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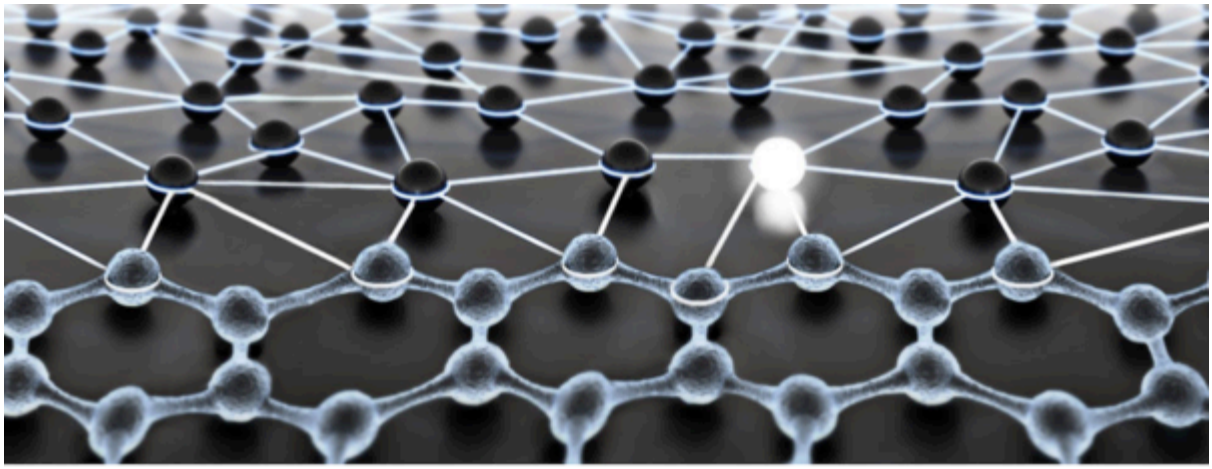
5th HVM New Materials & Graphene Conference & Showcase Cambridge

6-7 November 2019



HVM NEW MATERIALS 2019
6-7 NOVEMBER #HVMGNM19 CAMBRIDGE
5th HVM New Materials Conference, Showcase & Technology Briefing Day www.cir-strategy.com/events

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Day 1

Session 1

Ferrari

- Placing Graphene on the hype-cycle curve using example of magnetic storage, evolution of carbon coated data storage discs
- Trade-off between thinness of deposited graphene layer (higher readability by head media) and thermal vulnerability (data loss within 1 year likely at 1 layer of graphene coating)
- Cambridge working on dynamic solution (HAMR), periodically changing between heated state (warm + soft = easy data reading) and cooling (cool + hard = reliable data storage capacity)
- mechanical proof of concept and proof of resilience well advanced; graphene can withstand laser treatments inherent in HAMR and at 2 layer thickness can also cover any substrate wrinkles (which could leave to deposition irregularities sand/or bare patches at 1 layer)
- Business case for graphene: no point in replicating what existing technology already does quite well, graphene needs to spawn its own innovative applications
- Main challenge: how to get form lab (where you can now make any graphene-related gadget you dream up) to real-world fabrication and use at scale.

Koziol

- Innovation in transport sector (especially aviation) driven by expectation of what smart materials ought to deliver: safety, low maintenance, autonomy
- Goals are self-awareness, data harvest, self-repair capabilities. Example: even very recent Airbus 350 requires anti-lightning-strike 'old fashioned' copper layer in its fuselage; can composite aircraft skins be lightweight, flame retardant, self-healing?
- electrification big driver of innovation in chassis/body engineering in aviation, automotive
- Teaser: can natural fibres be smart? Aircraft skin design 75% hemp-based supposed to mimic Kevlar properties

Iqbal

- Overview of patent landscape attached to several commodities (graphene, gallium nitride, hexagonol boron nitride…)
- Globally China now files vast majority of patent applications - question came up in Q&A to which extent this is and indicator of actual commercial activity? to what extent patent application = market share?
- EU: UK,D,F the big 3

Price

- Supporting proliferation of smart devices by
- in praise of digital identity for consumer good; examples: intelligent labels allow shifting of close-to-sell-by-date, stock management of medication re expiry date, gathering consumer data

- RFIDs implemented in men's' suits at M&S, fully autonomous checkout in retail in Japan
- 'Changing the mantra' - in SI, small is better, in flexible RFIDs, simple is better
- Pragmatic Ic's miniaturised clean room, 'fab in a box' allows modular, mobile near-shore manufacture of smart labels.

