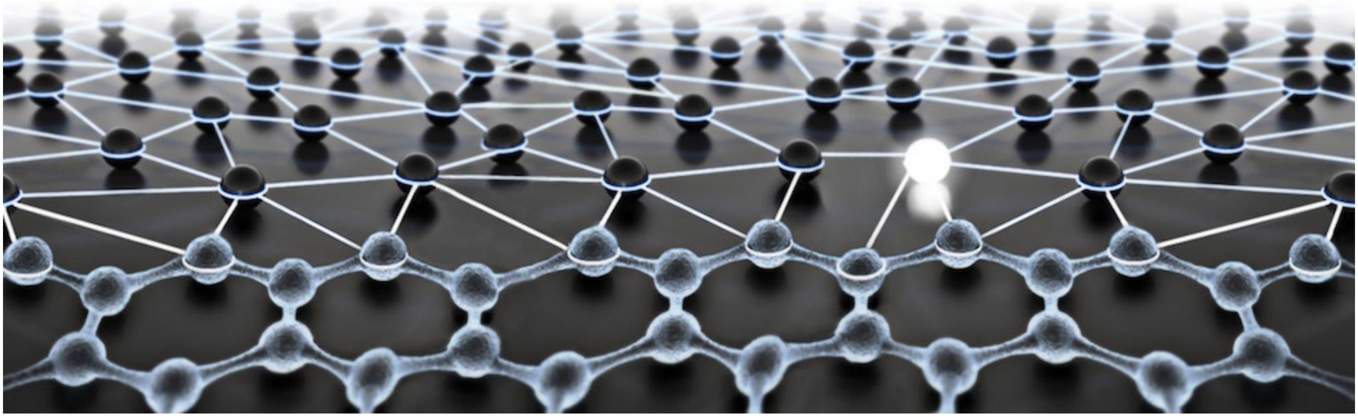
HIGH VALUE MANUFACTURING GRAPHENE+



HVM GRAPHENE+ CONFERENCE 2014 OXFORD

Session 1 – Introduction: Functional Materials
10:00 Dr Justin Hayward, Director, CIR Strategy - **HVM & G+ Introduction**
10:05 Professor Peter Dobson OBE, Warwick Manufacturing Group - **Chairman's Introduction**
10:10 Audience - **Collected Intelligence - open comments & questions**
10:40 Prof Vladimir Falko, Distinguished Professor, Lancaster University
Electronic applications of graphene heterostructures with other 2D materials
10:55 Dr Felice Torrisi, Research Scientist, Cambridge Graphene Centre
General Applications for Graphene-based supermaterials
11:10 Panel with Chairman
11:30 Coffee break

Session 2 – **Materials & manufacturing - applications in electronics, aerospace, health, energy**
11:40 Dr Martin Kemp, CTO, Haydale
The Role of Functionalisation in the Graphene Supply Chain
11:50 Dr Richard van Rijn, CTO Applied Nanolayers
Wafer scale production of graphene: opportunities and challenges
12:00 Dr Paul Reip, Founder, Intrinsiq Materials
Electronic inks and pastes for packaging, batteries, sensors, displays and touchscreens
12:10 Toby Middlemiss & John Bexkens, Product Manager Motorsport & Composites, Oerlikon,
Diamond coatings transforming surface engineering
12:20 Professor Tony Anson, Brunel University
Adding Value to Medical Implants by the use of Diamond-Like Carbon Coating
12:30 Gavin Farmer, Carbodeon, NanoDiamond materials
Hard as Hell, but Cooler
12:40 Panel with Moderator **Ian Burnett MIET, JEMI UK**

