TALGA RESOURCES

Emerging industrial Scale Graphene Supply
IDTechEx Show, Berlin
Martin Phillips, Chief Operating Officer

11 April 2018
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Talga Resources

Vertically integrated advanced material technology company focusing on graphite and graphene
VERTICALLY INTEGRATED ADVANCED MATERIAL SUPPLY CHAIN

European operations and business units

- **Talga Mining Sweden**
  100%-owned high grade graphite deposits – Largest resources in Europe

- **Talga Advanced Materials Germany**
  100%-owned test process facility located in Rudolstadt, Germany

- **Talga Technologies UK**
  Product development and marketing team located in Cambridge, UK
TALGA MINING - SWEDEN

Vittangi Graphite Project - Europe’s largest mineral resource of graphite

- Trials of solid graphite electrodes cut straight from surface
- Wide, uniform mineralisation starts at surface – can support big mine life and industrial scale production
- Simple process, no drilling/blasting/dust
TALGA ADVANCED MATERIALS - GERMANY
Scaling Up Proprietary Bulk Graphene Processing Technology

- 100% owned proprietary test facility scaling up process for production of graphene and micrographite
- Servicing graphene collaborations with industrial partners & customers
- Commissioning of next scale up (phase 3) underway
TALGA TECHNOLOGIES UK

Group of 5 PhDs (Chemistry, Materials) in R&D Project Partnerships and Formal Industry Agreements
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Some current collaborations include:
OUR PRODUCTS

We make added value and enhanced Products used across four key sectors, with batteries being one in energy.

BUILDING MATERIALS
- Combined graphite and graphene mixtures for high strength building materials
- Conductive screeds for de-icing systems
- Conductive flooring, wall panel systems combined with heating or cooling systems

ENERGY
- Micro-graphite for current lithium-ion high power batteries
- Next generation anodes with higher energy performance
- Conductive additives for lithium-ion batteries and flexible, printable batteries for ‘Internet of Things’ and ‘Wearable’ devices

COATINGS
- Eco-friendly chrome-free based pre-treatment coatings
- Pre-fabrication and post fabrication anti-corrosion coatings
- Marine anti-fouling coating systems

COMPOSITES & RESINS
- High strength carbon fibre resins
- Engineered plastics and polymer composites
- Lightning strike protection and EM shielding
- Thermal sink polymer resins
- Conducting inks and pastes
PROVEN INTEGRATED SUPPLY CHAIN

View full video here: https://www.youtube.com/watch?v=G7dndP7NGco
ENERGY PRODUCTS

Graphite and graphene materials for current and next-gen batteries
SOLUTIONS THROUGH BETTER MATERIALS
Automotive sector pushing hard for next gen battery materials to increase safety/performance and lower cost

CURRENT LI-ION CELL COMPONENTS

TRENDING LI-ION TECHNOLOGIES

- **Silicon** additives and solid silicon electrodes (potential 3,579mAh/g)
- **All-solid state** with no electrolyte or liquid (potential low cost and safe)
- Next generation under advanced R&D: 
  - **Li-sulfur** (very high energy and eco friendly) 
  - **Li-air** (petrol power potential) 
  - **Sodium-ion** (abundant and low cost)
- **Graphene** tends to be used in more next gen batteries than graphite due to higher conductivity, surface area and physio-chemical potential, and can be used across more parts of battery than just anode.

Source: Johnson Matthey
**SILICON ELECTRODES ENABLED BY GRAPHENE**

Talga is developing materials for current additive silicon and next gen solid silicon electrodes

- Industry needs higher capacity batteries (longer range). Addition of silicon up to 30% will double reversible capacity to $>750 \text{ mAh/g} = >50\%$ vs Standard Graphite
- Many new battery technologies require graphene more than graphite e.g. Samsung silicon battery\(^1\)
- Goldman Sachs estimate an Rmb6.3bn (US$0.9bn) addressable market by 2025 for graphene in batteries\(^2\)

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\(^1\) Source “Graphene balls for lithium rechargeable batteries with fast charging and high volumetric energy densities”, Nature Communications 8:1561. Samsung

\(^2\) Source “Chinas Battery Challenge; A New Solution”, Goldman Sachs Feb 2017
TALGA MATERIAL ADVANTAGE

Talga’s patent pending technology liberates graphite as well as graphene from raw ore, enabling use in Li-ion anodes with less processing steps than peers.

- Talga anode graphite has unique morphology and unmilled small size, with graphene-like structures increasing Lithiation sites.
- Tests at WMG confirm Talga anode capacity of 420 mAh/g vs pure graphite limit 372 mAh/g and average ASX graphite co’s 360 mAh/g.
- Excellent stability: 99.9% coulombic efficiency and >99.5% reversible capacity over 1,200 hours cycling.
- Cost effective process but needs optimising to commercial levels, then watch this space!

Higher performance with less manufacturing steps = lower eco-impact.
TALGA PARTNERS THROUGH ‘FARADAY CHALLENGE’

UK Government funding through Innovate UK’s £246 million ‘Faraday’ initiative to create new battery technologies and local supply chains

- € 0.95m budget over 1-2 year period for 3 programs:
  - **Scale up** of Li-ion electrode materials; higher performance current
  - **Graphene-silicon** and alloy anodes (Safevolt);
  - **Sodium-ion** batteries for automotive power applications.