Session 2

Fox

- Capitalism good circular economy mechanism - if there was money to be made from waste plastic, it would be used; now largely ending up as dead end, landfill
- Lead battery market - most polluting industry simultaneously the most intensely recycled industry; more than 40 mill t of lead batteries in circulation
- Aurelius approach: accept demand for continues recycling, reduce detrimental ecological side effects of recycling and achieve superior economics
- Claim: we achieve 85% reduction in carbon footprint
- What does 2nd generation recycled material look like? Performance must equal that of virgin material (actually superior performance for lead acid battery recycled by Aurelius method, emerges as nano-structured lead)
- New principle: move away from pyrolising waste for energy, instead try and preserve molecular complexity in waste.

Morris

- Regulatory landscape around energy storage, lit review
- 50MW cut-off above which permission of ownership neds to be obtained from Gov (under national infrastructure remit)
- storage valuable source of electricity re flexibility - me by inflexible rules and regulations
- Encouraging EV uptake: lack of charging points major barrier to progress; grants for domestic charge points available, but public infrastructure nowhere near supporting EV large scale
- EnergyREV-UK looking to customise advice to budding entrepreneurs in EV through an online platform…somehow.

Wilding

- High volatility the new normal - commodity prices, energy prices, exchange rates…
- Small footprint manufacturing (3Dprinting) leads to more near-shoring
- Risk to upstream supply chain absolutely needs to be considered at product design stage - possible back-up materials (steel vs aluminium), agility, transparency (where is material right now, continuous monitoring of location and performance)
- Macro data like weather, seismic events etc. are being factored into supply management of materials needed
- Downstream supply chains: different strategies in different geo settings; Africa may be around affordability in consumer goods, in Eu it may be marketing and brand management
- Supply chain management revolves around relationship management

- EV supply chain circles the world---map of key resources globally - risk profiles of supply chains influenced by LIC politics (DR Congo, cobalt trade), availability (trade conflicts)

Spittle

- Space tec for lithium extraction, remote sensing
- Catapult = 9 organisations set up to drive tech innovation close to clusters of excellence
- commodisation of electronics led to cheaper, smaller satellites …constellation of satellites, droves cost of data down…publicly available data from taxpayer-funded projects
- remote sensing potentially opens up new source locations for sought-after minerals
- Role of satellites in mining life cycles: Prospecting, water supply, planning, environmental impact management
- Lithium prospecting by satellite imaging: chlorophyll one useful indicator measurements for underground lithium deposits
- 2020 satellite tech rollout into Bolivia - 'foot in the door' but also chance to get in early on planning for environmental and economic impact (don't ruin income stream from tourism around large scenic brine lakes…)

Agnew

- How does innovation work in a large global company? Cross fertilisation key; "Often people have solved your problems in another market"
- Low orbit satellites at ca 1000km above earth in polar sun-synchronous orbits (solar panels always facing the sun)
- Airbus invested in a satellite in geospatial orbit to act as download intermediary
- Formula 1 design philosophy: constant adjustment to car data as they come in (beavering away in between races, 14 day gap) so that by and of season car is 85% redesigned.
- "Iteration to Success" - Airbus obtains innovative concepts in 3 steps: NDA - pay for a sample (removes 90% of hype merchants) - xyz (?) - …
- Airbus owns a unique satellite-like glider (?) that can go into stratosphere; acts as a space-approximating test platform.