13:00 Lunch and Exhibitions

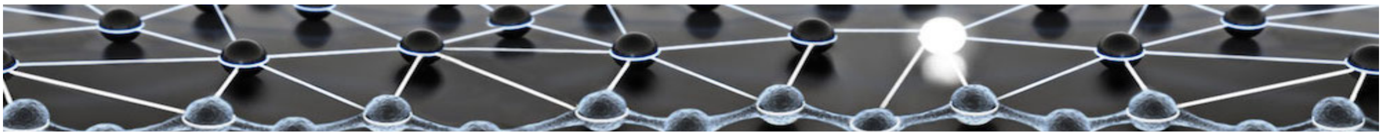
Session 3 – **Case studies of market experiences**
14:00 Ian Walters, CTO, Perpetuus Carbon Group
Graphene alternatives: are they underestimated?
14:20 Paul Ladislaus, Senior Chemical Engineer Thomas Swan
A new industrially relevant route to high quality graphene
14:40 Dr Ravi Sundaram, Development Scientist Oxford Instruments plc
Capital Equipment considerations for 2d materials moving from Lab-to-Fab
14:55 Dr Emma Kendrick, CTO Energy Storage, Sharp Electronics
The use of carbon in next generation battery technologies
15:10 Panel with Del Stark, Founder, Nanopro
15:30 Tea break & showcase networking

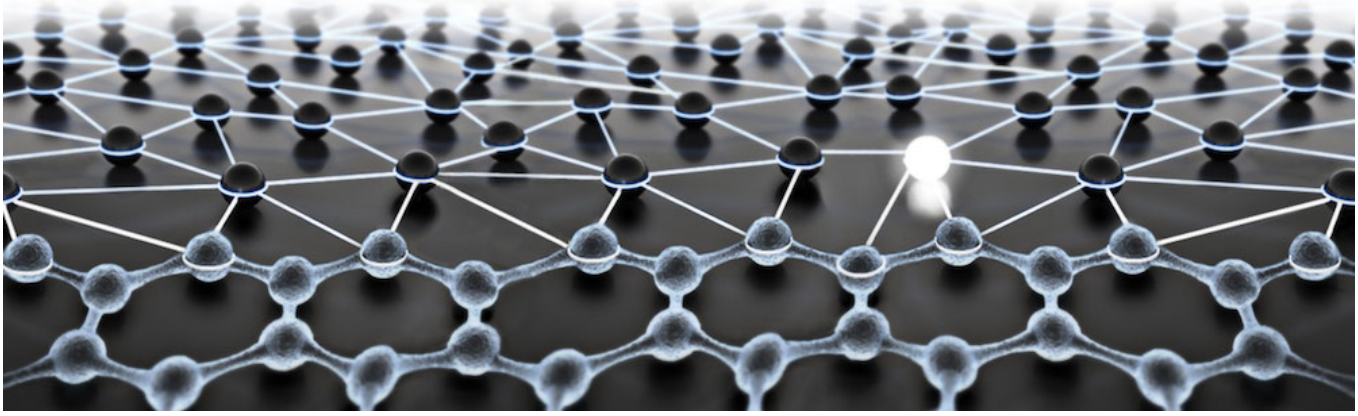
Session 4 – **Innovation | Funding | Commercialisation**
16:00 Nabil Zahlan, GrapheneSIG
Working together to commercialise Graphene applications
16:10 Dr Alec Reader, Nanotech Community, the KTN
Healthcare & Nano-medicine: UK update & recommendations
16:30 Dr Tom Taylor, Head of Future Businesses, CPI
Graphene applications and the CPI approach to Innovation
16:50 Dr Pēteris Zilgalvis, Oxford University & European Commission
State roles in Innovation: regulatory, business and innovation law and policy

17:10 Panel with Prof Peter Dobson; Chairman's Summary

17:30 **Networking & Drinks Reception**

This HVM Conference is organised by CIR Strategy in association with the HVM Catapult, GrapheneSIG and various private sector sponsors. It is part of the CIR Conferences Series, which has run since 2002. The upcoming Graphene+ Summit 2014 takes place on 3 November 2014 Cambridge: www.cir-strategy.com/events/register or 01223 303500





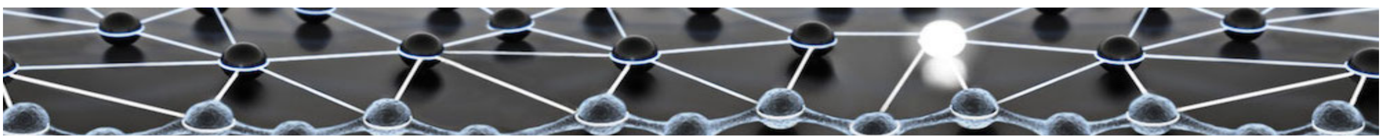
Notes by Nina Klein,Oxford University PhD candidate, edited by CIR Ltd