- Binding collaboration agreements signed with partners including Jaguar-Land Rover, Johnson Matthey, Croda, Faradion, PV3, Cambridge University and Warwick Manufacturing Group.
**EUROPEAN BATTERY GIGAFACTORIES**

Location advantage to supply fast growing Li-ion battery supply chain

- **Multiple** Li-ion “Gigafactories” underway or planned in EU
- **Majority** of raw materials are currently imported into Europe from Africa (cobalt and graphite) or China (graphite)
- **Talgo’s** graphite and cobalt-related deposits in Sweden represent an important potential non-Africa, non-China supply
- **Rocketing growth** in EV’s underwritten by many EU governments
- **Direct rail-links** to multiple ‘Gigafactories’ creates different supply-demand dynamic to standard China supply story

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Source: Benchmark, Roskills, Recruit.
**EUROPE GIGAFACTORY STARTUPS**

Global Li-ion cell production set to more than double by 2020, with Europe near quadrupling from 2020-25

### Global Lithium Ion Battery Manufacturing Capacity (Giga Wh)

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<th>Capacity (GWhr)</th>
<th>Asia</th>
<th>ROW</th>
<th>Europe</th>
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10yr CAGR 20%

### Installed Capacity GWhr

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<th>Company/JV</th>
<th>2020</th>
<th>2025</th>
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<td>Terra E Consortium</td>
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<tr>
<td>Sweden</td>
<td>Northvolt</td>
<td>8.0</td>
<td>32.0</td>
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<tr>
<td>Poland</td>
<td>LG Chem</td>
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<tr>
<td>Germany</td>
<td>LeClanche</td>
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<td>3.4</td>
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<tr>
<td>Germany</td>
<td>BMZ/Bosch</td>
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<td>3.0</td>
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<td>Hungary</td>
<td>Samsung</td>
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<tr>
<td>UK</td>
<td>WMG/Coventry</td>
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<td>1.0</td>
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<tr>
<td>France</td>
<td>Saft</td>
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<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>21.5</strong></td>
<td><strong>81.5</strong></td>
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Note: Daimler and VW have not declared if making cells in Europe
Source: Bloomberg, Benchmark*2023, Avicienne, UBS
COATINGS, COMPOSITES & BUILDING MATERIALS

Functionalising Graphene to make dispersable additives
FUNCTIONALISED GRAPHENE IN EPOXY RESIN

Positive initial test results of epoxy thermosets as coatings formulated using Talga’s graphene and dispersion technology

Successful first stage test-work completed on two-pack epoxy polymer resins for the large volume marine coating market

- 2x orders magnitude improvement in corrosion resistance compared to control epoxy top-coat and zinc-rich primer epoxy coatings
- 160% improvement in tensile strength
- 80% improvement in abrasion resistance

Patent lodged over Talga’s graphene enhanced epoxy formula and dispersion technology

Epoxy based coatings dominate steel protection for marine exposed infrastructure
FUNCTIONALISED POLYMERS FOR COMPOSITES

Stronger epoxy resins for carbon fibre composites in aerospace and automotive

Positive results in epoxy resin systems to make composites stronger, lighter and conductive (for lightning protection, de-icing or EM shielding)

Epoxy resins is used to make carbon fibre composites, a lightweight material widely used in aerospace, automotive and wind turbine sectors

Current market looking for less weight (for less fuel use in planes) plus conductivity (for lightning protection, de-icing or EM shielding)

Emerging markets in textiles, plastic and fibres for ‘wearable’ technologies & 3-D printing

Talga prototype tests are underway at TWI near Cambridge
GRAPHENE ENHANCED ADMIXTURES

High strength concrete using graphene enhanced admixtures

Graphene admixtures added to concrete **improves strength**

**Applications** include high rise buildings, roads and rail

**Urbanisation** and requirements for lower volume/lower emissions is driving demand

strengthens concrete at **low loadings** so can be lower in cost in some application

See ASX:TLG 11 May 2017

High strength concrete bridge, Sweden

Concrete graphene mix
GRAPHENE/GRAPHITE IN SCREEDS

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

Graphene added as nano-enhanced admixture to concrete enable electrical or thermal conductivity.

Applications: electricity distribution, underfloor heating, domestic geothermal wells, ice-free road-bridge-tarmac areas.

German government plans upgrades to >7,500 kilometres of high voltage electric power lines.

Thermally conductive concrete for cooling underground power lines.
CHEMICALLY COUPLED GRAPHENE DISPERSIONS IN METAL COATINGS

In ASTM-standard salt exposure tests Talga chemically coupled graphene dispersions in coating applications improves performance over chrome-containing reference.

Standard ASTM B117
After 1,500hrs accelerated corrosion (salt spray)

TALGA IS EMERGING AS AN INDUSTRIAL SCALE GRAPHENE PRODUCER

100% control of the biggest graphite resources in Europe where massive new demand for Li-ion batteries is located.

Unique ore type that provides higher performance via patent pending processing technology.

Graphene on track to take market share in future from currently used graphite types.

Significant in house technical capability with vertically integrated strategy capturing more of downstream market opportunity.

Formal collaboration agreements with major supply chain industries.

Positioned to profit from the shift to stronger, lighter, safer and more economic batteries that is now well underway.
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