Session 3

Schultz

Digital Twins: dynamic VR entity that equates to physical entity, process or organisation; not necessarily a 3D model
----nothing new beyond spring conference presentation? ----

Hancox

- Computing algorithms now reliably at superhuman performance levels
- Deep learning now penetrating many industries …. cancer cell detection, real time translation, pedestrian detection for autonomous cars, video surveillance, diabetic grading…. simulating and predicting
- simulation no longer requires lots of extraneous expertise
- 'big bang of modern AI'

Gompes

- briefing on emerging complexity of cybersecurity threats; 'legacy security is constantly outpaced'
- traditional cybersecurity is based on known evil, identifiable threat that has occurred before - what do you do in a zero day situation?
- famous example of fake € transition order by German energy firm, 1st example of convincing voice print fake to syphon of money; fake emails purporting to be internal Darktrace mail
- Immune system analogy, Darktrace flags pattern mismatches, based on understanding of client's 'system', constantly adapts as system evolve through new projects, contacts, processes
- Case study 1: 5 NHS trusts deploy Darktrace defence, 100% record of being ransom-attack free
- Case Study 2: unusual interaction with a sub-package of software protecting a biomed facility, not detected by conventional malware defences.

Handley

- if AL and machine learning so flawless, how can meltdowns and fatal accidents still happen?
- Stochastic vs deterministic - former accepts some level of randomness; latter takes nil variability of output for granted
- ML always gives us an answer, but not always the correct one…

Day 1
Session 1

Developments in Graphenes

Prof. Andrea Ferrari, Director, Cambridge Graphene Centre

- ✓ IBM's memory of the hard disk drive (HDD) – developed in 1956, weighed over a ton, 5MB data memory (IBM350), without carbon over coat
- ✓ Today - memory increased to 10Tb/in^2 with carbon over coat
- ✓ Thinner carbon over coat achieved from 7-9nm in 1998 to 2.5-3 nm in 2016
- ✓ Thinner the carbon coating higher the storage
- ✓ Optimum thickness - <2 nm
- ✓ Friction, wear, corrosion, and thermal stability - important.
- ✓ Carbon over coat <2nm – damaged protective properties of carbon over coat
- ✓ 2-4 layers of graphene - reduction in friction and provide better corrosion and wear than carbon over coat
- ✓ Production of graphite from SiC by Acheson in 1896 for lubricant applications
- ✓ Cost-effective, large scale graphene with AIXTRON and Neutron systems.
- ✓ AIXTRON - large-scale production of graphene through chemical vapour deposition (CVD)
- ✓ Neutron - a roll-to-roll system capable of depositing large areas of graphene on metal foils under ambient conditions

Innovation in Functional and 2D Advanced Materials

Prof. Krzysztof Koziol, Cranfield University

- ✓ Challenges in aircraft manufacturers - developing lighter, fuel-efficient and environmentally-friendly aircraft for novel aero-structures using advanced materials
- ✓ Materials development for the aircraft started with wood
- ✓ Giant spruce wood used as a construction material for the first flight in 1903 by Wrights
- ✓ Then, steel, titanium, aluminium composites and now light weight carbon-based composites are used
- ✓ Need for development of cheaper multi-functional materials and structures for aircraft-electrification
- ✓ Required - development of self-healing materials and 2D materials, reduction of cost in manufacturing 2D materials.
- ✓ HEMP-plane - back to wooden aeroplane with 75% HEMP based aircraft in the developmental stage
- ✓ Wooden based materials for cars - indicative of going back to use of past materials
- ✓ Waste utilization - to develop new materials, produce energy and develop new structures

IPR and Materials Innovation

Mash-Hud Iqbal, Partner, Marks and Clerk

- ✓ In the past decade (data from 2008-2019), significant progress in 2D materials achieved, driven by their interesting properties
- ✓ No. of patents increasing every year in the 2D materials
- ✓ China dominants in owning highest no. of patents in the 2D materials

