

Summary 3rd CIR Cambridge Graphene Business Conference 6 November 2015 CGD15

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1st SESSION

• CGC Director:

Graphene is the future of communication by 2024. It becomes better than silicon. The vision is to integrate modulators and photo-detector with graphene.

4x 28Gb transceiver prototype with graphene will solve the problem of heat that is insoluble to ongoing Moore's Law for data storage and transmissions with current materials.

• Former Vice Chancellor of Cambridge University – ADDRESS:

We worked in the USA on the Grand Challenges list. Is Graphene however the achievement of the 21st century? Our list was: Solar technology becomes economic; fusion energy; carbon sequestration; solve nitrogen cycle (which pollution issue many see as more tangible and urgent than global warming issues); clean water; restoring urban infrastructure; engineering better medicine; enhance virtual reality (flexible and wearable electronics – interest declared); prevent nuclear catastrophes; secure cyber space; personalised learning; reverses engineering human brain.

• IfM – Manufacturing landscape and drive for impact :

The UK is a manufacturing economy – many don't realise this!

UK manufacturing is high value manufacturing. (high UK made % of value in products of Airbus, electronic systems and so on)

85% of R&D finance comes from manufacturing companies.

Missing connection between lab R&D and alpha level production technologies with large scale manufacturing.

"Scaling up problem". (ed. *CIR Strategy's methods are a part of a solution*).

Government invests a lot in R&D creating great research but this is just an expense, we need to add value by delivering technologies through companies.

We like the current government in UK in 2015; for example, the recent very large investment in quantum technologies.

• Haydale C-Suite - KEYNOTE:

Market analysis on graphene is mostly wrong. Very hard to predict. Responses vested interest.

Composites: why? Huge market. Mostly Epoxy with graphene.

There exist very large markets for Graphene materials, but most are conservative and highly regulated. Look instead initially to unregulated markets: boats, wind energy, pipes, rails.

Industrial challenge is proving production is repeatable, consistent and cost effective.

They buy graphene from market place then characterising it and selling it [Characterization with O₂, COOH, F, NH₃. Inks, sensors, coatings, composites]

They focus on early adopters.

We do need standardization NOW. Consistent quality and value; a price good for stakeholders, before some other institution does it in a wrong way (government parties ?)

• Airbus Space and Defence - KEYNOTE:

It is all about lifecycle costs. Maintenance: what if we can leave things alone for a decade rather than 9 months!

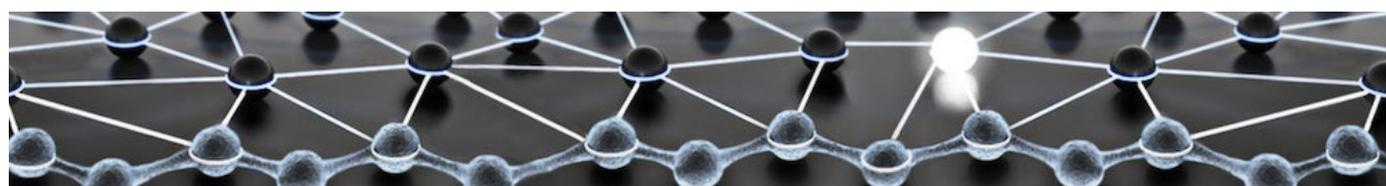
All our platforms are about fighting gravity.

Function/mass = Fuel save (environmentally good as well as economic)

Graphene is interesting also for its anisotropy, (channelling heat, heat dissipation & spreading). E.g. Delta ΔT of 300C on either side of a satellite module!

A Fusion power cell (dimension of a ball), maybe using graphene, would be solution for electric airplanes, which would be completely silent.

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Reliability is essential and the services around graphene (remember problem of aramide for PCB)
Safety and certification is also important

Main issues and R&D directions [airplanes]:

Propellers in rotors

Energy storage

Structures

Shielding (objects, rpg, radars, lighting,...)

