

THE MAGAZINE FOR 2D MATERIALS

GRAPHENE

November 2021

Issue #27

GRAPHENE IN COATINGS

Latest market and company developments in graphene for coatings and end user markets.

GRAPHENE PRODUCTS

All the latest graphene and 2d materials product news.

GRAPHENE INVESTMENT NEWS

Latest graphene investments, commercial agreements and rounds of finance.

LATEST NEWS

Market focus on what's happening in graphene research, composites, batteries, filtration, funding and finance.



Graphene Magazine is published by Future Markets, the world's leading publisher of market information on advanced materials and nanotechnology.

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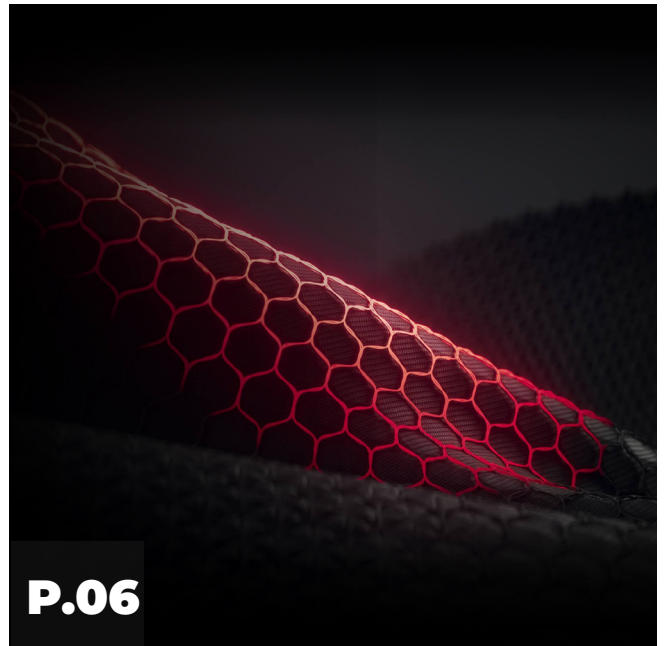
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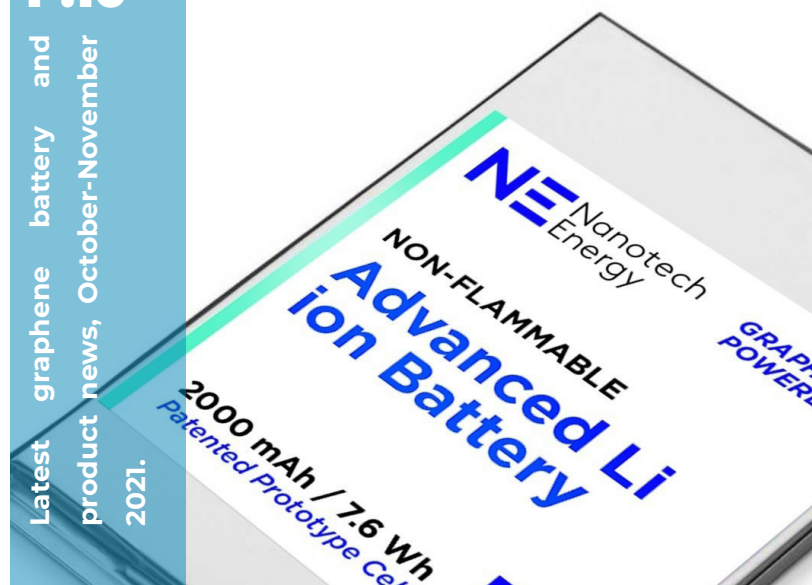


