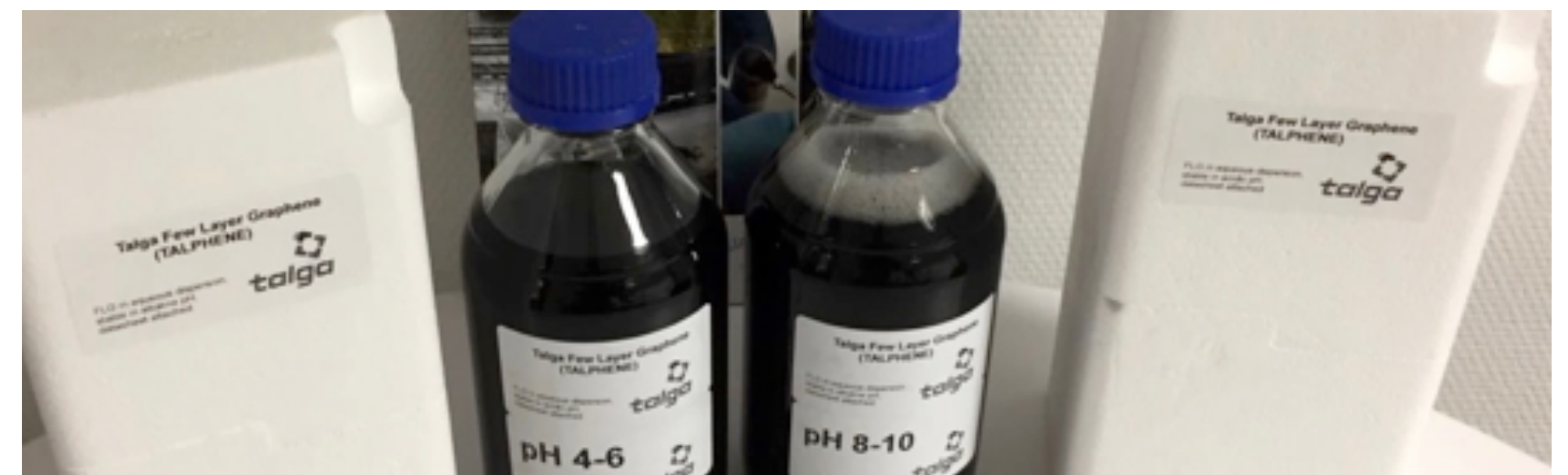
Talga has in-house ‘value added’ product development capabilities – start with internal prototype testing followed by external validation with end users

Product development strategy

- ▶ Talga’s UK team, based in Cambridge, focuses on developing value-added product applications using graphene and micrographite products for key end-user markets
- ▶ Graphene and graphite materials are chemically and physically tuned to be compatible with the end products allowing the end product manufacturers to achieve the Talga know-how in graphene and graphite incorporation into products by chemical and physical means
- ▶ Talphene™, is the brand backbone behind Talga graphene enhanced products

Partnering with customers

- ▶ Talga’s product development team collaborates with industry leading partners to accelerate the commercialisation of its graphene and micrographite products
- ▶ Resources are shared and various intellectual property agreements are in place to ensure commercial protection of Talga’s developments



MULTI-MARKET SECTORS FOR PRODUCT DEVELOPMENT



Talga has targeted four sectors where applications exist to improve functionality of materials



Talphone™ enhanced coatings

Advantages

- Eco-friendly alternative to toxic chromium based coatings
- Corrosion protection increased by up to 74% for mild steel
- Lower cost with reduction in Zn, Cu, PO4, ZrO4
- Eco-friendly marine anti-fouling



Energy

Advantages

- Enables higher performance & lower cost Li-ion, flow and alkaline batteries.
- Flexible, printable batteries for 'Internet of Things' and 'Wearable' devices
- Lower toxic footprint by enabling water-based battery chemistry
- Lower cost fuel cells



Composites

Advantages

- Stronger and lighter epoxy resin systems for Aerospace & Automotive composites
- Enables lightning strike protection and EM shielding in carbon fibre planes and EV's
- Replaces copper heating elements/wires to reduce weight of EV's

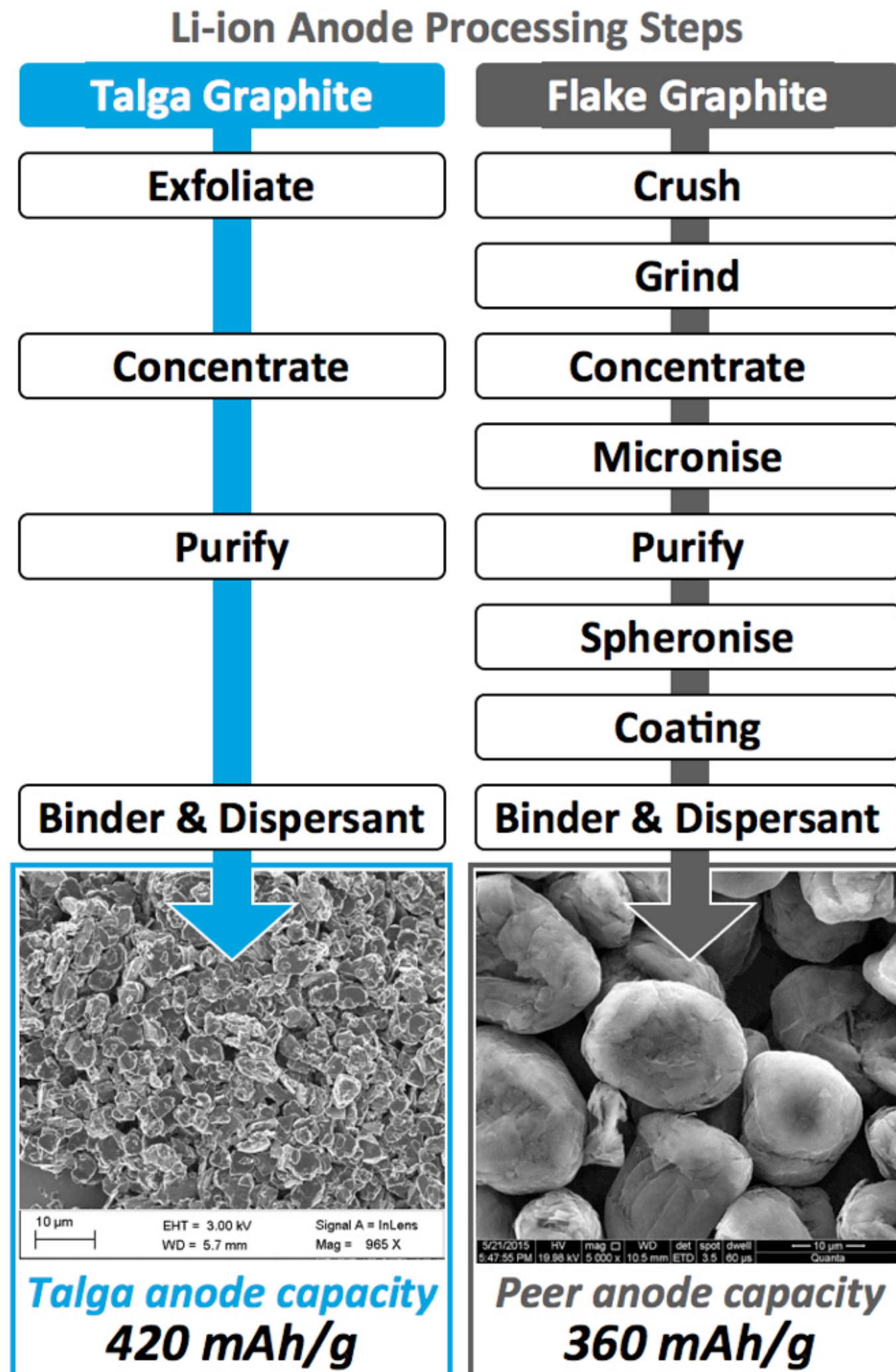


Construction materials

Advantages

- Improves strength, durability & impermeability and decreases industry CO2 footprint
- Imparts thermally conductive properties enabling underground cable power transmission economical.
- Impart electrical conductive properties enabling underfloor heating, de-icing of bridges & roads

RESOURCE AND PROCESS ADVANTAGES



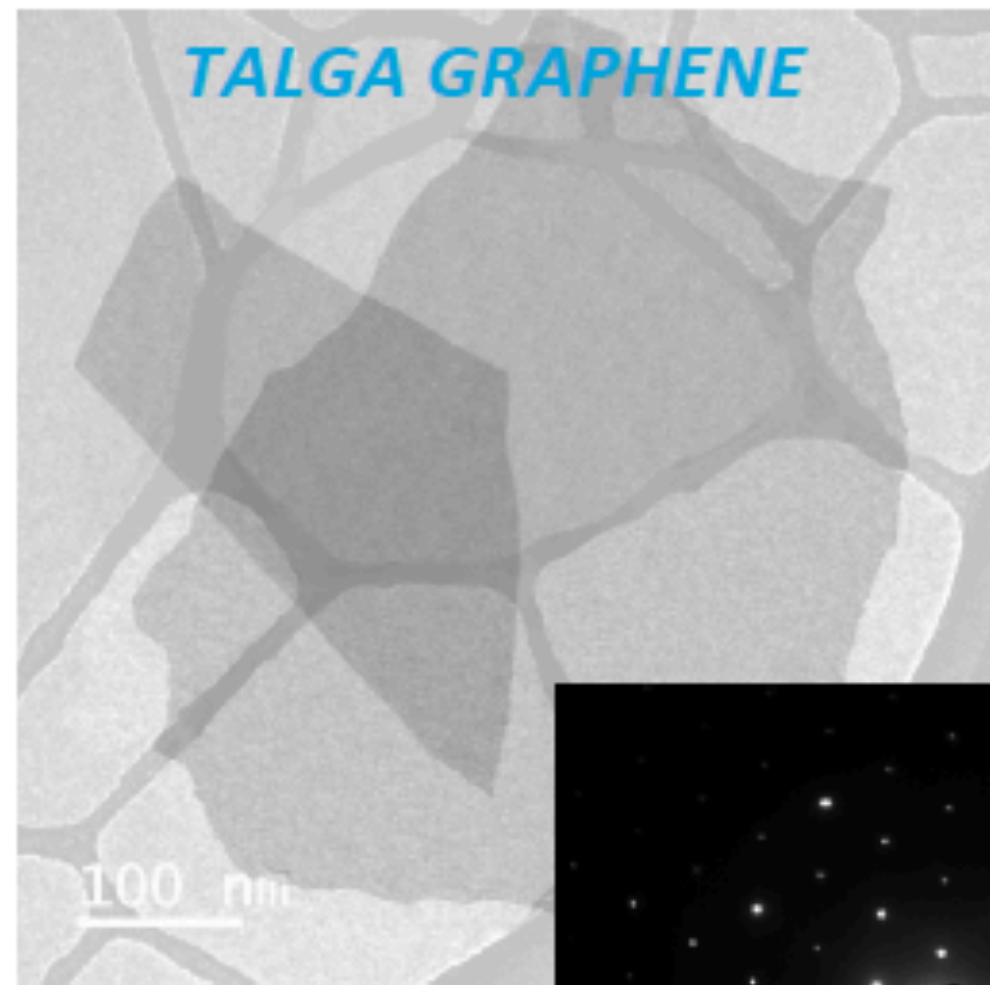
Talga's patent pending process technology liberates conductive material from natural graphite without processing steps required by peers

