14 October 2020

Progress Made with Novel Supercapacitor Materials

HIGHLIGHTS

- **Testing confirms that metal oxide decorated graphenes have significantly higher capacitance per unit area than that of activated carbon materials used widely in industry today.**
- **Test work undertaken with WMG UK, a world leading battery test facility.**
- **Research and scale-up test work is continuing with oxide decorated graphene materials for supercapacitors.**
- **First Graphene has a worldwide exclusive licence to the technology, which is being optimised with PureGRAPH® materials.**

First Graphene Ltd. ("ASX: FGR" or "the Company"), is pleased to advise it has completed initial testing of their novel supercapacitor materials in collaboration with Warwick Manufacturing Group (WMG) a world leading battery test laboratory. Initial results show the materials perform well in supercapacitor cells. Further work is underway to improve cell performance.

Background – Batteries and Supercapacitors

Chemical batteries, such as those based on Li-ion technology, store large amounts of energy which can be discharged over many hours or miles. The energy is released by a chemical reaction which occurs between the anode and cathode. After many cycles the chemistry needs to be replenished and the battery replaced.

Supercapacitors, based on electrical double layer capacitance (EDLC), offer rapid charging and discharging giving a high-power density. These supercapacitors usually use activated carbon as a high surface-area charge storage medium. They do not depend on a chemical reaction as they work on charge separation within the device. This means that EDLC supercapacitors are stable and can typically withstand many charge / discharge cycles.

For electric vehicles (EVs), an ideal energy storage device combines a chemical battery (high energy density and hence long range) with a supercapacitor (rapid charge and discharge) to effectively manage periods where high power is needed for relatively short times, such as when starting and stopping. This will extend the battery life and ultimately extend the range of the vehicle[1].

Pseudocapacitor Energy Storage Systems

An ideal route to this combined system is through the use of pseudocapacitor technology, where charge storage occurs through the electrical double layer capacitance mechanism and very rapid redox reactions between the ions in the electrolyte and the active materials on the electrode surface. Pseudocapacitance can increase the performance of a supercapacitor by an order of magnitude.

Research Being Undertaken by First Graphene

At the University of Manchester, a novel route to manufacturing materials which are suitable for pseudocapacitors has been identified. The manufacturing process has been progressed by First Graphene Ltd, who have successfully taken the concept from the laboratory scale to an operational environment in a very short time, representing a scale up from a Technology Readiness Level (TRL) of 3 (experimental proof of concept) to TRL6 (technology demonstrated in relevant environment).

The ideal pseudocapacitor material is a hybrid, consisting of an electrochemically active metal oxide such as manganese (IV) oxide supported on a porous, electrically conductive scaffold such as graphene. This combines the benefits of the high theoretical specific capacitance, wide potential range and high electrochemical activity of manganese (IV) oxide with the good electrical conductivity and versatility of graphene.[2]

First Graphene Ltd have successfully demonstrated that this material can be manufactured at scale via a proprietary electrochemical process. Figure 1 shows high surface area manganese oxide "rosettes" grown onto the surface of a PureGRAPH® platelet. The process is extremely flexible and can be used for deposition of any single or mixed transition metal oxides. This opens other applications, such as electrocatalysts for water-splitting cells used in the production of hydrogen gas.

[1] Applications of Supercapacitors in Electric and Hybrid Vehicles – Research Report UCD-ITS-RR-15-09
[2] Wu D, Xie X, Zhang Y, Zhang D, Du W, Zhang X and Wang B (2020) MnO2/Carbon Composites for Supercapacitor: Synthesis and Electrochemical Performance. Front. Mater. 7:2. doi: 10.3389/fmats.2020.00002