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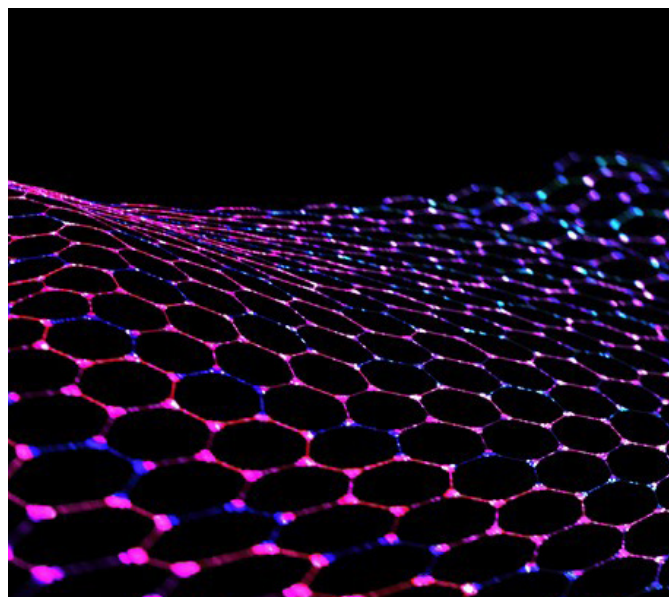
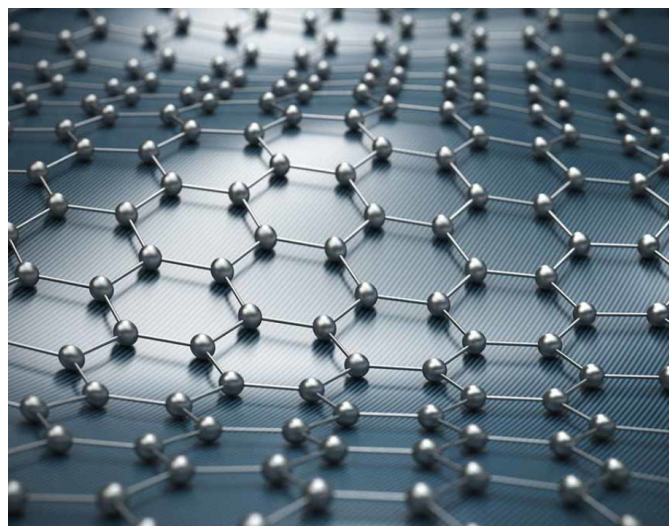
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& Business Finance

Latest graphene investments, commercial agreements
and rounds of finance. October-November 2021

Zentek (formerly called Zen Graphene Solutions) has entered into an agreement to raise CAD\$20 million (around USD\$15,928,000). In addition, the Company intends to complete a concurrent non-brokered private placement for gross proceeds of approximately CAD\$12.5 million (around USD\$9,954,000). The net proceeds from the Offerings will be used for capital expenses, research and development, acceleration of business growth opportunities and working capital. Closing of the Offerings is expected to occur on or about December 8, 2021 and is subject to regulatory approval, including that of the TSX Venture Exchange. The company has also been selected as one of three technologies for phase 1 of the Innovation Solutions Canada (ISC) challenge to develop a portable detection device for SARS-CoV-2 in wastewater. ZEN has received a \$148,000 award from ISC to develop its first prototype.