- ✓ Among the UK institutions, Cambridge enterprise is holding significant position in the UK patents

Revolutionising Electronics in Everyday Items

Dr Richard Price, CTO, PragmatIC Printing

- ✓ Metal oxide based flexible RFID tags called flexible integrated circuits (FlexICs) to replace conventional silicon integrated circuits (ICs) which are brittle silicon-based materials
- ✓ Production of silicon-based materials takes as long as a month whereas a day for FlexICs
- ✓ Ultra-low cost flexible integrated circuits (FlexICs) thinner than a human hair that can be embedded into everyday objects
- ✓ 80% lesser tag cost compared to silicon
- ✓ Process Design Kit that will expand the potential for its mass market uses of flexible electronics
- ✓ Highly scalable modular production, fast throughput and, therefore, low assembly costs
- ✓ The technology enables the potential for trillions of smart objects across a wide range of sectors

Session 2

Aurelius Environmental "Journey of the molecule: from waste to paste

Dr Athan Fox, CTIO, Aurelius Environmental

- ✓ Waste looked as resource for new materials for the circular economy
- ✓ Lead-acid battery also known as the world's most recycled commodity product
- ✓ Recycling of lead batteries using pyrometallurgical process considered as the world's most polluting industry (emission of SO_2, Pb dust and CO_2)
- ✓ Innovative process for recycling the lead acid batteries using citric acid, a patented process
- ✓ Zero SO_2 and Pb emission and 85% reduction in CO_2
- ✓ Production of ultra-pure (99.99%) lead-citrate and leady oxide (99.99%)
- ✓ Production of citric acid (leaching reagent) from municipal waste via fermentation process
- ✓ Waste used to treat waste (Zero waste)

EnergyREV sprints and storage local energy systems

Dr Madeleine Morris, Imperial College Grantham

- ✓ Consortium for smart local energy systems
- ✓ Review of the policy and regulatory landscape for smart local energy systems
- ✓ Tackle challenges

- ✓ Five themes - Definitions matter, Ownership and visibility, Market access and stacking value, Importance of user-centric smart design, Creating future zero-carbon smart local energy systems today
- ✓ Working paper in progress, can be accessed via the consortium's website

The flexible nature of supply chains

Professor Richard Wilding, Cranfield University

- ✓ Risk, vulnerability in supply chain
- ✓ Temple of supply chain resilience
- ✓ Foundation - effective supply chain strategy
- ✓ Floor of the temple - product design
- ✓ Four pillars
- ✓ Agility for supply chain operations flexibility
- ✓ Collaboration - internal and external for resilience
- ✓ Supply chain risk management culture
- ✓ Supply chain design – consider locations, network and equipment used
- ✓ Roof - supply chain transparency
- ✓ Crown of the roof - continuous monitoring and intelligence

Using Space Technology for Lithium Exploration

Spittle

- ✓ Demand for Li in the market increases rapidly
- ✓ 3.9 million metric tons of recoverable lithium deposits on the planet
- ✓ Extracting minerals damage the environment
- ✓ Right strategy can minimize the damage of the environment
- ✓ Satellite applications - Catapult space data for mining
- ✓ Earth observation satellites for scanning huge area to identify potential mineral deposits
- ✓ Clear opportunity for UK to grow the economy

Session 3

Briefing on Digital Twins: what are they and why should we care

Schultz

- ✓ Digital twin - virtual representation of a physical object or system throughout life-cycle
- ✓ Highly complex virtual model of a physical thing
- ✓ Uses real-time data and other sources
- ✓ Facilitate learning and reasoning, dynamic recalibration for better decision making

Why every industry should be thinking about AI

Jonny Hancox, Deep Learning Soln Architect, NVIDIA AI

- ✓ AI helps computers achieve superhuman capability in image recognition
- ✓ Capacity to analyse complex situations
- ✓ Better than humans
- ✓ Provides useful information from large amount of data
- ✓ GPU-accelerated computing
- ✓ Deep learning – applications across several industries