High performance with less manufacturing steps = Lower eco impact

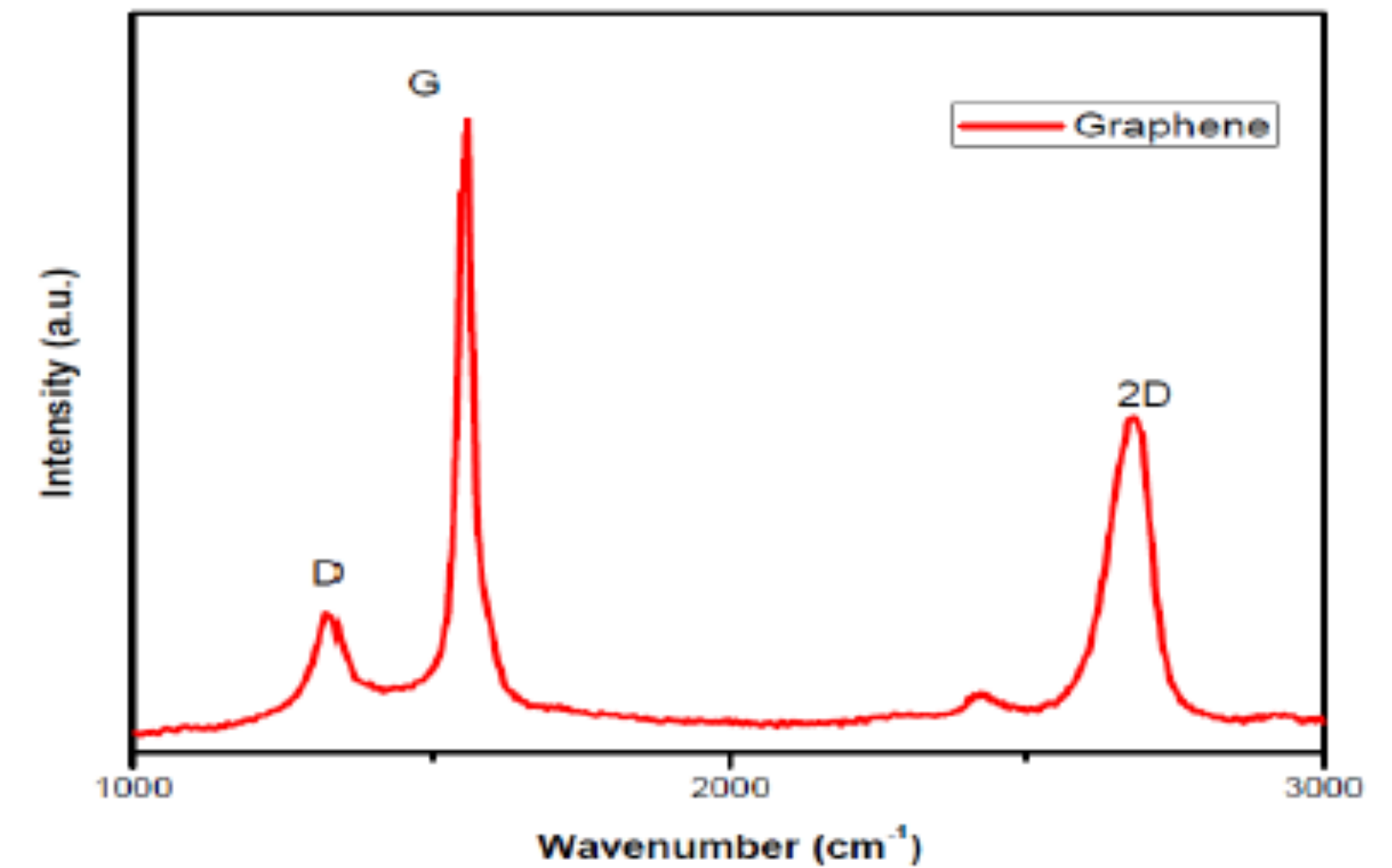
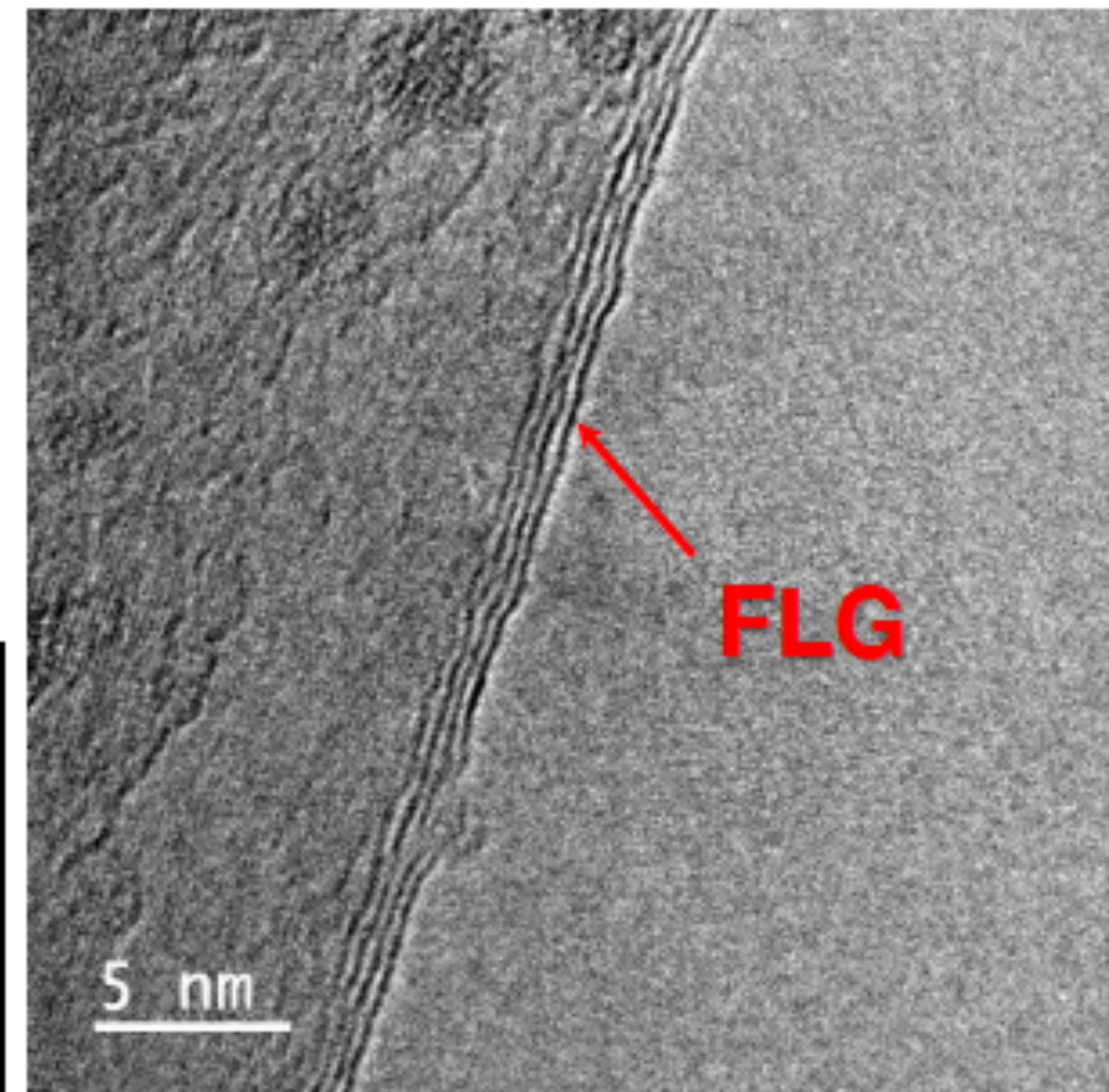
- ✓ Talga electrochemically expanded graphite anode material shows enhanced performance (420mAh/g) Vs theoretical maximum of graphite (372mAh/g)
- ✓ Excellent stability with 99.9% coulombic efficiency and low capacity loss with 99.5% retained over 1,200hrs
- ✓ Talga anode material is more conductive than standard graphite, enabling higher performance, longer life cycle and roles across multiple new battery types going forward