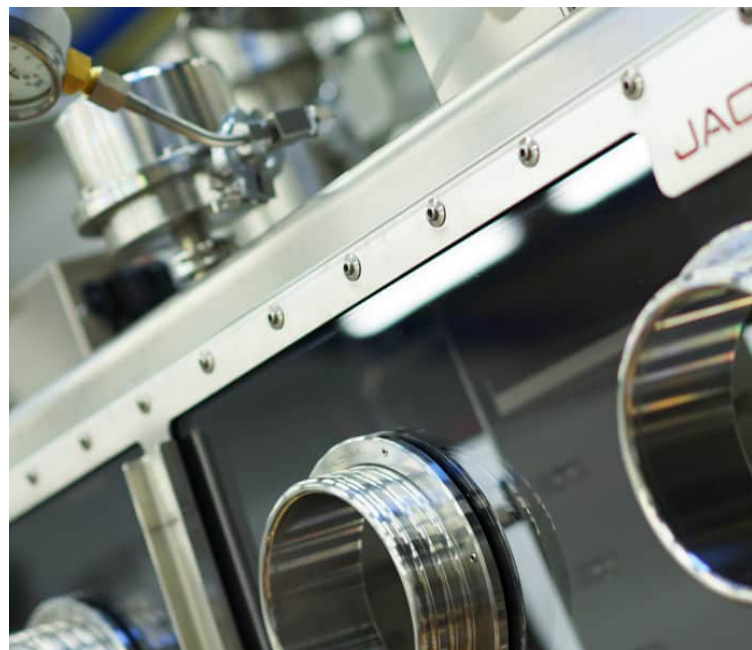


Johns Hopkins and **Morgan State University** have received a five-year, \$7.5 million grant from the U.S. Department of Defense, to create the Center for Advanced Electro-Photonics with 2D Materials to develop two-dimensional materials for use by DoD. The joint research effort will target three specific areas of 2D materials technology: wearable photovoltaics and thermally managed photosensors augmented by plasmonic nanostructures; hybrid photovoltaics—thermoelectric technologies for the use of individual warfighters; and interrogation of quantum defects with light and quantized photogalvanic effects.

First Graphene Limited has secured a funded development project to look into the feasibility of enhancing long rubber gloves, or gauntlets, used in the nuclear decommissioning industry. The project, conducted through Sellafield's Game Changers Programme which connects innovative solutions to complex nuclear industry challenges, aims to develop needlestick and puncture-resistant rubber gauntlets for operators who are using decommissioning gloveboxes at the United Kingdom's Sellafield Nuclear Site. The gloveboxes can contain hidden

sharp objects, such as cropped cables, pipework or needlesticks, that could tear or puncture gauntlets and thus expose handlers to harmful radiation. The objective is to develop gauntlets that will keep the operator's hands safe without significantly reducing dexterity or increasing the weight or load. Following a competitive tendering process, First Graphene's proposal to investigate the feasibility of using the Company's PureGRAPH® graphene technology was selected. Initial development work conducted by First Graphene's Research and Development team has shown that the addition of PureGRAPH® in certain rubber systems can increase tear strength and puncture resistance.

A £9 million project to develop new chemical processing technology that could save hundreds of millions of tonnes of carbon dioxide (CO₂) emissions has commenced at UK Universities including The University of Manchester. The SynHiSel programme has received a total of £9m in funding, from the Engineering and Physical Sciences Research Council, part of UK Research and Innovation, and from industrial and University partners. The project, will investigate how to develop more efficient ways of separating chemicals. As part of the project, the **University of Manchester** will develop graphene-based membranes.



GRAPHENE

PRODUCT

NEWS

October-November 2021

Low-cost, high volume production and ease of integration is crucial for the development of widespread application of graphene-enabled products. This month we look at recent developments and breakthroughs.

LAB TO PRODUCT

California-based company **Lyten** has developed a graphene-enhanced lithium-sulfur battery for electric vehicles. The battery reportedly achieved a higher gravimetric energy density than traditional lithium-ion and solid-state technologies. Lyten is said to have has previous collaborations with the US government for military projects. The product is named LytCell EV and was designed to deliver three times the energy density of conventional lithium-ion batteries. The company reported 900 Wh/kg, precisely three times as much as the batteries in circulation today. Lyten Sulfur Caging is the name of the technology used in LytCell batteries to unlock the performance potential of sulfur by halting the advance of polysulfide, a cycle-life compromising factor that has so far prevented the practical use of Li-S in electric vehicles battery powered. Based on testing, a LytCell prototype reportedly proved to withstand more than 1,400 cycles very well. Further information at <https://lyten.com/>

First Graphene (FGR) has signed a collaboration agreement with Malaysia-based DSP, a manufacturer of high density polyethylene (HDPE) sheet extrusions. The collaboration will focus on the development of PureGRAPH-enhanced HDPE sheet and welding wire, providing an increase in durability and abrasion resistance. HDPE can be used as an alternative fabrication material in a number of applications and provides benefits such as high impact resistance, corrosion resistance, anti-fouling properties and reduced carbon footprint. The initial collaboration agreement is for one year and has the ability to extend further at the end of the term. Further



information at <https://firstgraphene.net/> dical and dental applications. In addition US-based CVD graphene developer **General Graphene Corporation (GGC)** has launched its new Gen3.0 CVD graphene production line. This 20-meters long roll-to-roll based system can produce single- and multi-layer graphene materials on copper films up to 400 mm wide. GGC says that with the new line, its manufacturing capacity exceeds 100,000 m²/year. The company is now able to supply affordable and highly consistent CVD graphene in industrial



volumes.