Optics (lasers, receivers, lenses, mirrors)

Displays (wearable electronics, flexible electronics) – helps the astronaut, pilot or military person reduce clutter and improves efficiency

Ice prevention and de-icing

Constellation of satellites can be the future (1 photo every 2h in same place)

Main issues and R&D directions [Satellites] :

Solar arrays (there is a lot of solar radiations to harness; PV cover glass could be made thinner and lighter using graphene)

Multilayer insulation (thermal shield)

Structures

Antenna and mechanisms (higher conductivity needs)

Shielding

Optics [Laser communications]

High altitude pseudo satellites Zephyr, solar powered (up in 2 hours can stay there for 3 month)

Platform & Payload can be enhanced by a monolayer material because the weight of the structure is reduced increasing available payload for services within the vehicle module.

Can someone enable the use of graphene with SiC or Phosporene?

• **Questions :**

Plasmonic structures with graphene? Yes, these are being looking at.

Safety for the new materials? Hard to understand from a government point of view at the moment: not enough scientists or engineers in parliament.

2nd SESSION :

• **TATA STEEL - KEYNOTE:**

Graphene applications on steel for energy storage. Corrosion is one large problem to solve for steels. Steel can enable a large-scale implementation of energy storage tech.

Applications of steel in energy storage:

1 Building integrated PVs

(Functioning coatings on steel for buildings, which are active, capture and then store thermal energy in phase material)

2 Batteries (electroplated steel cans, electrodes and casing)

3 Fuel cells (usually gold plated stainless steel bipolar plates but should be made cheaper, maybe with graphene ?)

4 Supercapacitors (mostly aluminium and copper but steel for casing)

Performance improvement required for steel:

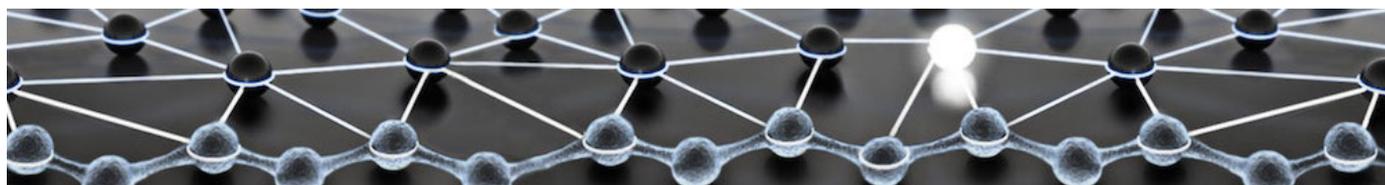
1 good, electrical conductivity

2 electrochemical stability (corrosion prevention)

3 Thermal conductivity (high power devices)



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4 formability and strength - tribology

Replacement of gold for coating in LC steel.

Industrial challenges :

Scale graphene coatings to cover the scale in which the steel industry operates, which is enormous.

• Nanocarbon :

Why it is better to do Graphene transfer in your lab instead of involving 3rd parties.

Most popular CVD Manufacturing graphene on copper, on silicon carbide, graphene transfer [Electrochemical delaminating] and flakes.

5 reasons why is better to do transfer in your own lab :

1 Safer: no need to share details of applications.

2 Faster: full control.

3 Cleaner: full control, no carriers issues.

4 Cheaper

5 Optimized: you test and you see results, you learn and can optimize.

• Graphenea :

The company offers graphene dioxide, CVD and nanoflakes. Central hubs in Spain and US.

• Cambridge Nanosystem :

Innovative technology spin-off from Cambridge. Transform Methane into graphene powder, atmospheric plasma to break difficult and stable molecules like methane (also CO₂ or other carbon based molecules)

As byproduct of process to make graphene powder, there is hydrogen, which has uses.

CN can make very large quantities. They can also make graphene oxide (GO) adding O₂ to the process.

They sell graphene powders, carbon nanotubes (CNTs) and inks.