QUALITY GRAPHENE FOR BULK VOLUME MARKETS

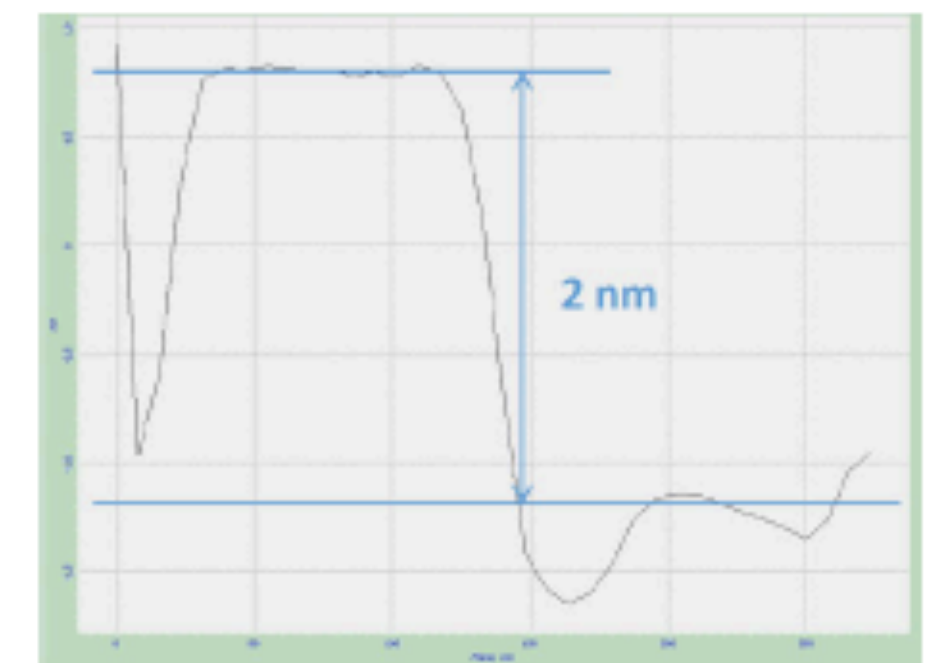
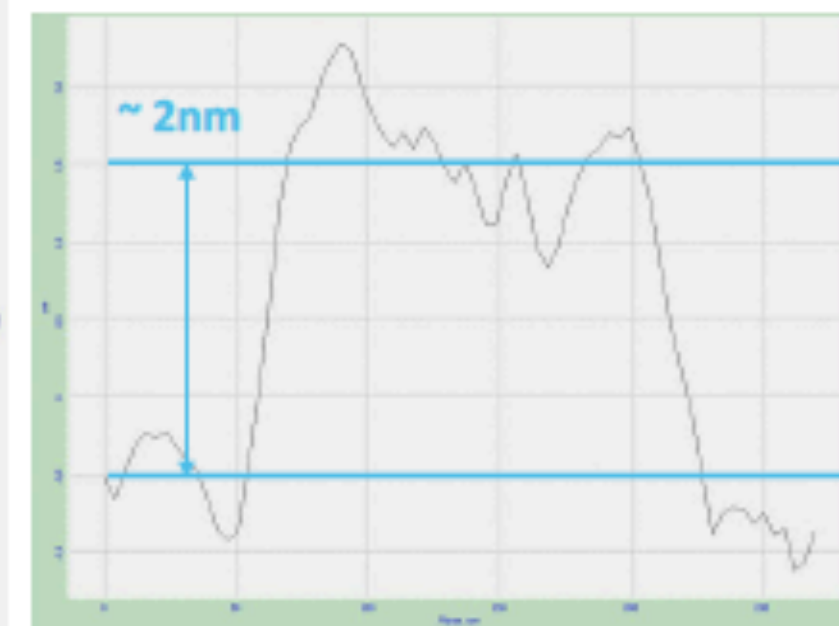
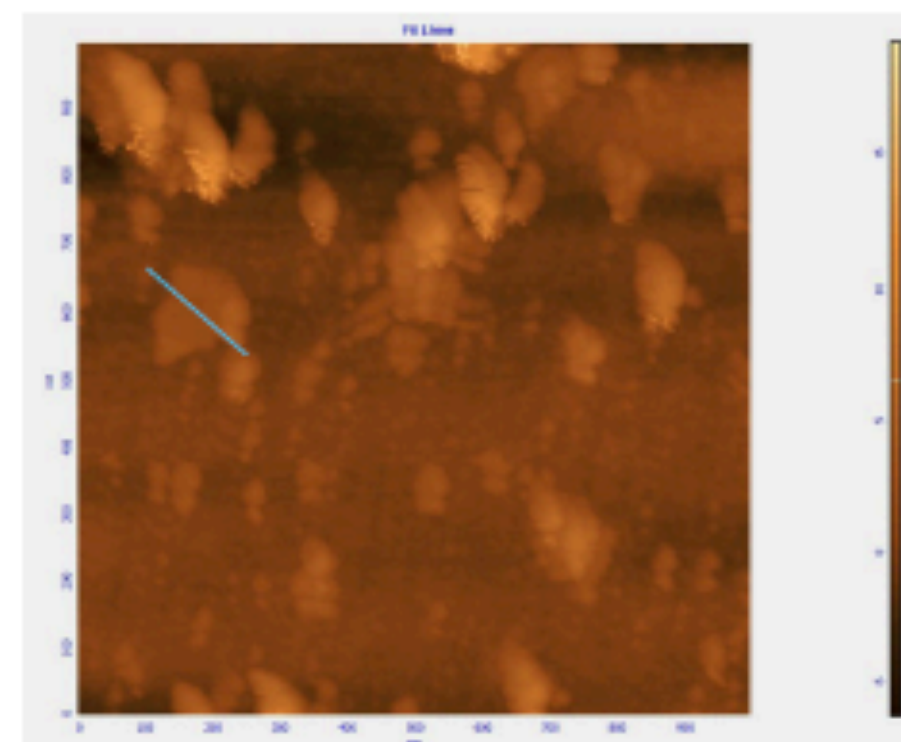
Multi-academic partners and institutions confirm high quality FLG for bulk volume additives



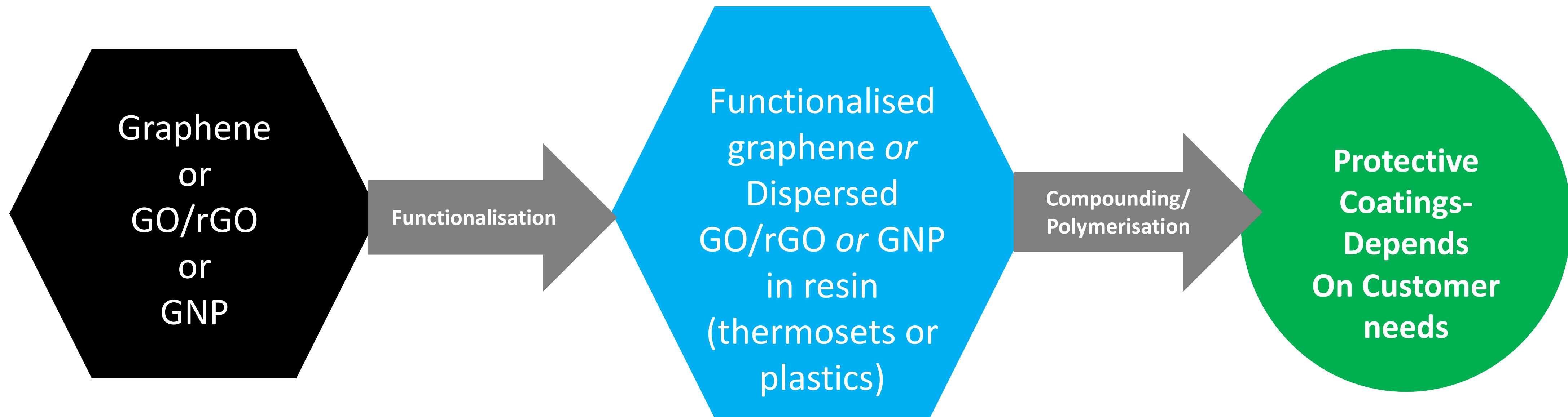
100 nm



HR-TEM confirm high quality,
1-4 layer graphene

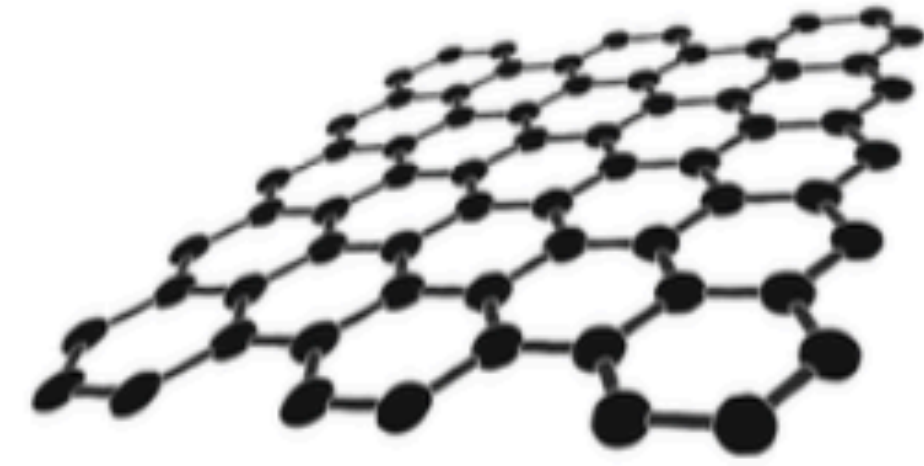


PROCESSING GRAPHENE INTO PRODUCTS



✓ Improved performance can be seen only with correct dispersion

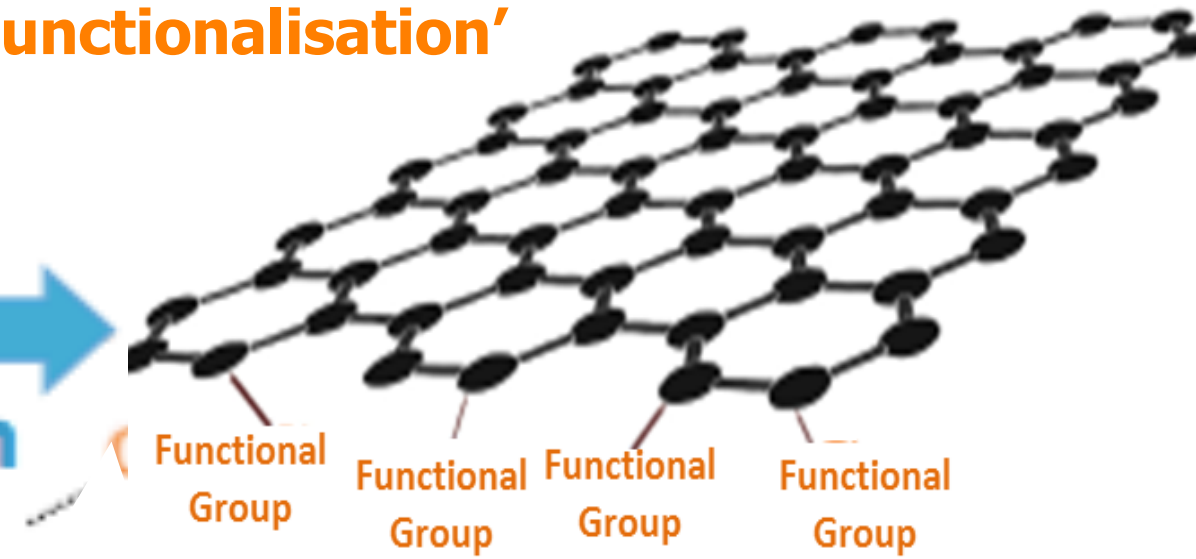
TALGA GRAPHENE COATINGS



Talga Few layer Graphene

Chemical
Modification

'Functionalisation'