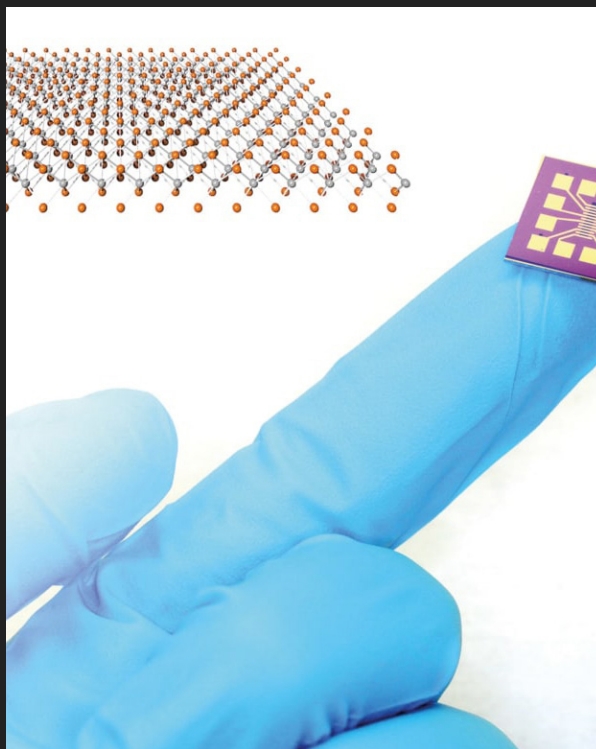
NeoGraf Solutions has extended its range of next-generation graphite materials with the launch of Graf-X™ graphene nanoplatelets (GNP) and graphene precursors (GP). Both high-performance additive materials deliver enhanced strength, performance, and reliability in a broad range of thermoset and thermoplastic applications. NeoGraf is a fully integrated graphene product supplier with a GNP capacity of more than 750 metric tons and a GP capacity of approximately 1300 metric tons at their facility in Lakewood, Ohio.

Japanese trading house **Sojitz Corp.** has acquired an equity stake in **2D Materials Pte. Ltd.** The company was spun out from the National University of Singapore's Centre for Advanced 2D Materials. This proprietary production process is a clean manufacturing process and produces high-quality graphene at a high yield. 2DM not only offers high quality graphene in the powder form, but it also supplies graphene in various formats such as masterbatches and suspensions

GRAPHENE SENSOR

Paragraf has developed a new sensor range capable, it claims, of unmatched sensitivity and linearity when placed in low temperature environments and in strong magnetic fields.

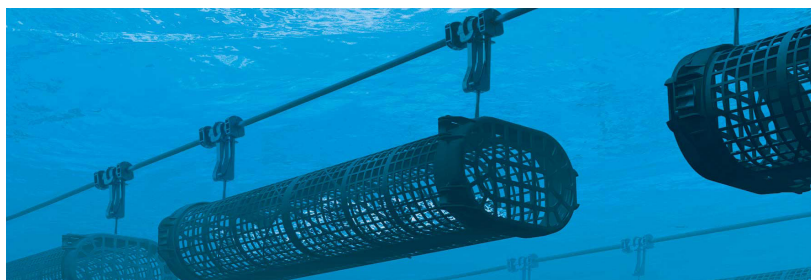
Tested at the High Field Magnetic Laboratory (HFML) at Radboud University Nijmegen, the GHS-C sensors support operation in magnetic fields up to 30 T and at cryogenic temperatures (down to 1.5 K). The sensors deliver a degree of accuracy that has not previously been achievable under these conditions, sustaining non-linearity errors of significantly less than 1% across the full measurement range. The transformative magnetic field measurement capabilities of the GHS-C devices are due to the graphene sensor elements. Graphene's inherent high electron mobility directly translates into high sensitivity capability, which is maintained across the entire magnetic field range – making these devices far simpler to calibrate.