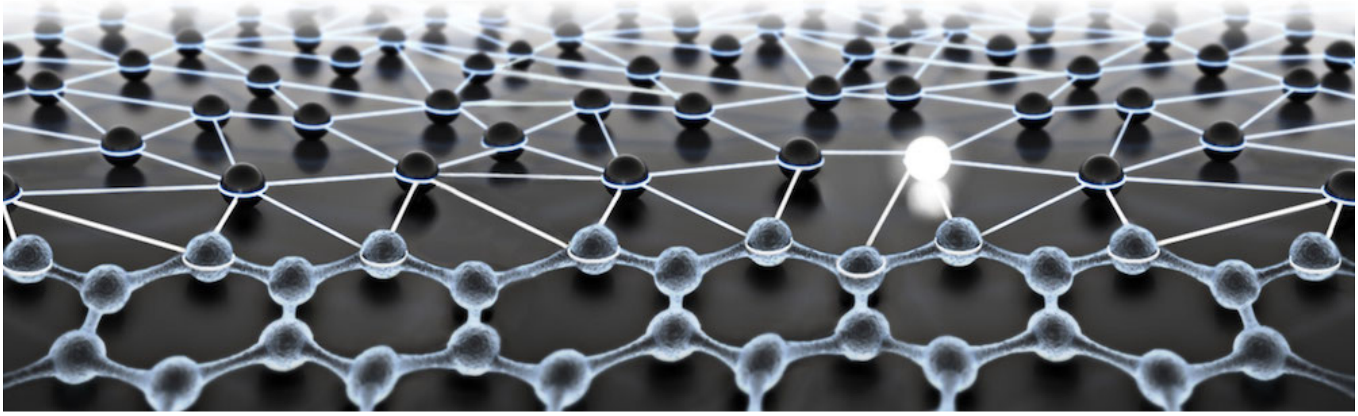
Session 1

Justin Hayward
CIR consulting and conferences, good track record
Routes to Value - bring activities into process diagram, goals and values of business as aims, small steps to move towards rationally
Cambridge good technical support needs expertise in sales, CIR fills the gap

Peter Dobson
Day ahead - latest graphene developments, alternative carbons based materials
New discovery to commercialisation is a long process, 20-25 years
Nature Materials 12 173 2013 - materials genome project
PD in Philips just as GaAs was hitting the market, lasers for CD-ROMS
Graphene is at the start of the process, need to be realistic about commercial time frame
PD now quantum technology, government expects money in today and wealth creating before next election, need to manage politicians' unrealistic expectation
Innovation timescales, Technology Readiness Levels, funding gap 'valley of death', could be two 'the Darwinian sea', Horizon 2020 addresses higher TRL levels
Today - identify any road block, where are graphene applications on TRL scale, is there anything graphene can't do?!? What is actually realistic?

Audience
Graphene cant do - can do lots of things, limitation is production, 2.5Kg on good day currently, insufficient resource and research going into manufacturing product
Soldering on graphene - other materials non-carbon based, 'is there anything government funded graphene research can't do', can do lots of very sexy research, the moment you develop it comes out of the lab and someone must buy it, you need quality control standards and low price, why should you replace what you already have, pitching to non-specialists is difficult, development cycle 3 years from initial contact, in a materials business you wont make any money for 7 years
Soldering - sputter few nm
Who is the customer for what application -
Russian company - produce SWCNT in high volume, guarantee 85% purity, never seen before in industry, 10tonnes/year, CNT 1983 discovered just beginning to have scalable production, claiming low prices





What was the driver, the application - replacing carbon black

Currently CNT are a mixture of wall numbers, not pure currently, amorphous carbon and residual catalysts

Replacing carbon in tyres - largest markets are in areas which are uninteresting, not high tech or sexy is necessarily firs to market, need to get immediate revenue to aim to longer goal