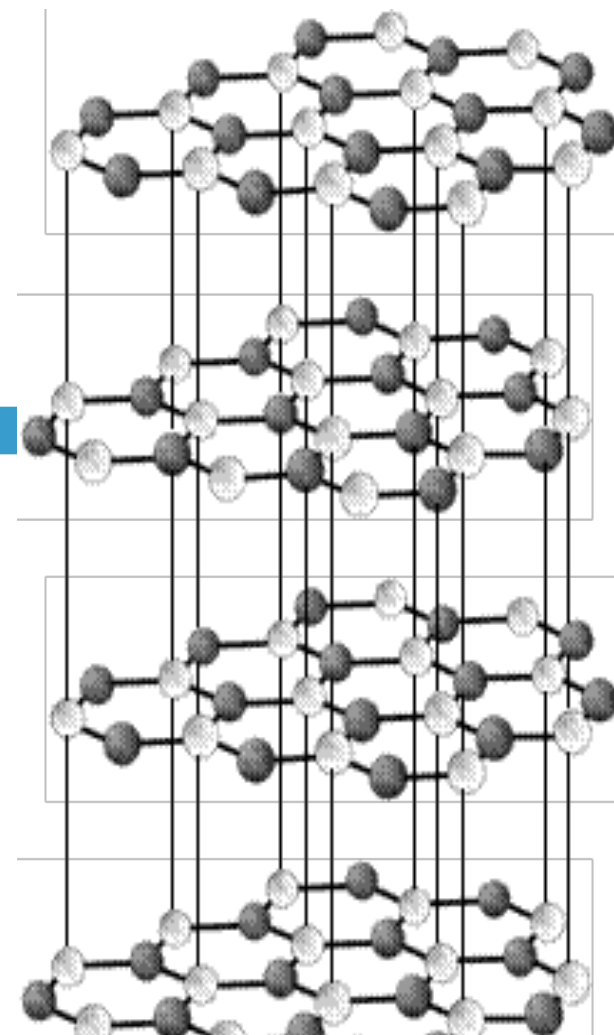


Surface Interaction/Adhesion

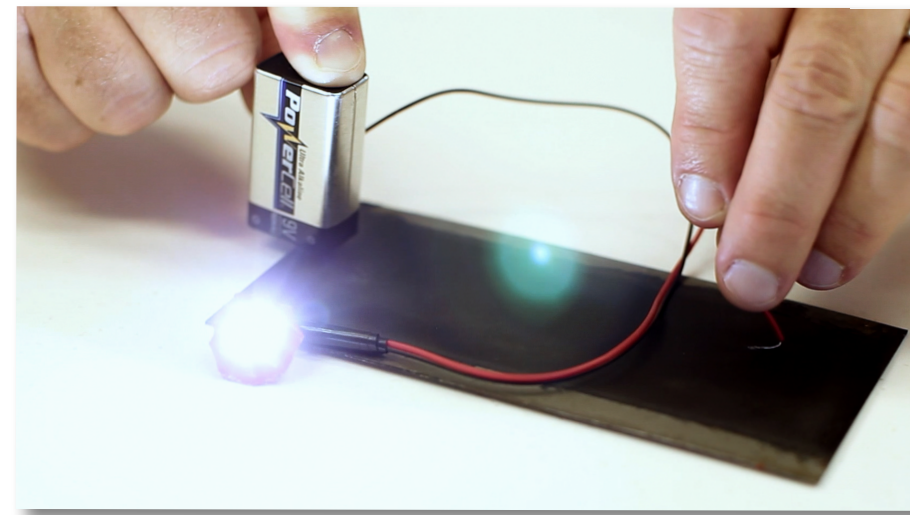


Metal substrate

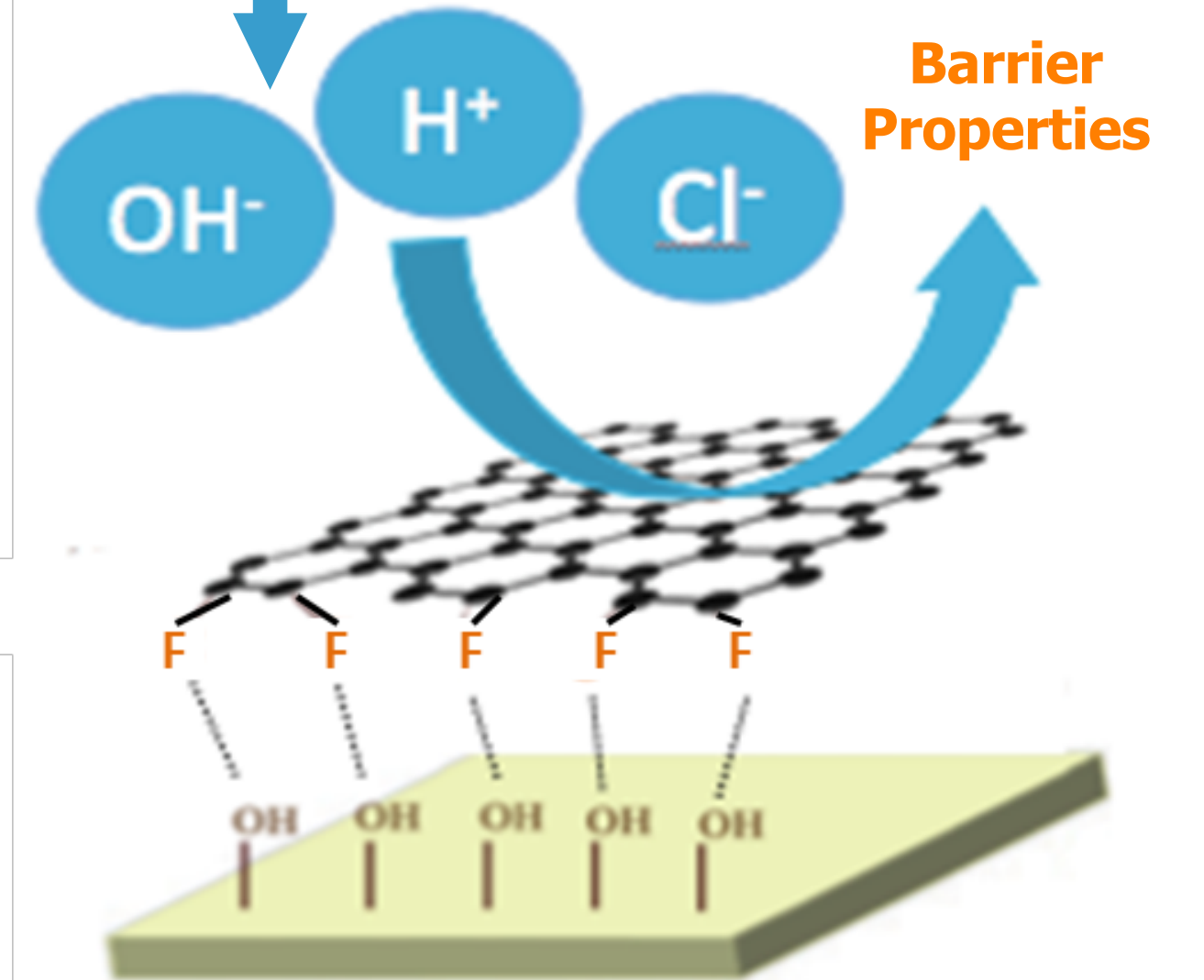
Talga Novel
Exfoliation
Process



Talga Raw Graphite Ore



Talga Few Layer Graphene
Coated Metal

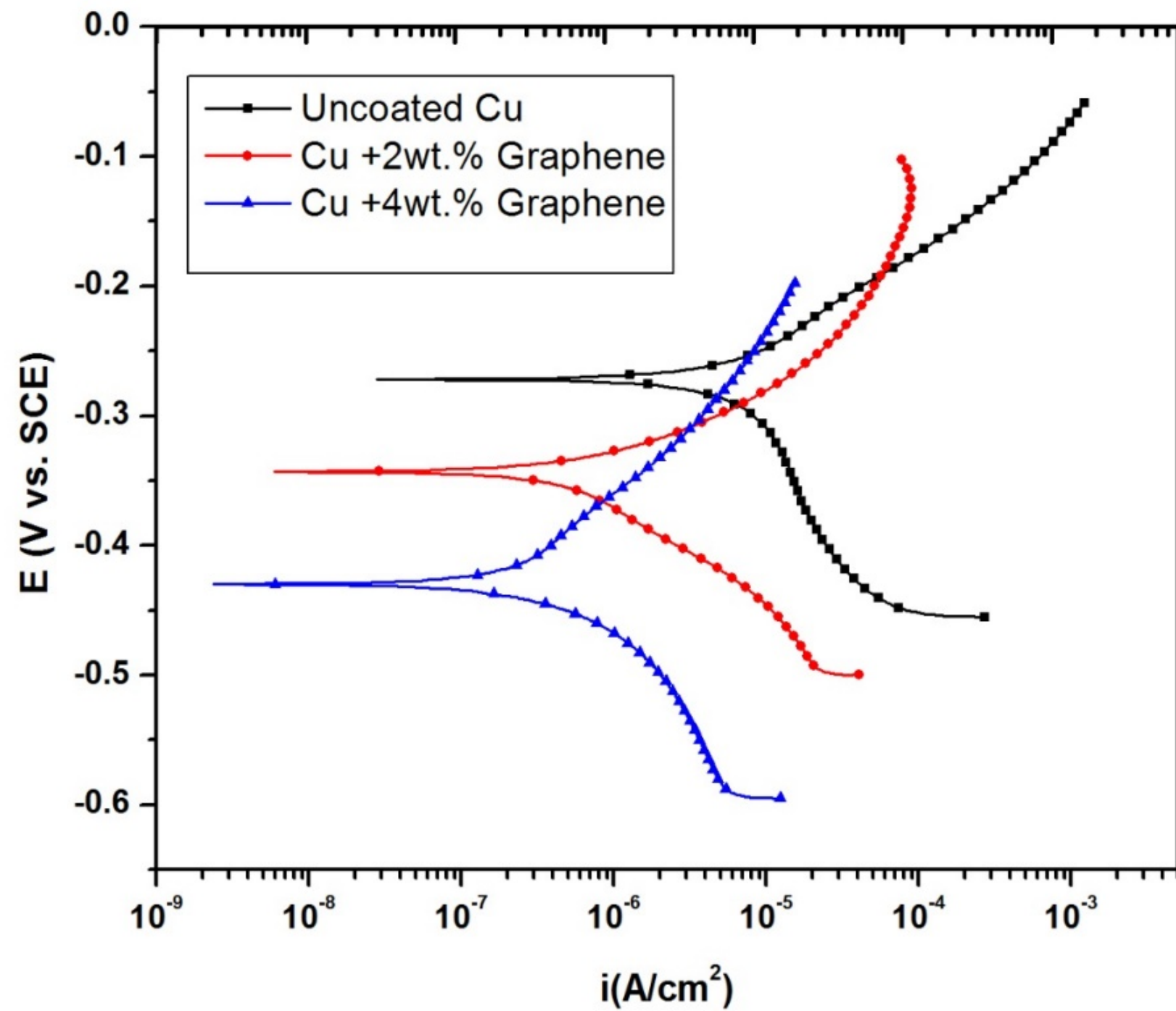


Barrier
Properties

