Further gains from Talga high energy battery anode product

- **Ongoing optimisation of Talga's graphene silicon Li-ion battery anode product, Talnode™- Si, returns further performance gains**
- **Now delivers ~70% more energy density than commercial graphite-only anodes**
- **Provides a "drop in" solution for improving current Li-ion battery performance**
- **Commercial samples under confidentiality and material transfer agreements scheduled to commence delivery end of February - recipients include some of the world's largest electronic corporations**

Australian advanced materials technology company, Talga Resources Ltd ("**Talga**" or "**the Company**") (**ASX:TLG**), is pleased to announce further test results from its high energy graphene silicon lithium ion ("Li-ion") battery anode product Talnode™-Si.

Following initial test results (ASX:TLG Oct 2018) further optimisation of Talnode-Si, with up to 15% silicon loading, has been underway at Talga's battery material facility in the Maxwell Centre of Cambridge University, UK. Highlights of new half cell cycling test results include:

- ~70% higher reversible capacity (~600mAh/g) than commercial graphite (~350mAh/g)*
- Coulombic efficiency of 99.5% - 99.9% with first cycle efficiency ~ 91%
- Up to 94% reversible capacity (after >130 cycles in a range of silicon loadings)

Talga Managing Director, Mr Mark Thompson: *"The rapid development of our natural graphite anode products for Li-ion batteries have been extraordinary and the continued positive market response to products under development, Talnode-Si and Talnode-X, as well as our flagship product, Talnode-C, support plans for scaling up of Talnode products as part of our vertically integrated business strategy."*

Figure 1 *Scanning electron microscope image of Talnode-Si particles.*

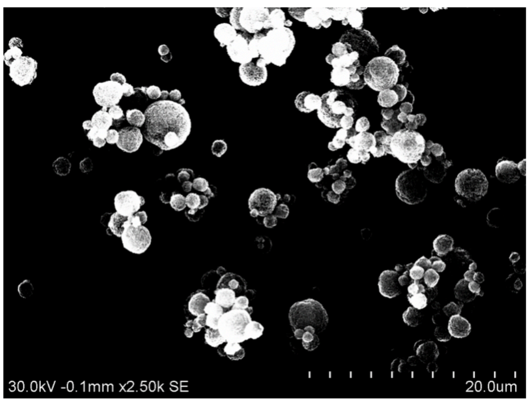
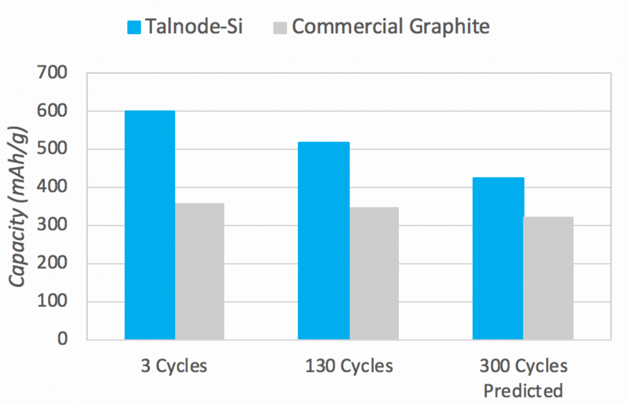


Figure 2 *Capacity tests of Talnode-Si versus commercial graphite reference.*



Moving Forward

Talnode-Si consists of a mixture of silicon and graphene particles engineered by Talga to be suitable for existing Li-ion battery manufacturing equipment as a high performance, cost-effective and scalable replacement for standard graphite anode materials. Commercial samples are being prepared, under confidentiality and material transfer agreements, with delivery commencing end of February 2019. Recipients include some of the world's largest electronics companies.

Development continues under the Safevolt project, a part of the £246 million UK-funded Faraday program, with Talga partners Johnson Matthey, Cambridge University and TWI. Based on the encouraging test results to date the Company has opted to progress to full cell testing and optimisation of Talnode-Si. Progress on the other Faraday projects, "Scale-up" and "Sodium" is continuing according to plan and updates will be provided as the programs proceed through their individual project stages.