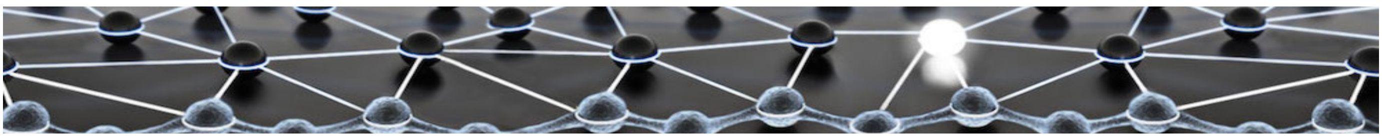
Characterisation - tools to understand nanoparticles has helped, graphene is a generic term need to specify x-y dimensions, need knowledge to understand type of graphene for effect, knowledge needs to become more widely available from universities to business, needs to be integrated into production process not special sample prep, tools are in place right now for graphene because you can get so much combined, end of production line characterisation is still an issue, currently no instant tools, cant apply microscopy in production, top down doesn’t work material in need to be the name each time

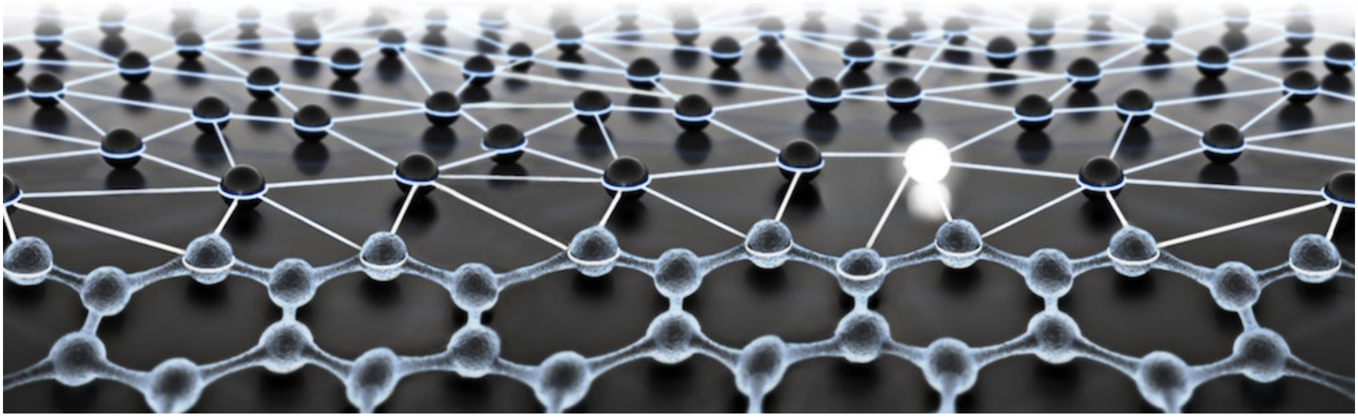
Nanomaterials company - to apply a new additive to an old material you have to follow the component trail to the end, valuable to end customer and through supply chain but then you reach a small company at the end who cant take the risk or time to see a new research project, need more willingness to experiment at application level, close collaborating between nano and established manufacturers, initiatives to team up SME with Larger to address gap, IP generation

Interest in graphene, but what to do with it - why move to a composite instead of steel, you haven’t worked with it as long so you wont know its properties, interest but lack of confidence, production scale oil and gas requires large scale would use all carbon fibre in the world, certification and non-destructive testing are also a problem, new adoption requires lots of materials, oil and gas is a conservative industry, DLC on the inside of pipes need is there but who funds the research, MoSteel pipes is low friction surface

Don’t know who is using nano - Industrial companies do use it but don’t disclose that they are using nano, you don’t know who is using you just see competitive advantage in the marketplace

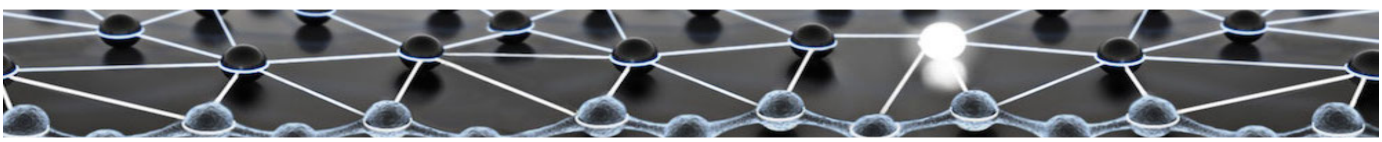
UK parent office report - leader in academic publication 1000 but on 50 patents, 3000 from china US Korea, why are we behind? Applying through companies abroad or it feels to young, keeping is secret is safer is the general feeling, process patents are generally weak, innovation timescales mean you can patent to early, see USA QD patent rush, patent metric is not always best. IPO data lots of china applications are very simple, the worth and value was minimal, number are not always best metric. When to patent, process patents can be valuable tools for licensing. Secret vs filing you must consider funding, funding secrets is risky prefer to see assent, IP in the UK we are behind the US, academics want to publish not file need to have more incentives and be shown how. REF analysis now recognises patents.