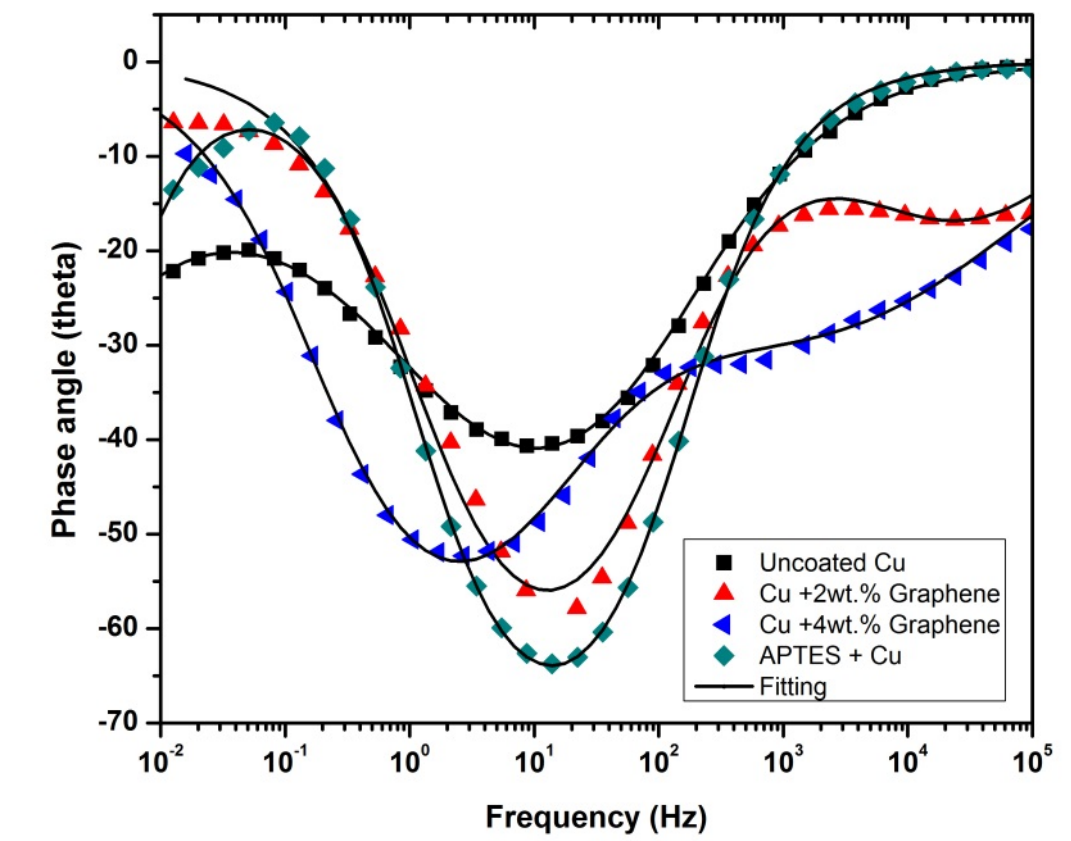
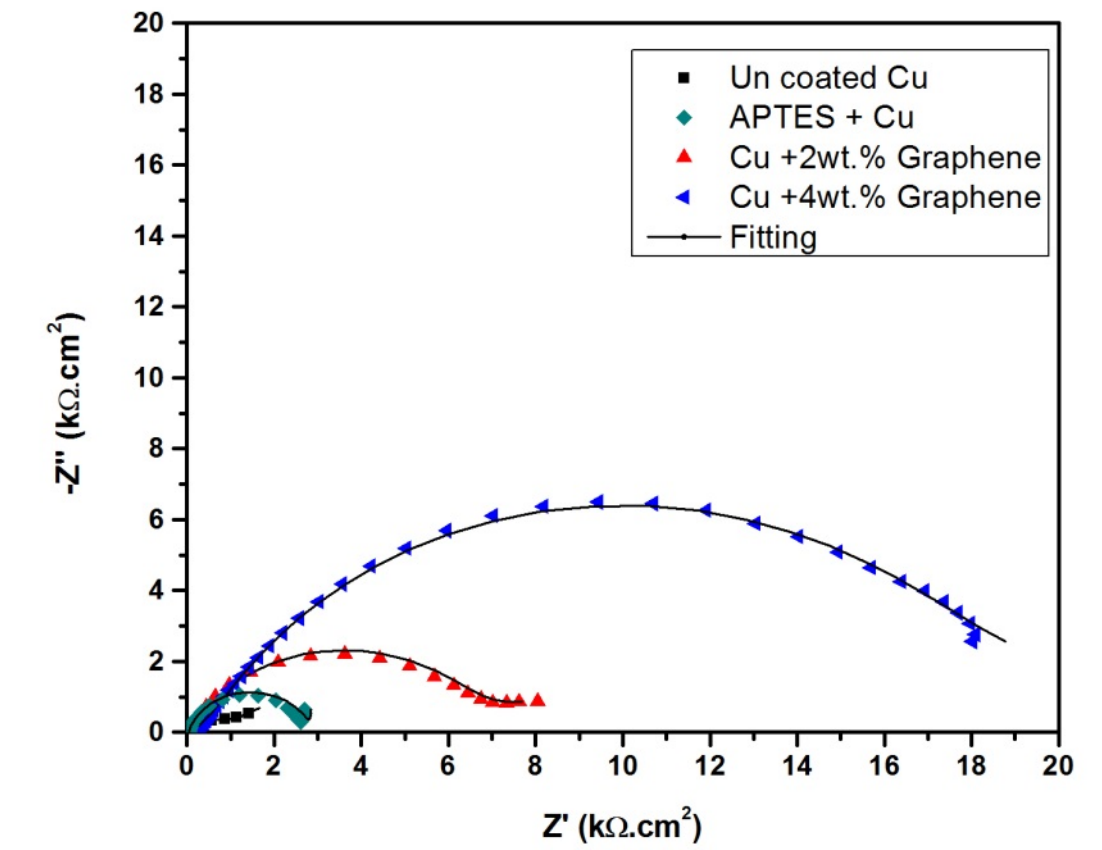
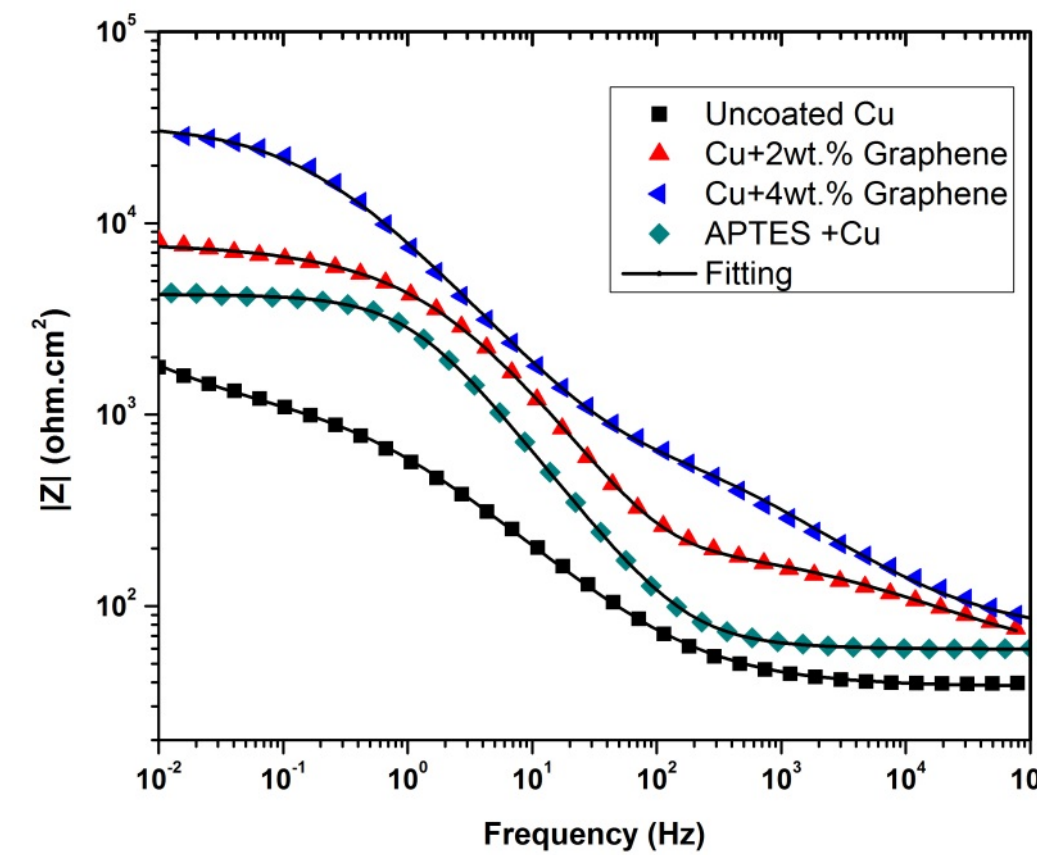
GRAPHENE PRETREATMENT Evaluation– Copper

Graphene based pretreatment shows improvement in Copper as well

Linear Polarization

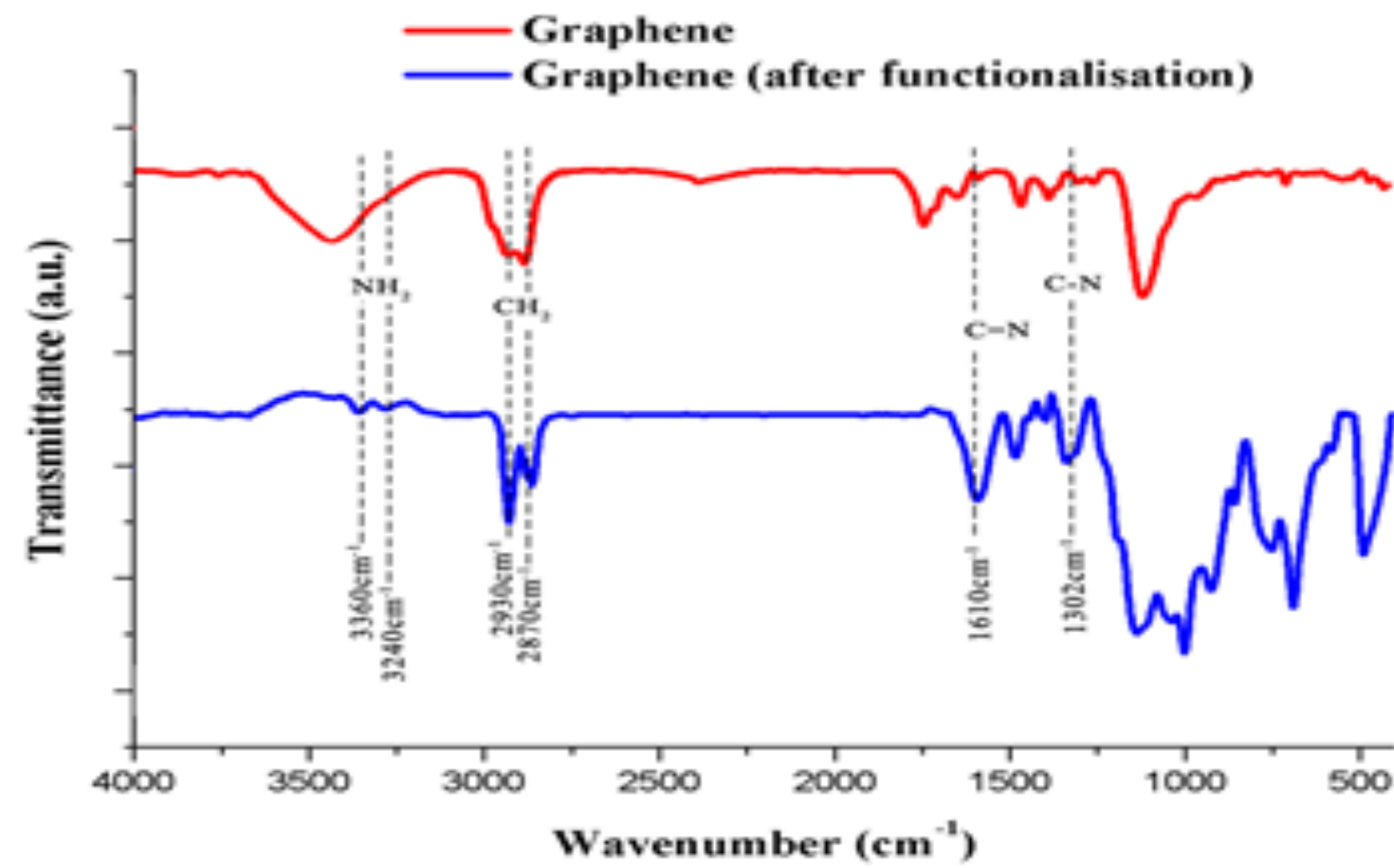
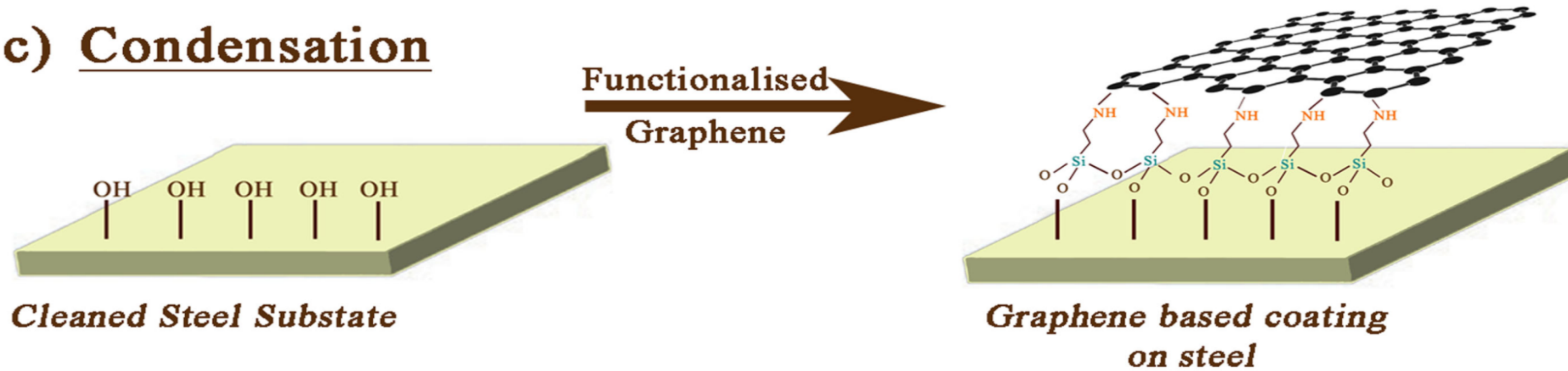