About Talga

Talga Resources Ltd is an advanced materials technology company enabling stronger, lighter and more functional graphene and graphite enhanced products for the multi-billion dollar global battery, coatings, construction and composites markets. Talga has significant advantages in graphene production owing to its vertically integrated high grade Swedish graphite deposits and in-house process to product technology. Company website: www.talgaresources.com

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** After 3 cycles. See Figure 2 for details.*

Project Background

The Safevolt project (ASX: TLG 26 March 2018) is a UK Government funded Talga-led program run in conjunction with consortia partners Johnson Matthey, the University of Cambridge and manufacturing research group, TWI.

The project is an enabler for industry wanting higher Li-ion battery capacity above the level of standard graphite (exceeding theoretical maximum of 372mAh/g). In theory, a silicon anode is capable of providing approximately 10 times the gravimetric (or 3 times the volumetric energy) of the standard graphite anode Li-ion battery. However, silicon experiences drastic volume change during charge and discharge cycles, causing sharply shorter battery life and/or failure.

The project looks to three key solutions in solving silicon anode life issues: stabilising the silicon as it expands, maintaining conducting percolation and solid electrolyte interface control.

Market

In some commercial Li-ion batteries (for example: BTR, Panasonic, Hitachi, Maxell among others), small amounts (3% - 5%) of silicon are already added to the carbon anode to enhance cell energy.

Recently, several automotive manufacturers have stated their intent to move to higher energy-to-weight ratios in their next generation battery packs and other large groups in the anode supply chain have communicated the use of silicon technologies in graphite to produce silicon oxide-based graphite, for example:

- **Volkswagen** - Estimates that cell energy density will increase by 25% from 2018 to 2025 and are targeting 20% silicon anodes from 2020 (*Volkswagen Modular Electric Platform presentation, Dresden Germany, 17 Sep 2018*).
- **Hitachi** - Piloting a Si-graphite anode to form higher energy density batteries (*Hitachi presentation, AABC 2018, Osaka Japan*).
- **BTR** - The worlds largest anode manufacturer has a silicon-graphite anode in production and is looking to increase silicon loadings (*BTR presentation, Benchmark Minerals Graphite + Anodes 2018, Newport Beach USA*).
- **Samsung** - Has patented and begun marketing graphene coated silicon anode materials.

Ultimately, higher capacity batteries can benefit industry by extending device operating times (or range in an EV). Higher capacity can also lead to lower costs, as the increased energy density decreases the cost per unit of energy (kW/hr) for the total battery pack. This increased capacity is a critical metric for customers, and particularly China where lucrative new energy vehicle subsidies are tied to energy density.

China regulatory authorities stipulate higher capacity targets for automotive Li-ion batteries in its five year plan and features silicon anodes in its roadmap (*China Industrial Association of Power Sources presentation, Advanced Automotive Battery Conference 2018, Osaka Japan*).