• Thomas Swan :

Chemical company. Family business, which gives flexibility to invest or change strategy as needed; always been profitable and well run, stable, growth since the 1920s. North of England based. Good relationships with many players over the decades.

3rd SESSION :

• Novalia :

Print is everywhere, how to add interactivity to print ?

DIGITAL IS : Touch, connectivity, data.

Revolutionise the digital world with paper interactive surfaces.

• OCSiAl :

Industrial scale facility for single wall carbon nanotubes SWCNTs. Now have 50t production capacity per annum being implemented to make a total of 60tpa, reactors in Russia.

80% single wall per batch.

Focus on Touch screens, paint and coatings, lithium battery, polymer composites.

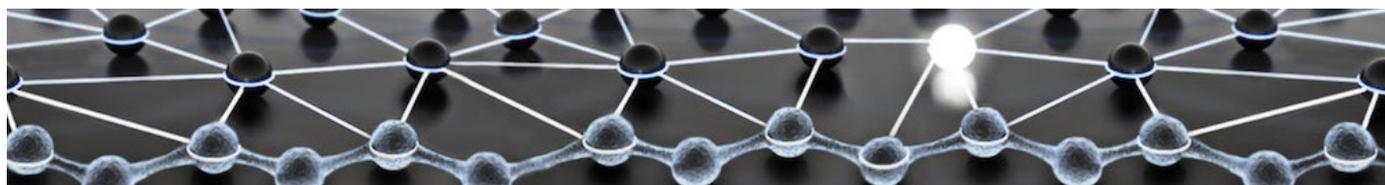
Tuball for antistatic, ESD properties, e-paint, conductive paints.

Tuball coatings gives "permanent conductivity antistatic properties".

• Standard Graphene :

Team emergent from Samsung. Korean company.

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CVD for Touch panel & OLED
Flakes will lead the market.
9-year-old research on flakes in 2015.
Graphene aerogel for electrodes.
Self-sensor composite.
Composites (e.g. polyurethane foam)

• **Super capacitor technologies research division of lead sponsor :**

Fluorination by plasma for hydrophilic 10wt% for moisture control.

• **FlexEnable - KEYNOTE :**

Activating surfaces, wearable, automotive, any surface brought to life.
Work also on flexible sensor arrays (fingerprint sensor, smartcards, et c)

4th SESSION :

• **Marks & Clerk** : IP landscape in Graphene research. UK patents in 4 universities. Patent families described globally by geography and sector, and over time to 2014. A time lag of 18 months exists for accepted, published patents, which were the type studied.

• **ENSO Ventures :**

Venture capital for Life science, advanced materials, advanced chemicals.
They follow companies from 7 to 10 years, longer than normal VC, higher average investment over time.
Graphene hype in 2004, bubble burst in 2008. Chasm described in detail as lesson. Possibly emergent now. Story unfolds.

• **BP plc (ICAM) KEYNOTE:**

Used and commercialised nanomaterials in lubricant oil (titanium based) 40% less friction.

Pipelines extremely long (thousands of km), remote, hot/cold conditions etc, several phases of material pass in great volumes, producing large amounts of unwanted material and erosion etc. Oil, gas, water, sand in pipes.

Undersea work at 10,000ft under the sea, and then a further 40,000ft under the seabed. Contrast to Airbus above the atmosphere.

For BP, 2D materials good for :
Firstly for corrosion resistance, surface treatment, deposits & fouling, self indicate damage,

Secondly against bio films formations in pipes, low wear friction, offshore pipe work.

BP don't know how composites fails, otherwise they will use them everywhere.
BP look forward for sensing technologies to solve this.



For ecosystem strategy (tools): routes-to-value, value network analysis, opportunity & threat prioritisation, business intelligence; future conferences, briefings, masterclasses, bespoke & private brokerage events please contact us.

For information about the next **conference** & executive briefing with master class in this programme please see www.hvm-uk.com Delegates of earlier graphene festival events are offered discounts.

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