Electrochemical Impedance Spectroscopy



FUNCTIONALISATION OF GRAPHENE FOR COATING

c) Condensation

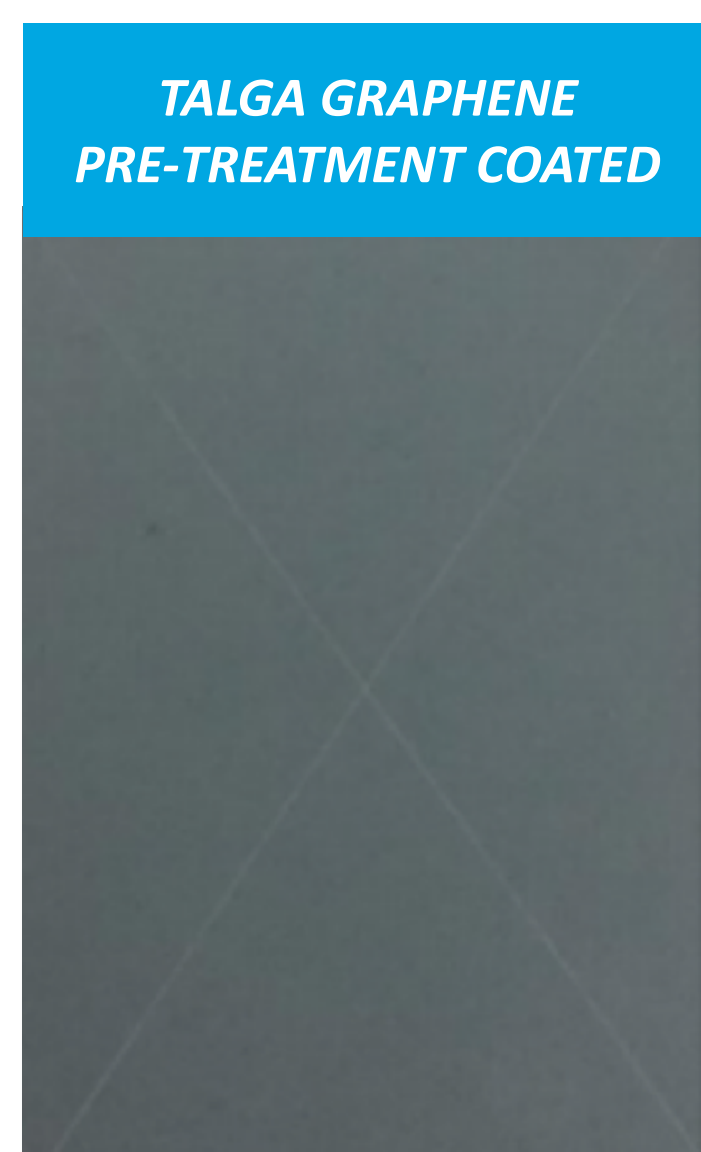
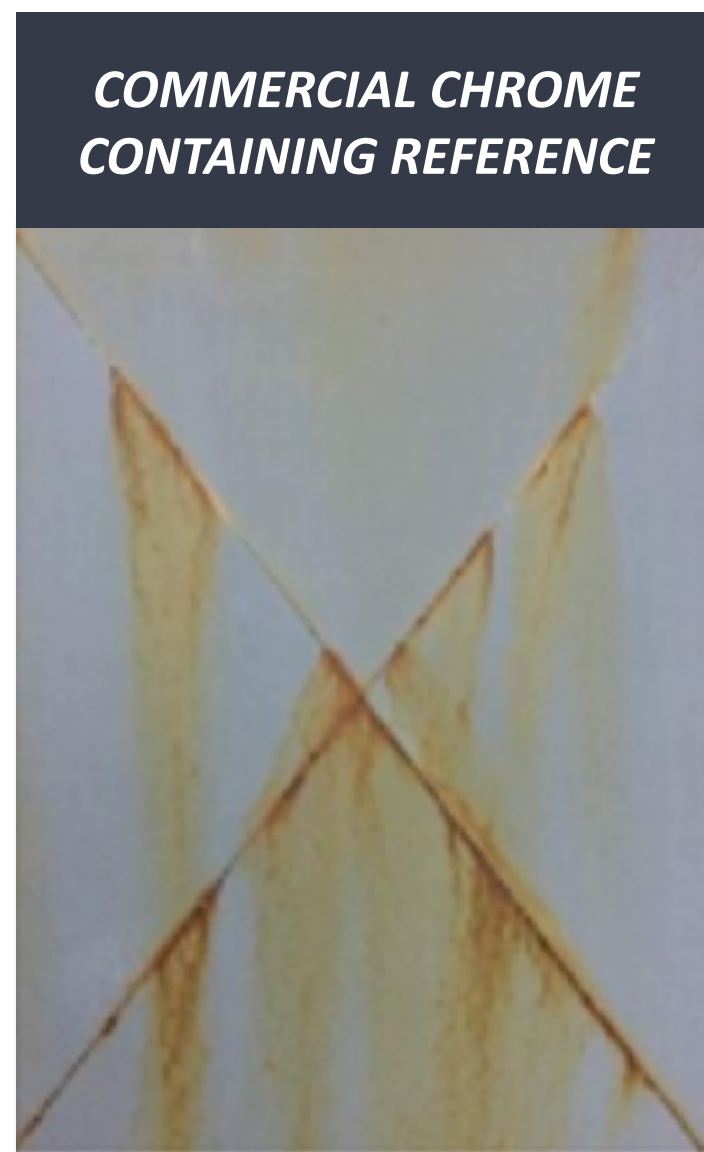


GRAPHENE PRETREATMENT Evaluation– Galvanized Steel

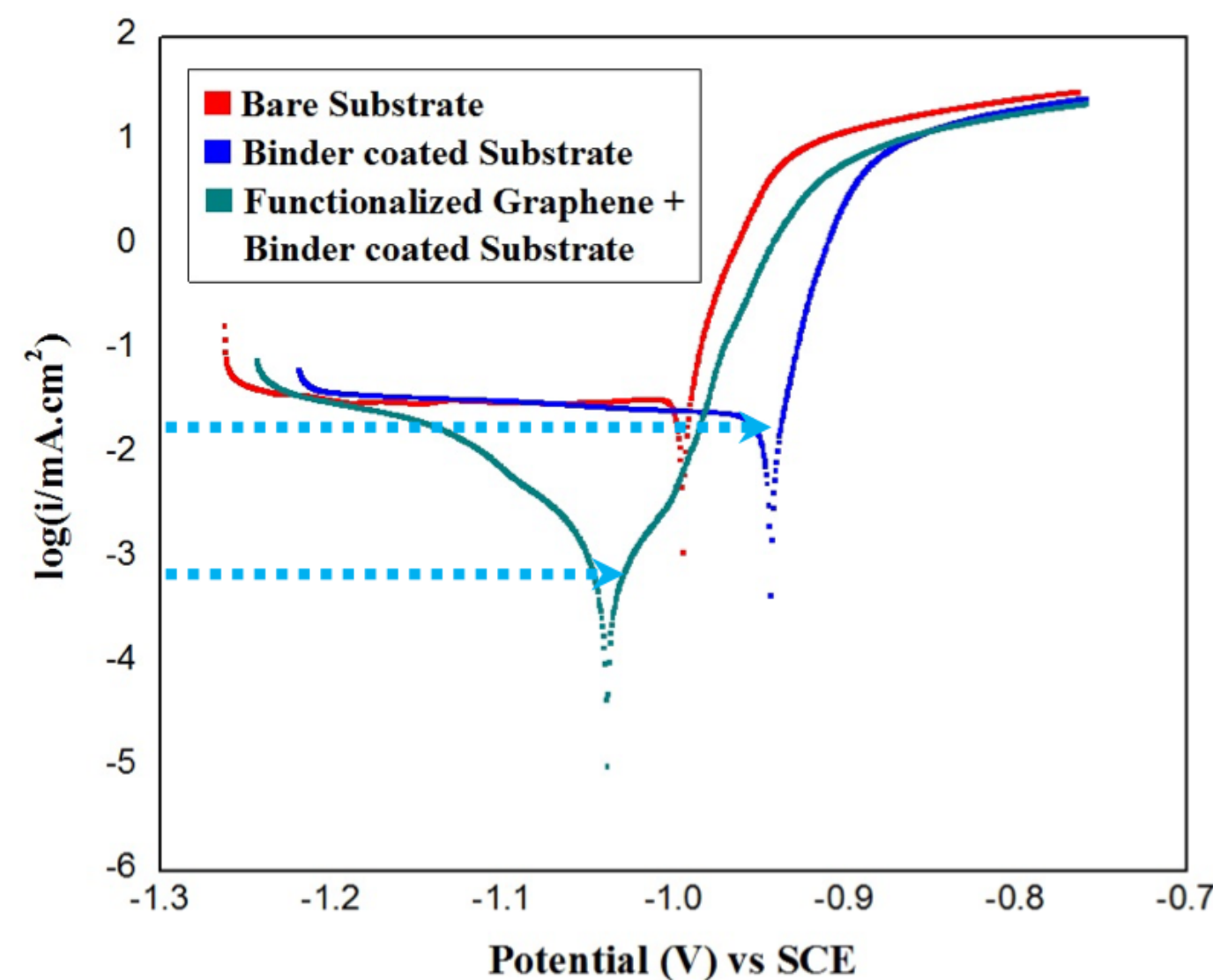


In ASTM-standard salt exposure tests Talga graphene formulation improves performance over chrome-containing reference. Patent lodged and customer trials in progress.