based on clients' process requirements. <https://2dmsolutions.com/>
Clean TeQ Water is currently working on a new graphene membrane technology that promises to remove micropollutants at substantially reduced energy cost and with less brine production. The company recently demerged from parent company Sunrise Energy Metals to focus on further commercialization and growth of its broad portfolio of new water treatment technologies. The company's results from its first official quarter were solid, with cash receipts of A\$1.6 million, a 38% improvement compared to the previous quarter as a subsidiary. In early 2019, **Elecjet** ran a successful Kickstarter campaign for its graphene-enhanced USB-C / A fast charging power bank. The company is now launching the Elecjet Apollo Ultra - a 37Wh (10,000mAh) power bank that can be charged at 100W, and can output at up to 87W across its two ports. The product has received excellent reviews for the speed of charging (<https://www.pcworld.com/article/551531/this-usb-c-power-bank-charges-insanely-fast>.



GRAPHENE OYSTER BASKETS



In collaboration with **Hexcyl Systems**, a leading supplier of systems for oceanic farming, **First Graphene Ltd.** has developed graphene-filled high-density polyethylene (HDPE) materials for making super-strong HDPE oyster baskets for long-line farming systems. Using First Graphene's PureGRAPH products, HDPE showed improvements in strength, wear resistance and longevity. The initial results confirm the potential of graphene as a high performing additive for HDPE. "A low dosage of less than one per cent of PureGRAPH has generated an increase in yield strength of more than 60 per cent, when compared to the base HDPE product," said Craig McGuckin, Managing Director, First Graphene. "Samples showed a more than 10 per cent increase in ultimate tensile strength and at the same concentration, abrasion loss was reduced by more than 50 per cent."

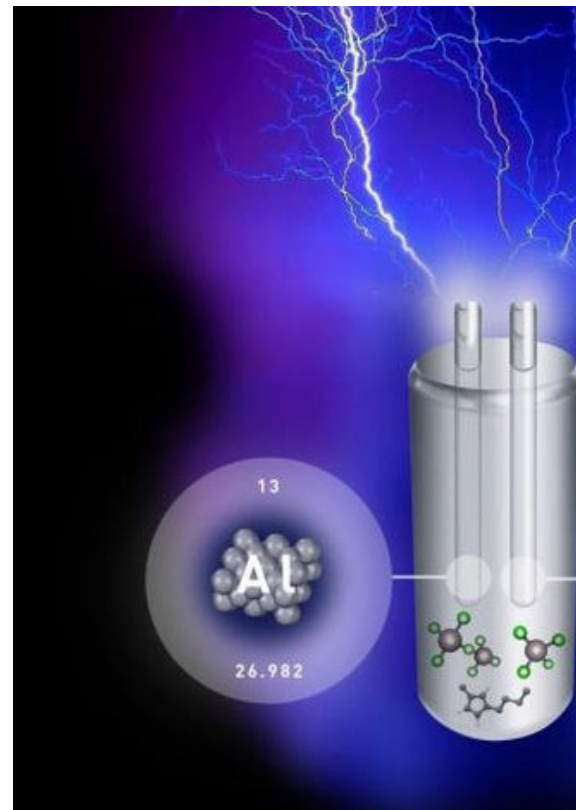


BARE has made commercially available the Women's Evoke Wetsuit incorporating graphene. According to the company "The Evoke leverages heat-capturing Graphene Technology to provide enhanced thermal insulation and equalized heat distribution to your entire body." By strategically weaving graphene into the core area of the suit, the warmth generated by the body moves from warm areas of the lining to cooler areas for added reflective properties. The new Evoke is available in 3mm, 5mm and 7mm thicknesses, and ranges in price from US\$384.95/~€337 to \$599.95/~€516. www.baresports.com