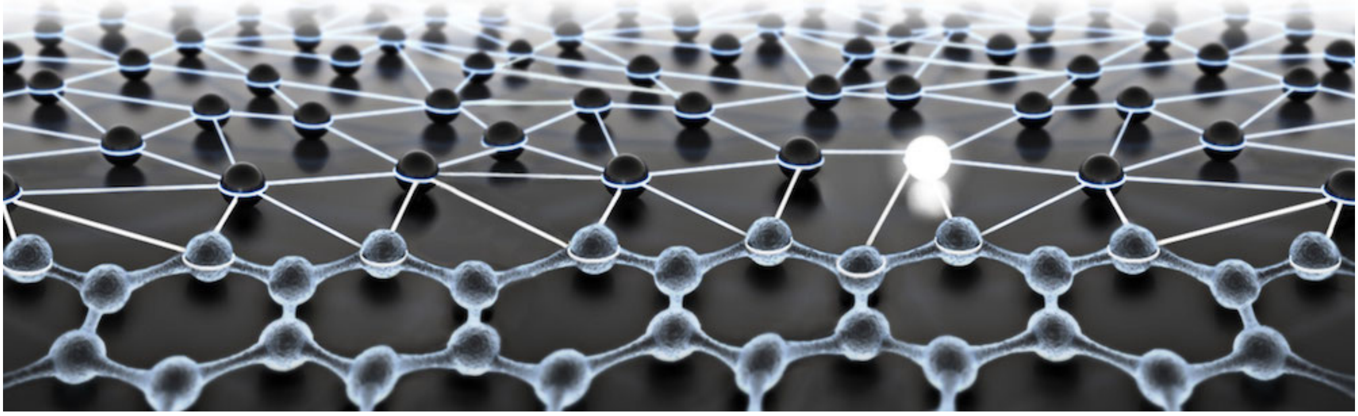




Vladimir Falko
Devices to exploit both properties of graphene - focus on optoelectronics and quantum
Take away - graphene is first member of materials family which retain stability as single or bi-layers, weak Van der Walls coupling so can be grown on substrates, closest brother hBN, then TM dichalcogenides, then III-VI semiconductors, all can be grown or exfoliated to give atomically thin films.
Optoelectronics - atomically think, single layer absorbs 2.3%, use in transparent electrodes and photodetectors,
Photodetectors - how to get stronger absorption, Ga/In chalcogenides, multilayer GaTe rather slow but sensitivity for visible is very good
Combing - broader range of materials is available you can combine them with graphene, vertical heterostructure, can make photodiode too
Transistors - tunnelling transistor, atomic film of hBN separated graphene films, generate high frequency irradiation GHz range THz for very thin films due to short tunnelling times
Exception to long delay time - 2D metals quantum hall effect, resistivity is quantised, SiC substrate to grow graphene monolayer achieved 1 part in 10^^{10} NPL quantified, can grow on wafer scale to mare circuits with resistance down to 100ohm range, make a transferable resistance standard
Single electron transistor - based on QD in circuit with side gates, electron transfers betweens dots, one electron transfer per cycle, to give quantum current standard, cycle in GHz range rather than MHz range, currently accuracy isn't better than superconducting QBIT but making progress
Quantum circuits - CVD growth but hard to manufacture bilayer, bilayer has specific band structure, apply voltage to control band gap, use gap opened to confine electrons in quantum dots without physical edges which reduced impact of impurities
Future - interacting with water and ice, coat hydrophobic objects in water to deliver chemicals in controlled way, modelling properties of 2D materials beyond graphene and heterostructures, growing III-V semiconductors on graphene to use as transparent electrode
Graphene flagship - fundamental science of graphene and 2D materials, aiming at TRL 5, takes 10 years, market in 20 years, explain this to European commission, target to reach TRL 3 high standard of nanofabrication, understand environment issues, what functionality can be provided