ASTM B117 – Salt fog Test



ASTM G59 – Linear Polarization



- Functionalised Talphene formulation coated GI shows lowest Corrosion current compared to binder
- Corrosion potential moved to more negative direction

✓ Improved Corrosion performance two order of magnitude (Corrosion rate 0.37 to 0.0062 mm/Y)

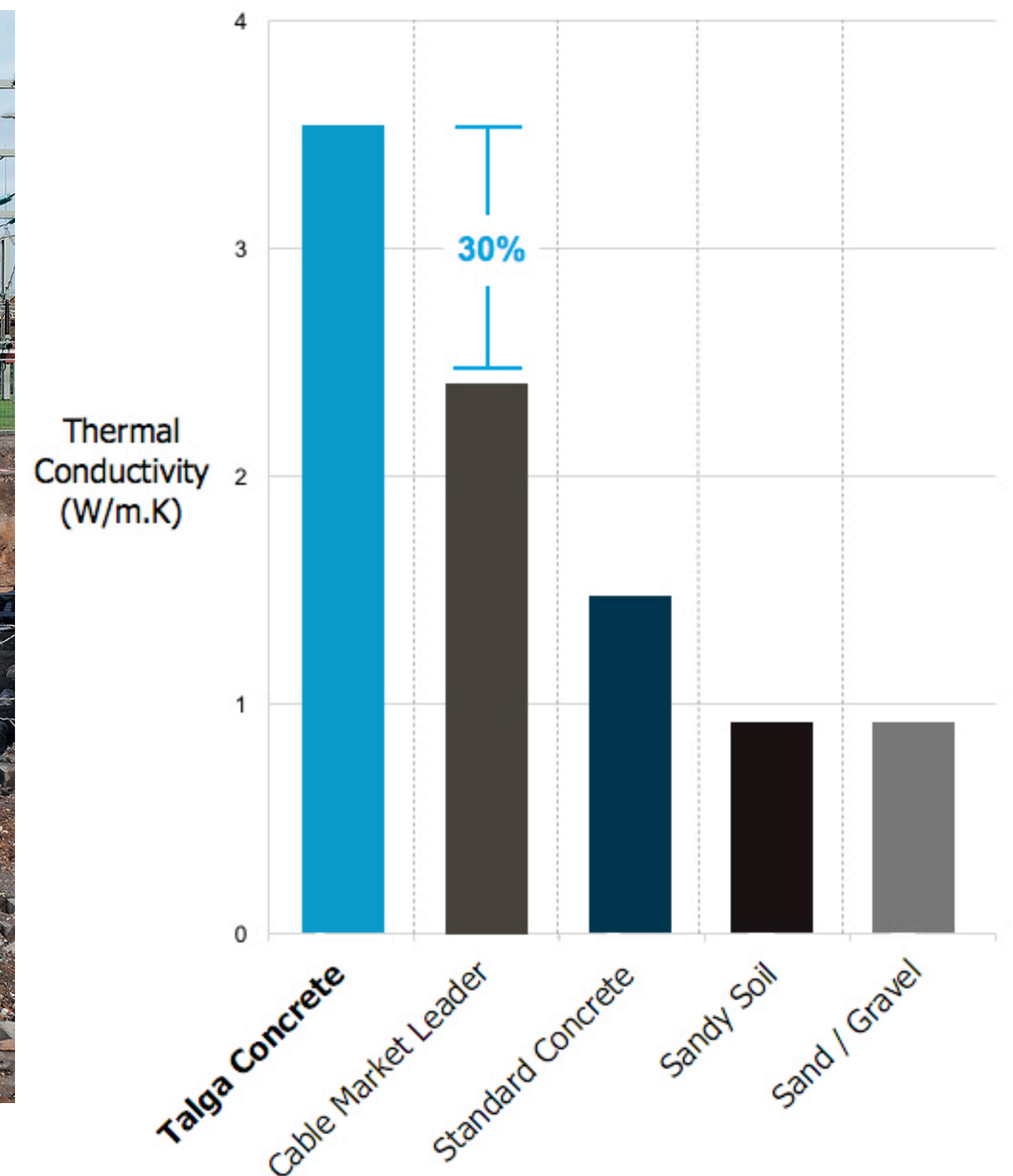
CONSTRUCTION PRODUCTS - CONCRETE

Thermally conductive concrete is a growing market which has potential to be an early adopter of graphene enhanced products.

- ▶ Graphene added to concrete can enable electrical or thermal conductivity
- ▶ April test results of Talga product shows up to 30% more thermal conductivity than market leader
- ▶ Applications include heat dissipation for underground power transmission cables, domestic underfloor heating.
- ▶ German government plans upgrades to >7,500 kilometres of high voltage electric power lines



© Heidelberg Cemeht.
Thermal concrete in underground power line application.



CONSTRUCTION PRODUCTS - CONCRETE

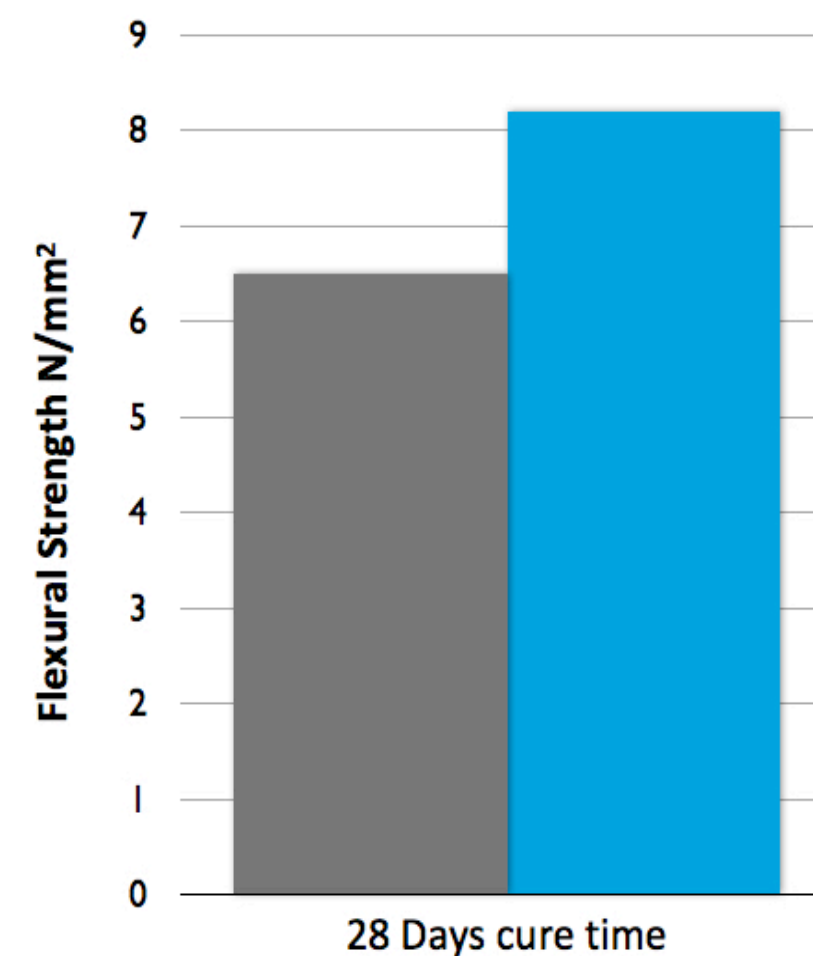
High performance concrete

- ▶ Talga graphene concrete product shows 26% increase in flexural strength and 14% increase in compressive strength over reference (high strength) sample
- ▶ Rapidly growing urbanization and requirements for lower volume/lower emissions is driving demand
- ▶ Graphene strengthens concrete similar to carbon nanotubes but potentially at lower cost.
- ▶ Electrically conductive concrete being developed & tested.