GRAPHENE BATTERY NEWS



Graphene battery traditional battery designs, c o m p a n y including higher capacity and **Nanotech Energy** faster recharging capability, is building a according to Kavanaugh. The new manufacturing facility in new campus is anticipated to Nevada. The Nanotech Energy bring more than 1,000 jobs to campus will span more than 1 the region over the next five million square feet and include years, including a significant multiple buildings. The Northern number of engineering and Nevada facility is part of the research positions. The first company's plans to expand building is slated to open in Q4 operations on a massive scale, 2022. The high-volume facility will including globally, said Nanotech significantly increase Nanotech Energy CEO and co-founder Energy's manufacturing capacity Jack Kavanaugh. Nanotech is to produce and scale its patented, currently based in Los Angeles non-flammable Graphene-facility in Northern California. Organolyte™ batteries and other graphene-powered products, Nanotech's graphene technology including EMI (electromagnetic holds several advantages over interference) shielding,



Graphene

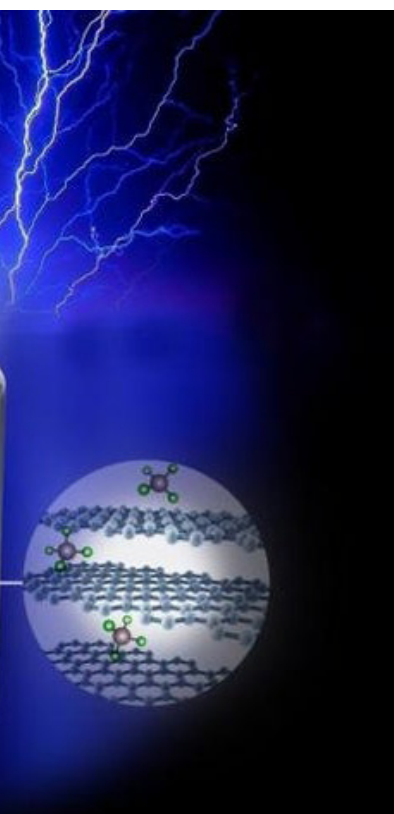
transparent conducting electrodes, conductive inks, conductive adhesives and silver nanowires. Nanotech Energy recently announced \$64 million Series D funding at a \$550 million post-Series D valuation. The Series D funding led by Taiwan's largest financial services company, Fubon Financial Holding Co, and brought the total amount of funding raised to date by Nanotech Energy to \$94.9 million. Further information at <https://www.nanotechenergy.com/>

NEO Battery Materials Ltd. intends to implement graphene as a conductive additive

when manufacturing the silicon anode materials and as a potential candidate as a nanocoating layer to enhance cycling durability. The conductive additive improves the electrical conductivity of the active material (i.e., silicon and/or graphite) and is an essential component along with the binder and active material to fabricate the end-product anode. The Company intends to become a silicon anode active materials supplier to the electric vehicle industry. Further information at <https://www.neobatterymaterials.com/>.

GRAPHENE PILOT PLANT

Graphene Manufacturing Group Ltd. has commenced construction on a pilot production and testing plant for GMG's graphene aluminium-ion batteries. The Company has committed additional expenditures to allow the Pilot Battery Plant to produce pouch pack cell format batteries in addition to the previously announced coin cell format. This addition to the facility is intended to potentially accelerate the development of G+Al Battery pouch packs and allow early collaboration with some of GMG's major customer prospects and their specific requirements. Pouch pack cells are typically used in personal electronics such as cell phones, laptops, as well as in electric vehicles and grid storage batteries. Pilot production of a prototype coin cell battery is targeted before the end of 2021 and a pouch pack commercial prototype battery is targeted before the end of 2022. Subject to successful commercial prototypes and a final investment decision, GMG expects to construct an initial commercial coin cell G+Al Battery manufacturing facility, followed by first production and sales of G+Al Batteries. Further information at <https://graphenemg.com/>



GRAPHENE COATINGS NEWS



University of Manchester spin-out SmartIR is developing technology that will enable satellites to regulate their temperature. Its graphene-based smart coating for satellites will enable them to manage thermal energy in real-time, depending

on whether a satellite's surface is Earth's shadow or on the side closest to the sun. SmartIR is the latest company to join the European Space Agency Business Incubation Centre United Kingdom (ESA BIC UK) at the Science and Technology Facilities Council's (STFC) Daresbury Laboratory. Professor Coskun Kocabas, SmartIR's Scientific Director and co-founder, said "Applying graphene technology to space industry is a fantastic opportunity to take the capabilities of current thermal management systems to a new level, whilst significantly reducing satellite power consumption and cost."