Felice Torrisi
Properties - transparency high, reflectance low, highly conductive with doping or metal meshing out performs current conductors, flexibility can be retained



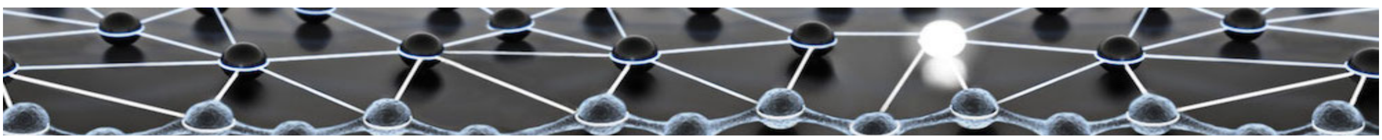


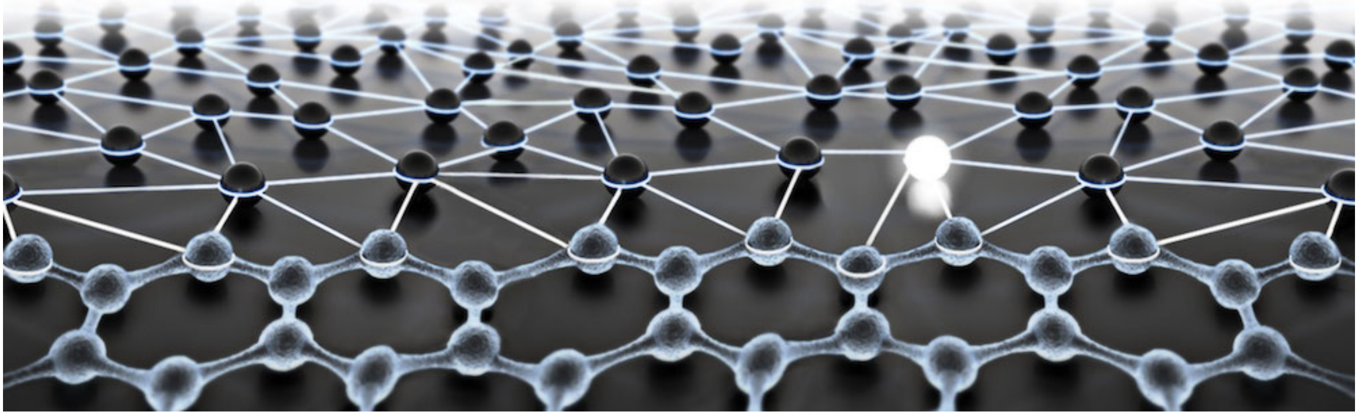
Potential - conductive inks, chemical barriers, sensors, heat spreader, automotive, energy, touch panels, high speed RF
Market predictions - mainly composites, energy, painting and coatings, production need to fulfil specification
End user applications - electronics, composites, energy, most need to be flexible, need overall is for a flexible material
Flex electronics - many applications and already demonstration incorporating graphene, but each uses a different manufacturing method and they are not scalable
Commercialisation - show better performance and lower cost, but need manufacturability and up scalability
Current generation - TC: brittle, expensive. Inks: expensive, post processing, unstable. Org polymers: limited performance, unstable, expensive.
Multiple graphenes - mapping methods with performance and cost, if good problems are stability or temperatures, liquid exfoliation is a promising process
Graphene ink - need to control monolayer yield and flak size tuning, ultrasonicate in solvents, shear forces require 100mN to shear layers, bath sonicator produces good monolayer yield, flake size tuned by centrifugation, concentration tuned by centrifugation
Continuous printing - roll to roll, continuous fast and economic, inkjet printing problem is nozzle adjust ink parameters to match to give single drop on demand, interaction with substrate controls drop shape deposited
Printed transistors - compared to organics higher mobility but on/off is a big problem but progress is being made
Substrates - demonstrate graphene printing on paper and various substrates, build database of properties to determine manufacturability
TC - produce a printed graphene transparent conductor for a smart window, big difference is you can flex

Panel
Sell for filtering - might be mass production application to justify further research
Metamaterial - graphene and dielectric with new properties?
What industry sector would most benefit from graphene, which are in the UK - FT: composites for aerospace or automotive, printed electronics is strong in UK. VF: Defects are at edge and don't affect quality of flake, ramen and TEM to characterise.