■ Reference Concrete ■ Talga Concrete

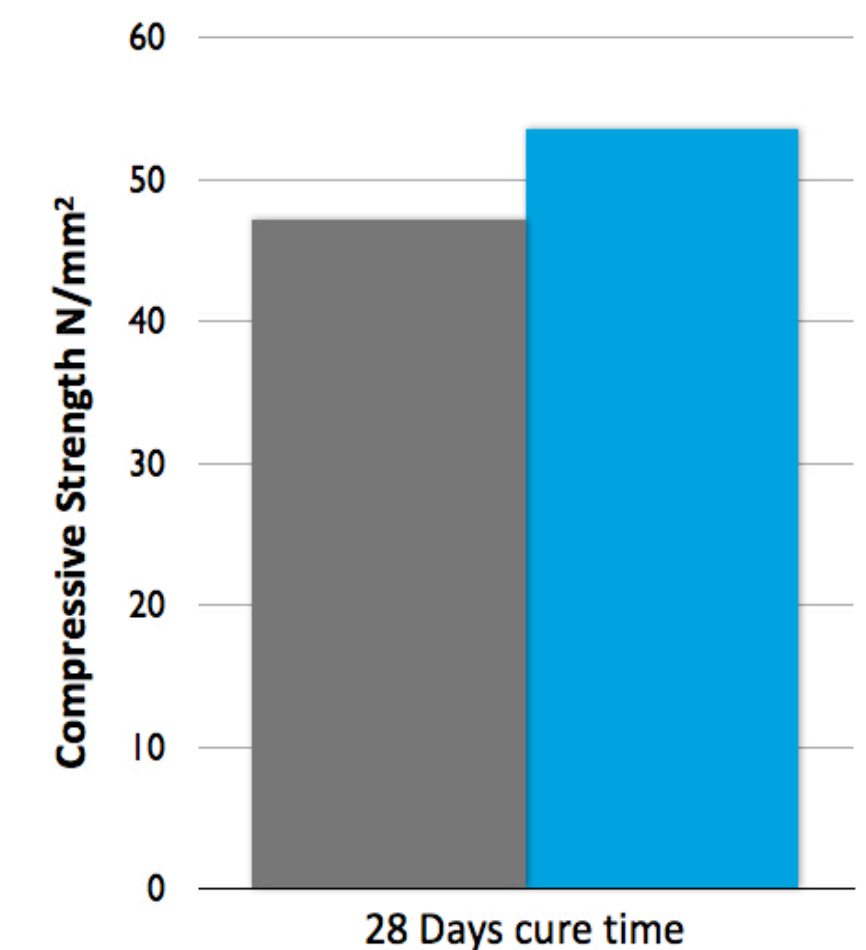
26% INCREASE IN FLEXURAL STRENGTH

DIN 12 390-5



14% INCREASE IN COMPRESSIVE STRENGTH

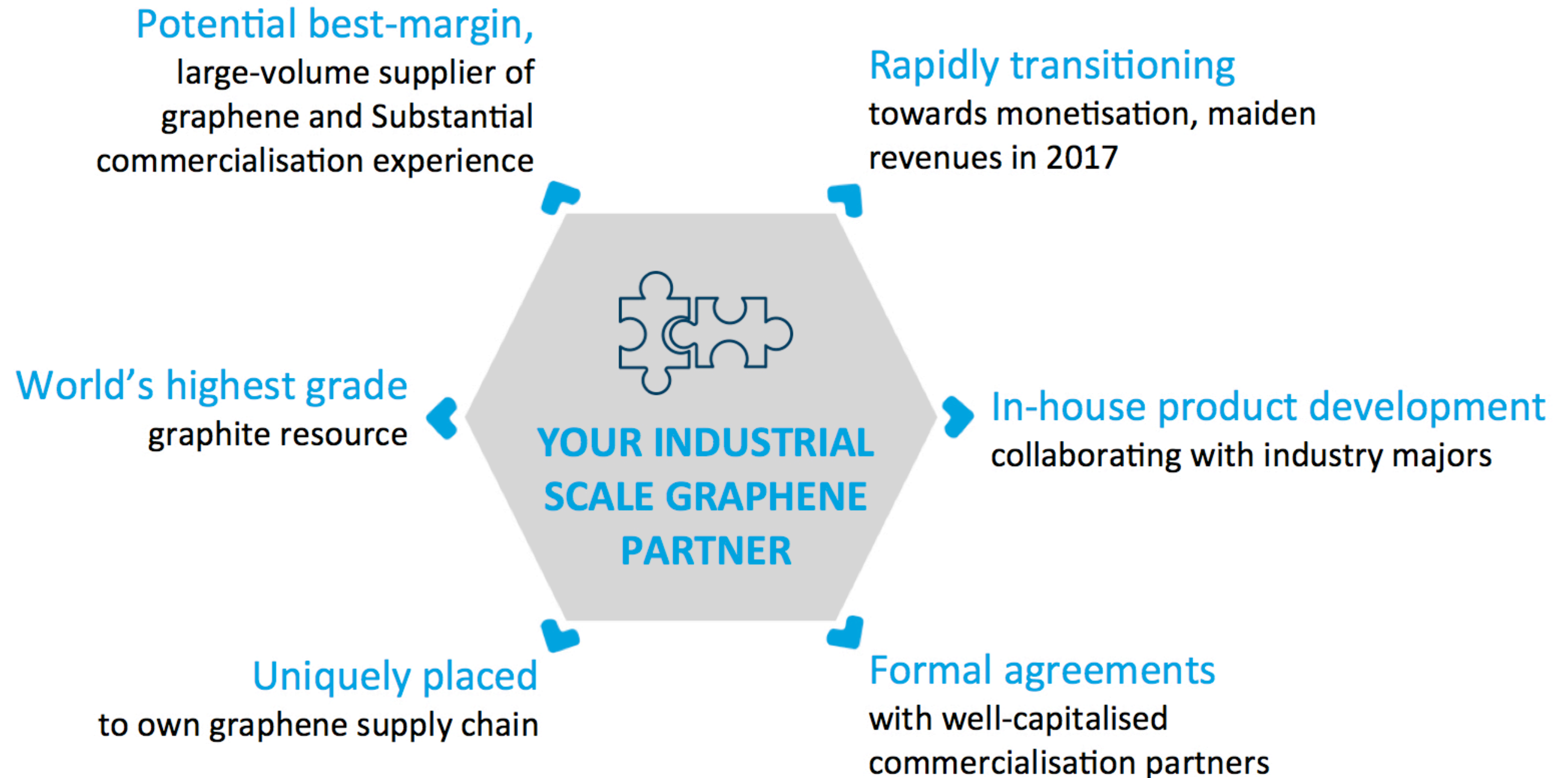
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Testing of Talga concrete products

SUMMARY – TALGA OPPORTUNITY

Technology minerals company commercialising mass produced graphene and products



BOARD OF DIRECTORS



Terry Stinson
Non-Executive Chairman



Mark Thompson
Managing Director



Grant Mooney
Non-Executive Director



Steve Lowe
Non-Executive Director



Ola Mørkved Rinnan
Non-Executive Director



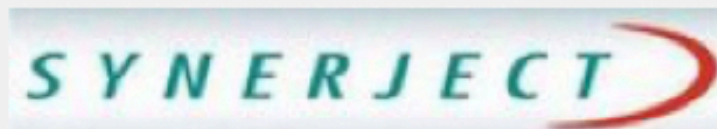
Managed the manufacturing division of the outboard marine propulsion products for a privately held US\$1bn multinational.



Oversaw the evolution of Carnegie Wave Energy from 2008 as it developed innovative renewable energy solutions in Australia.



Oversaw the company during the discovery and development of one of the largest Cu/Ni discoveries in Australia in the last 30 years.



Managed the company from 2000 to 2002 including the introduction of several new sales products.



Has led Orbital since 2008 and successfully secured a breakthrough deal with Insitu Inc. (Boeing) for the supply of global unmanned aerial vehicle propulsion systems worth up to A\$120m over a 3 year period.

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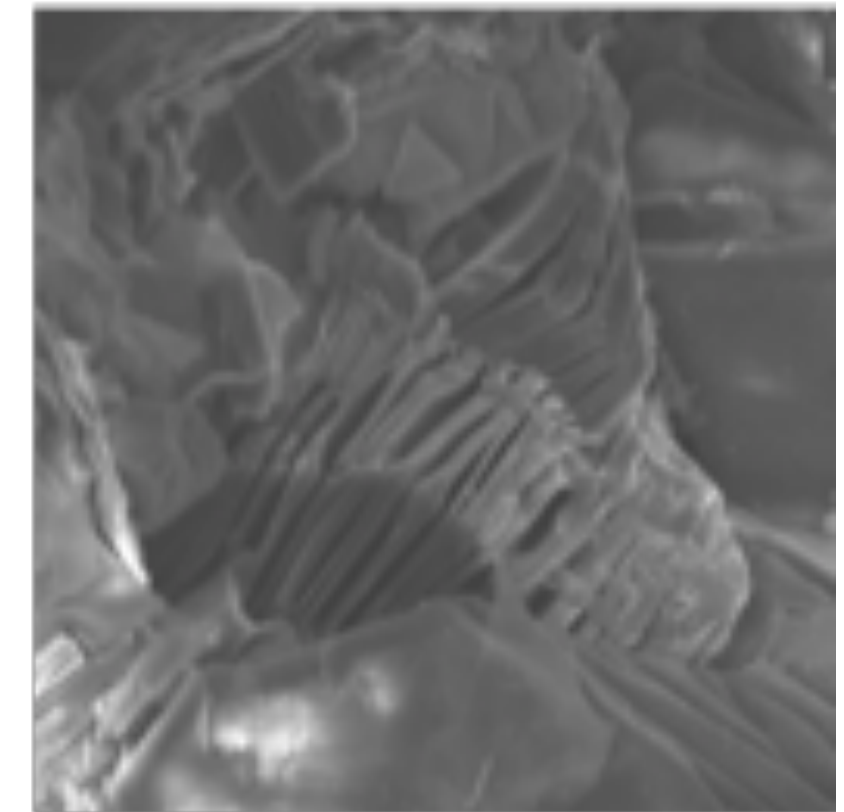
Prof.-Hermann-Klare-Str. 25, 07407 Rudolstadt, Germany

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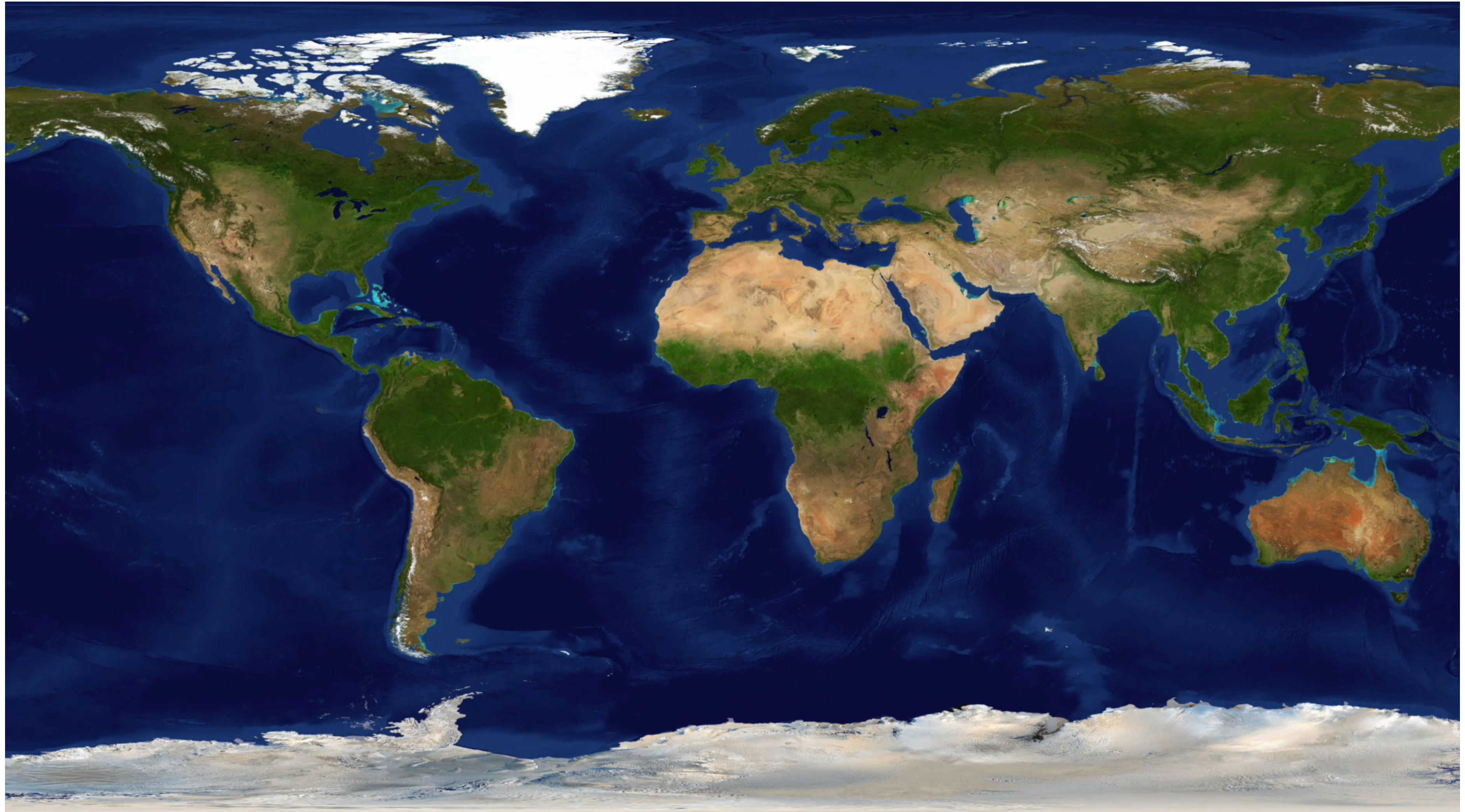
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TRIAL MINING - SWEDEN



Vittangi trial mining. For video see <https://www.youtube.com/watch?v=G7dndP7NGco&t=1s>

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