Sparc Technologies Limited has entered a joint venture (JV) agreement with its strategic partner and cornerstone shareholder, the **University of Adelaide**, to jointly progress a project that will deliver a process with the aim of producing commercially viable ultra-green



Graphene oxide based coatings are being used in water filtration membranes in Asia.

hydrogen (UGH). The Project will seek to further develop a process known as Thermo-Photocatalysis, which employs the sun's radiation and thermal properties to convert water into hydrogen and oxygen. Adopting this process to produce ultra-green hydrogen means that renewable energy from wind farms, and/or photovoltaic solar panels, does not need to be exploited for hydrogen production, nor does the process of electrolysis need to be employed. Sparc will seek to develop graphene coatings to be used in conjunction with photocatalysts.

Graphene oxide membrane coatings company **G2O Water Technologies** has been selected for the 3rd cohort of the water innovation accelerator Imagine H2O Asia. Since 2009, over 150 startups have secured over \$600 million in investment capital and received over \$1M in grants directly from Imagine H2O to fund pilot projects.

GRAPHENE ICING



Zentek Ltd. has developed a new, patent-pending, carbon-based, nanotechnology-enhanced coating designed to prevent ice accretion. During the testing process with a 3rd party lab, various coatings were tested for adhesion strength as measured by pressure in kilopascals (kPa) required to dislodge ice from the surface. ZEN's coating demonstrated an adhesion strength consistently around 20 kPa, a significant improvement over the current commercial products. ZEN's preliminary results have demonstrated a 96% improvement over aluminum and 80% improvement over the 100 kPa threshold. This winter, ZEN's coating will be included in flight testing on a specially equipped

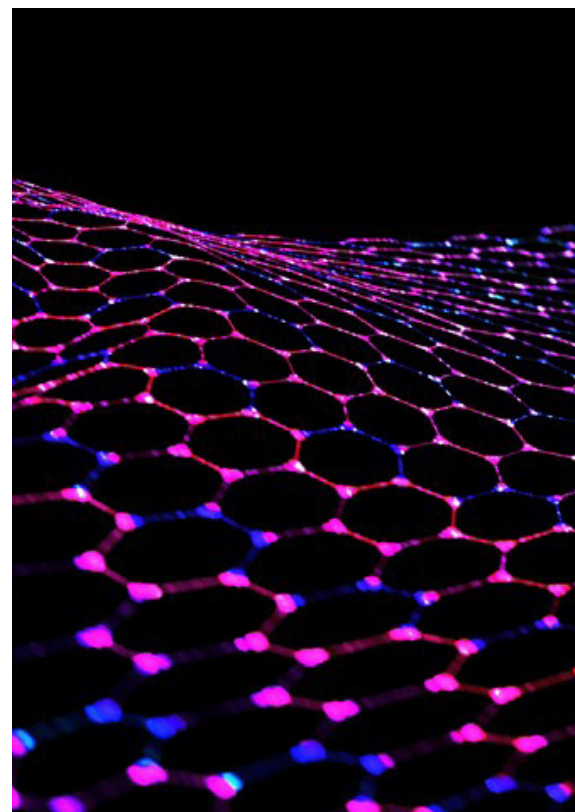
research aircraft under real world ice-forming weather conditions by this same 3rd party. ZEN will also test the feasibility of this coating as an effective passive means to de-ice drone propellers in flight to permit all-weather operations. If successful, this would permit safer drone operations in substantially more challenging weather conditions. On August 9, 2021, ZEN filed a provisional patent on this technology with the United States Patent and Trademark Office. The Company has begun to explore partnership opportunities,