Session 2

Martin Kemp
Nanotechnology and the lotus effects originally wanted to make everything waterproof

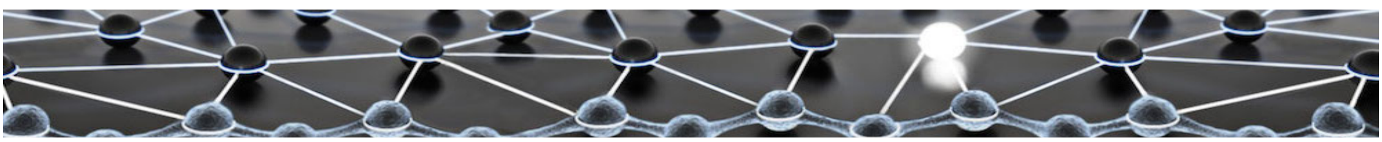


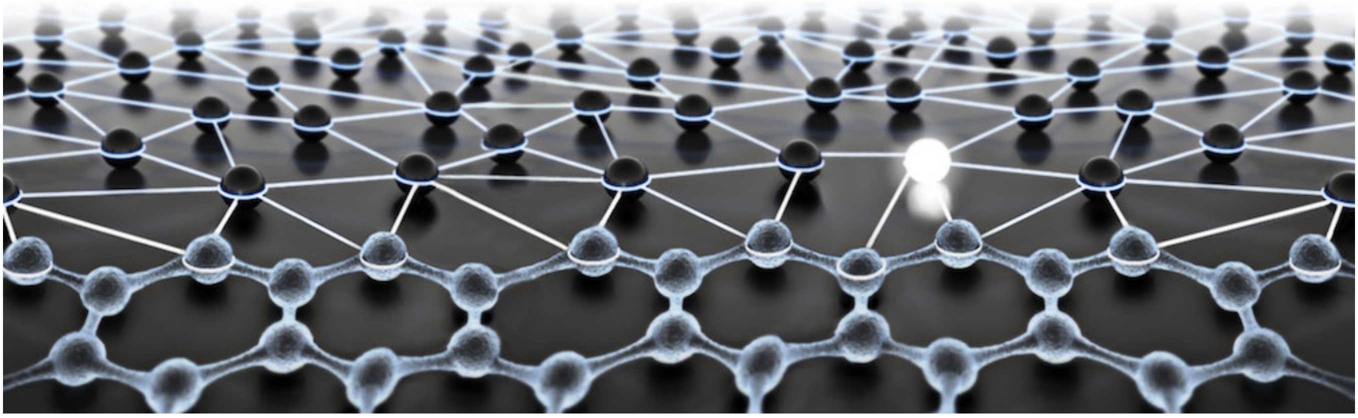


Functionality one of the key aspects to make nano tech work
Issues - consistency of supply, quality, price, classification graphene is too loose a word you need to segment the market place to develop further, it is inert and so need to be functionalised
Why functionalisation- compatibilisation make surface chemically active, promote dispersion and demixing important for nano, compatibilisation chemical interaction with matrix, cost benefit analysis for customers, want to achieve bespoke applications
Making the difference - source manufacture and materials (materials determine cost of product) , chemistry add chemicals, functionalise by reacting
Plasma processing - attach groups to process, types of group and degree
Benefits - no acid, no toxic waste stream, no damage process not achievable by others, scalable, verified by NPL, side benefit de-agglomeration, dispersion can be put into resins
Products - modified thermo plastics, flexible graphene inks, graphene PEDOT