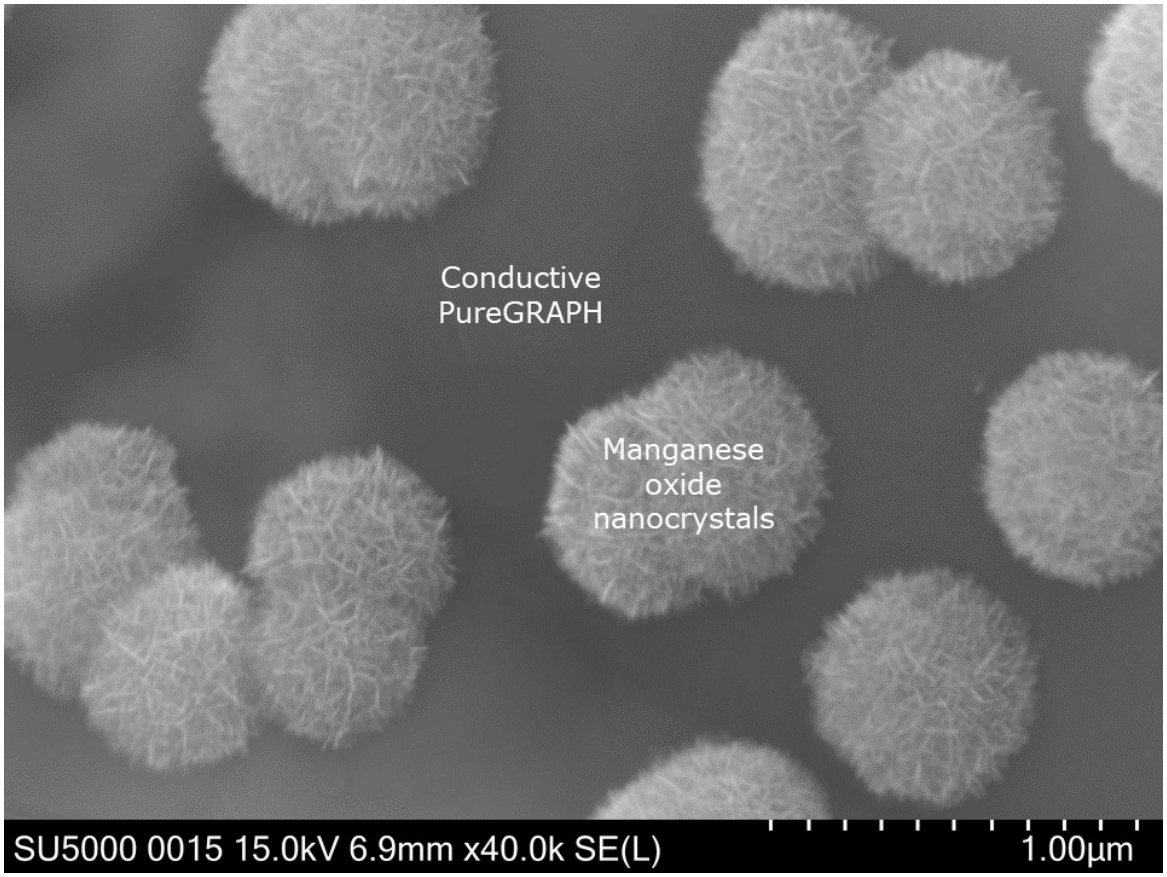

Fig. 1 Manganese (IV) oxide nanostructures grown directly onto a graphene scaffold.

Unlike competitor materials, which are often simple mixtures, these materials are unique – having a nano-scale active metal oxide grown directly and intimately onto a conductive carbon scaffold. The company recognises this unique material requires a novel cell design to optimise performance and continues to work with the University of Manchester on the materials chemistry and with WMG at the University of Warwick with regard to processing the materials into test cells and evaluating the electrochemical performance.

In initial studies, a cell architecture has been devised using the novel metal oxide decorated graphene and standard ancillary materials – binder, separator and electrolyte. The cells have been shown to perform well as supercapacitors easily matching the performance of industry leading activated carbons. Of particular note is the capacitance per unit area of the metal oxide decorated graphene which at 1.0 Farad/m^2 is significantly higher than activated carbon at 0.02 Farad/m^2. This indicates the manganese dioxide sample exhibits pseudocapacitive behaviour and is not solely reliant on double layer capacitance.

Working closely with the WMG and the University of Manchester, the Company has identified further improvements which will be required in the assembly of supercapacitor cells for these novel materials. The next phase of development will focus upon optimisation of electrolyte and cell lifetime improvements.

Craig McGuckin, Managing Director of First Graphene Ltd. says "*We have made good progress in developing these unique materials by scaling manufacture and demonstrating high surface capacitance. Further work is required. We look forward to developing an optimised cell with our research partners.*"

Mark Copley, Associate Professor of WMG says "*The metal oxide decorated graphenes are an exciting class of materials for use in supercapacitors. I look forward to continued collaboration with First Graphene to help them realize their energy storage application ambitions*".

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About First Graphene Ltd (ASX: FGR)

First Graphene Ltd. is the leading supplier of high-performing, graphene products. The company has a robust manufacturing platform based upon captive supply of high-purity raw materials and an established 100 tonne/year graphene production capacity. Commercial applications are now being progressed in composites, elastomers, fire retardancy, construction and energy storage.

First Graphene Ltd. is publicly listed in Australia (ASX:FGR) and has a primary manufacturing base in Henderson, near Perth, WA. The company is incorporated in the UK as First Graphene (UK) Ltd. and is a Tier 1 partner at the Graphene Engineering and Innovation Centre (GEIC), Manchester, UK.

PureGRAPH® Range of Products

PureGRAPH® *graphene powders are available in tonnage volumes with lateral platelet sizes of 20µm, 10µm and 5µm. The products are high performing additives, characterised by their high quality and ease of use.*

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With authority of the board, this announcement has been authorised for release, by Peter R. Youd Director, Chief Financial Officer and Company Secretary.