GRAPHENE TEXTILES NEWS



Versarien has improved performance and announced a extended product lifespan, with commercial lower environmental impact collaboration in their creation, while at the agreement with DKH Retail Limited, the worldwide wholesale distribution subsidiary of fashion brand Superdry, to produce graphene-enhanced clothes. Through the partnership, Superdry will pioneer the production of graphene-enhanced garments, using Versarien's GRAPHENE-WEAR™ technology, with a view to importing graphene's thermal and moisture management properties into its garments. Superdry believes that using Versarien's graphene technology will result in product lines with

American footwear and clothing manufacturer **Reebok** has launched the Thermowarm+Graphene apparel collection. The collection includes a cotton fleece hoodie, pants and zip-up jacket. Reebok's strategically placed Thermowarm+Graphene internal grid print zone technology helps retain between 8 per cent



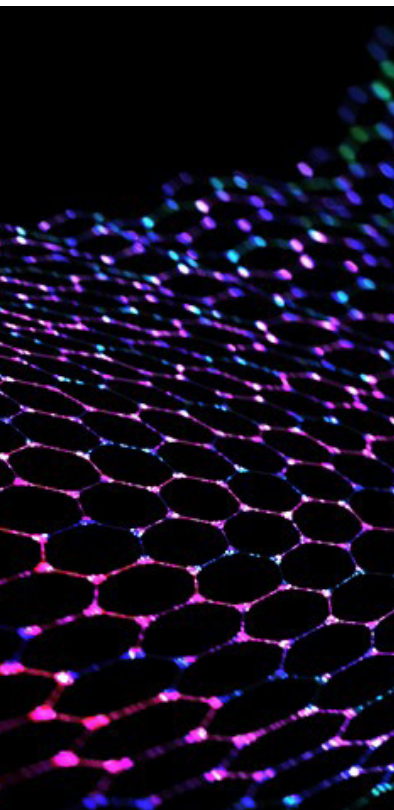
Graphene is being increasingly utilized in hard wearing outdoor shoes and heated textiles.

and 15 per cent more heat than unprinted zones, depending on the base fabric. The graphene-infused technology is integrated in over a dozen silhouettes ranging from performance running leggings to outerwear jackets, offering consumers an assortment that fits into a variety of athletic lifestyles. All collection offerings feature a strategically placed Thermowarm+Graphene grid print in the most pivotal heat retention zones where it would most benefit consumers – in garment hoods, shoulder panels and upper leg panels. Further information at <https://www.reebok.co.uk/outerwear->

thermowarm-plusgraphene-hybrid-jacket/GU5752.html

Directa Plus PLCs graphene nanoplatelets are being used in a newly-launched high-tech range of trail shoes. A specially developed graphene membrane is integrated into the lining of the norda 001 G+ Spike high-performance trail shoes, which are now available for consumer purchase. The company is responsible for the G+ membrane that is integrated into the Dyneema one-piece woven upper lining in the toe box of the shoes.

HEATED TEXTILES



GRAFREN AB has developed G-HEATEX™: the world first active heating fabric. G-HEATEX™ is graphene coated textile, which supplies powerful and uniform heat – being still soft, flexible, breathable and ultralightweight. Patented technology is based on ink, containing only graphene and water. G-HEATEX™ textile heaters are also available as a standard or custom products. Grafren AB has recently patented two innovations, which are now covering its full production cycle. The company now has the technology for separating high-quality graphene flakes from any grade of incoming material. The access to the high-quality

graphene will enable the company to work on graphene textiles. “We invented the method to incorporate [the] smallest flakes of graphene inside of the fabric on the nanoscale level,” says Grafren’s Technical Director, Dr. Mike Zhyback. Graphene nanoparticles — or flakes — are entirely impregnated inside the fabric and coating layer by layer in every individual textile fiber. Because of the high electrical conductivity of graphene, attached flakes create a “conductive skin” on every fiber, which makes the entire fabric electrically active. <https://grafren.se/>