TECHNICAL GLOSSARY

Anode	The negative electrode in a battery during discharge. In Li-ion batteries, it consists of graphite and other carbons coated on copper.
Aqueous anode formulation	A chemical formulation that contains graphite mixed in a water based solution which is suitable to be coated on copper and dried to leave a pure graphite based layer to form the Li-ion battery anode.
Battery capacity	The total battery capacity, usually expressed in mAh/g available to perform work. The actual capacity of a particular battery is determined by a number of factors, including the material properties, cut-off voltage, discharge rate, temperature, method of charge and the age and life history of the battery.
Battery efficiency	Refer to coulombic efficiency.
Battery module	An assembly of cells in series and parallel encased in a mechanical structure.
Capacity	Capacity represents specific energy in ampere hours (Ah) or mAh/g. Ah is the discharge current a battery can deliver over time.
Capacity fade/ ageing	Permanent loss of capacity with frequent use or the passage of time due to unwanted irreversible chemical reactions in the cell.
Cathode	Electrode that, in effect, oxidises the anode or absorbs the electrons. During discharge, the positive electrode of a voltaic cell is the cathode. When charging, that reverses and the negative electrode of the cell is the cathode.
Charge	The conversion of electric energy, provided in the form of a current, into chemical energy within the cell or battery.
Cell	A closed electrochemical power source. The minimum unit of a battery comprised of 4 key components including cathode, anode, electrolyte and separator. Li-ion battery cells come in three different shapes (design architecture) being prismatic, cylindrical or pouch.
C-rate	C-rate is a measure of the rate at which a battery is charged relative to its maximum capacity. A 1C rate means that the charge current will charge the entire battery in 1 hour (60 minutes), 0.2C means complete charging is made during 5 hours (60minutes/0.2 = 5 hours) and 5C means that complete charging was made in 12 minutes (60 minutes/5 = 12 minutes).
Coin cell	An electrochemical device, composed of positive and negative plates and electrolyte, which is capable of storing electrical energy. It is the basic "building block" of a battery in lab scale tests using circular half or full coin shaped cells.
Coulombic efficiency	The ratio (expressed as a percentage) between the energy removed from a battery during discharge compared with the energy used during charging to restore the original capacity.
Cycle	The discharge of a charged battery with subsequent recharge. The number of cycles a rechargeable battery can withstand before performance degrades is the accepted method of measurement for rating rechargeables' expected life.
Cylindrical cell	Components of a battery assembled inside a cylindrical metal container.
Discharge	The conversion of the chemical energy stored within a cell to electrical energy, and the subsequent withdrawal of this electrical energy into a load.

Few layer graphene (FLG)	Stack of graphene having a total thickness of 5 layers or less.
Graphene	A 1-10 atom thick layer of crystalline carbon, with superlative properties of strength, conductivity and transparency.
Graphene nanoplatelets (GNP)	Stack of graphene having a total thickness of 10-100 layers and properties of strength, conductivity and barrier properties that far exceed that of graphite.
Graphite	An allotrope of carbon in which carbon has sp2 hybridisation. Can be found as a natural mineral or can be synthesised using great pressure and temperature. Natural graphite consists of many stacked layers of graphene, approximately 3 million layers of graphene per millimetre of graphite.
Lithium	A soft, silvery-white metallic element of the alkali group, the lightest of all metals.
Lithium-ion (Li-ion)	Elemental lithium devoid of an electron having an oxidation state of +1.
Lithium-ion battery	Rechargeable battery where Li-ion shuttles between graphitic anode and cobalt, manganese, nickel and/or other metals in combinations as cathode.
mAh/g	Milliampere hours per gram – a unit for battery capacity/materials.
Milling	The process of breaking material into small fine parts by grinding following crushing, or machining/cutting material using rotating equipment.
NMC	A Li-ion cathode consisting of Nickel Manganese Cobalt Oxide.
Packaging efficiency	The efficiency with which the battery components (cells, electronic circuits, contacts etc.) can be packed in a given volume.
Percolation	The process of a liquid moving slowly through a porous substance.
Pouch cell	Battery cell packaged into a flat-shaped flexible, heat-sealable foil pouch.
Prismatic cell	A slim rectangular sealed battery cell in a metal or inflexible case. The positive and negative plates are stacked usually in a rectangular shape rather than rolled in a spiral as done in a cylindrical cell.
Rate capability	The rate capability specifies the speed a battery is charged or discharged.
Reversible capacity	The reversible capacity is the capacity that is available to the load after the electrode is formed.
Roll to roll fabrication	Continuous fabrication of battery cells using rolled sheets of battery components and coating them with the active materials as they roll onto a spool for subsequent cutting and packaging into cells.
Shaping/ Spheronising	The milling of graphite flakes into sub-15 micron sized spherical shaped particles to reduce size and surface area to suit formulations for Li-ion battery anodes.
Solid Electrolyte Interface	A solid electrolyte interface (SEI) is a layer formed on the graphite anode that can act as a barrier, obstructing interaction and resulting in increased internal resistance and capacity loss.
Specific energy	Specific energy, or gravimetric energy density, defines battery capacity in weight (Wh/kg); energy density, or volumetric energy density, reflects volume in litres (Wh/l). Products requiring long runtimes at moderate load are optimised for high specific energy; the ability to deliver high current loads can be ignored.