Using AI for Real-Time Threat Detection
Gompes

- ✓ AI-for cyber defence
- ✓ Legacy security is constantly outpaced
- ✓ AI required for addressing evolving threats in the digital age
- ✓ AI based Cyber immune system
- ✓ Self-learning for entire infrastructure
- ✓ Autonomous response like human immune system

Day 2

Session 1

Graphene, the route to commercialisation from the lab to the market place
Baker

- ✓ Silicon took around 30 years to reach the market from lab.
- ✓ Graphene is just 15 years young. It will take more time to reach market.
- ✓ Graphene has multiple properties – so used in different applications
- ✓ Graphene engineering innovation centre - key role in acceleration of graphene production and applications
- ✓ Working in partnership with industries - take new products and applications to the market quickly
- ✓ Creating graphene city by bringing academics and industries together - push the new materials to the market faster

Graphene and other materials
Butler

- ✓ Pioneer for more than 170 years (1845-2019) - in the development and application of inorganic chemistry
- ✓ Collaboration with wide ranges of companies-small and medium sizes
- ✓ Start-ups with new technology and new materials - test bed for production of 100-1000 of tons of materials capacity
- ✓ Platform for new technologies for advanced materials at WB ltd
- ✓ Production of Graphene oxide (GO) polymer composites
- ✓ Hydrothermal synthesis of metal oxides nano-particles
- ✓ High quality GO produced from graphite using a commercial and scalable process
- ✓ Hydrothermal process - important for obtaining different morphology with different crystal structure - useful in batteries-super capacitors development

- ✓ Developing metal oxides as a coating material for absorbing radiation

AI /ML challenges in Clinical
Dr PingPing Ni, Astra Zeneca

- ✓ AI – potential to solve challenges in the pharmaceutical industry
- ✓ Limitation in existing models
- ✓ Better, faster, and cheaper drug discovery and development
- ✓ Machine learning - predict compound properties
- ✓ Improve safety of novel drugs at lesser cost and time to clinic
- ✓ Large datasets to train deep learning algorithms
- ✓ Strategies and regulatory framework to deal with relevant ethics issues

Advanced human cell manufacture by cellular programming
Dr Thomas Moreau, Head of Research, BitBio

- ✓ Animal models used for drug discovery - but human cells are different
- ✓ Spending money on number of drugs decreases
- ✓ Pluripotent stem cells - unlimited source for the human body cells
- ✓ Injecting genetic programme and manufacturing human cells - a new bench mark
- ✓ Offering huge opportunities for basic research and clinical application
- ✓ Batch to batch reproducibility for applications, high throughput screening and cell therapy
- ✓ Purity results compared to current technologies
- ✓ Lesser production time and scalability

Session 2

A brief sprint through battery technologies
Professor Vasant Kumar, Cambridge University

- ✓ Tesla developed Li-ion battery - combined exiting cells, more than 10,000 cells, - a game changer.
- ✓ Battery properties target in 2030: 400wh/kg, 750 Wh/I, 2000 cycle $100/kWh and <12 mins charge
- ✓ Future cathode material - NMCs (811) to minimize the cobalt usage
- ✓ Anode material - carbon-silicon combination more suitable
- ✓ Available resources for lithium in the form of lithium carbonate (3000000 mtpy, $15-25/kg) -salt-lake, and rocks
- ✓ Alternative battery for lithium-ion could be Li-S. However, Li-S battery has some problems which is losing material in the electrolyte while it shuttles. This must be addressed.

Novel storage and battery materials
Tomov

- ✓ Electrochemical systems are solid oxide fuel cells - advantage of direct conversion of chemical energy (fuel) to electrical energy
- ✓ Improving performance and lowering cost - strongly dependent on commercially viable methods for nano-functionalization

- ✓ Inkjet printing technology - a feasible method for scalability and high-resolution ink delivery
- ✓ Low calcination temperature
- ✓ Inkjet printing of Li-S batteries cathode by 3D functionalization
- ✓ High theoretical capacity and Sulfur inexpensive
- ✓ Sulfur provide insulating effect - improved by mixing with conductive materials
- ✓ Volumetric expansion and shuttling polysulphide
- ✓ Sulphur deposited in the porous of nano porous silver tape
- ✓ Inkjet printing - applied for variety of functional materials for different applications

Inventions for large-scale clean energy growth

Ken Omersa

- ✓ Carbon - essential element for living
- ✓ Atmospheric carbon dioxide level - need to be controlled
- ✓ Innovative self-powered CO2 converter - for converting carbon dioxide, methane and air into useful chemicals – no external energy
- ✓ Syngas - a mixture of carbon monoxide and hydrogen
- ✓ Fuel cell (producing syngas and electricity) + electrolyser → more syngas by consuming electricity.
- ✓ Conventional chemical processing techniques – to convert syngas to liquid and solid chemicals

Session 3

Advanced materials for industrials

Hodge

- ✓ Different grades of 2D materials production in the commercial scale
- ✓ Collaboration with GEIC Manchester, Cambridge, NIBEC, WMG, DIT, BEIS, ODI close relationship with government
- ✓ Certification by verifying graphene production (2019-20)
- ✓ Registered for producing 1-10 tons per year in Europe
- ✓ hBN composites with graphene, FRP-graphene enhanced elastomers, graphene enhanced thermo plastics, 3D materials for aerodynamic applications, graphene carbon fibre reinforcement plastic body, automotive and aircraft interior, Graphene-ink
- ✓ High pressure process - production of graphene from graphite (100% yield)
- ✓ Graphene used in textile industries to replace toxic dyes
- ✓ Carbon collector replaced with Al-Graphene-reduces the internal resistance
- ✓ Supercapacitors, hybrid supercapacitors, supercapacitor production in commercial scale

Implementing AI and Machine Learning to Support RealTime Monitoring and Decision Making

Fidler

- ✓ Protect critical data systems and digital infrastructures
- ✓ Protection against pre-identified threats
- ✓ Cyber AI - a self-learning technology like human immune system – learns from data
- ✓ Self-learning ability - Cyber AI can uncover hidden patterns in information

Graphene materials: a key role in upcoming industrial energy storage, mobility and industrial products

Bohm

- ✓ Process the materials - advanced-quality without defects
- ✓ Si Nano wires

- ✓ Si-C core shell composites-low cost-large processing steps
- ✓ Shanshan - long steps-less power density
- ✓ Samsung - small steps high power density
- ✓ Si-Graphene with right proportion - good power density, low cost fuel cells
- ✓ Bipolar plates - Improved corrosion resistance
- ✓ Graphene coating on the bipolar plates - 500 times corrosion resistance
- ✓ Conductivity and adhesion of hybrid graphene-ink
- ✓ Commercial pull - Government supports in UK
- ✓ Cost of corrosion on economics $70.6 billion
- ✓ Challenges in corrosion of bridges in the UK and graphene contribution
- ✓ Wetting additives for coating the graphene
- ✓ Printing ink-billion-market

Investing in materials and 4IR technologies
Williamson

- ✓ Preferred investor for the University of Cambridge CIC large stake holders
- ✓ Cambridge - Largest technology hub in Europe
- ✓ Priority technology investment sectors - AI, Internet of things, quantum tech, autonomous systems
- ✓ Cambridge innovation capital
- ✓ Cambridge angels - for young start-ups
- ✓ Startcodon - Cambridge tech accelerator
- ✓ Investment in Pragmatic-flexilog IC, PervasIDRFID reader, Geospoc-big data platform enables the storage visualisation and analysis of extreme datasets generated by the internet of things, Prowler.io-AI based decision making from logistic to financial and education, Riverlane-Simulation software for quantum computers
- ✓ Algorithms for simulating materials and chemicals to quantum mechanical levels of accuracy

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