Richard van Rijn
Wafer scale production - the perfect monolayer, how to produce and test, supply semiconductor industry, building production line
Netherlands - has end to end tool chain of semiconductor industry, from chips to devices
Production methods - exfoliation, thermal decomposition on SiC but be grown and used on substrate so not transferable, CVD, focusing on CVD potentially highest quality for lowest price, growing on metal can transfer to another surface
CVD graphene - substrate metal structure/element choice, method thermal CVD / PE CVD / segregate carbon
STM studies of graphene growth - mechanical design to give stable imaging while varying temp, pre-seed and grow on Rh movie of growth, look at evolution of defects when different seeded regions grow together, different crystal orientations grow with defects between
Device made with two different growth methods which meet in the middle, shows problems of different orientations
Pilot production - growth on Cu for 8inch scale, shows graphene growing over Cu grain boundaries
Graphene as platform - hBN 2D material can be tested too, studies show can be grown on top as well as just transferred
Graphene production improvement - understand growth mechanisms, build reliable supply chain, engineer for volume production, characterisation to analysis product

Paul Reip

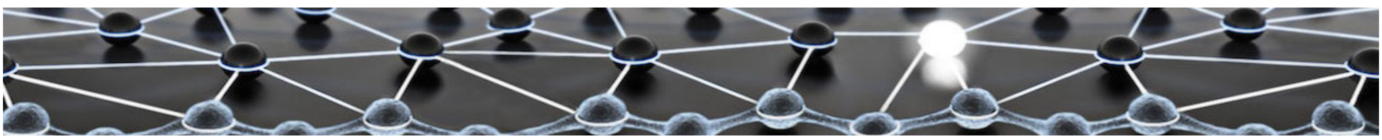


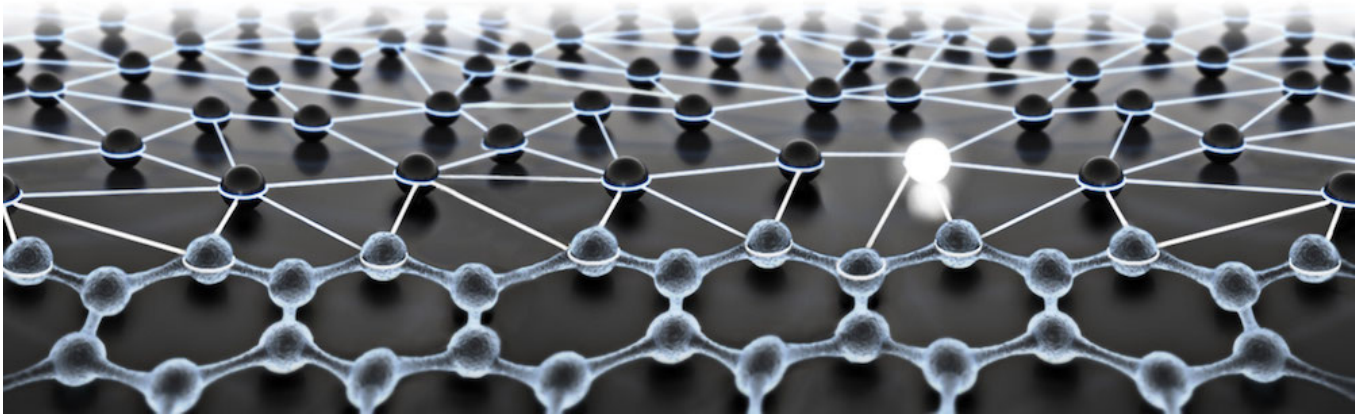


Made over 200 nanomaterials, 100 never created before, find an application to make money, not carbon material in direct competition with graphene, thoughts about how to commercialise
Word to remember is 'focus' - find an application and go for it, especially if SME
Production facilities - rapid prototyping, pilot plant, analysis suite
Which material to pick - went for Cu to replace Ag, cu very reactive at nm scale pyrofiric, control reactivity via 1nm polymer coating which you functionalise, can also replace internal cu with another in using same formulation
Formulation is tricky - they started from scratch, ink is very cheap and can be applied to many technologies, ink sits on surface for 9 months without reacting due to insulating coating, photonically curing method removes coating to give conductivity
Laser development - develop system to sell so that researchers can print ink and do their own curing without worries about laser safety
Applications - printed circuit boards use less material and reduces cost of goods, antibody sensor easy to integrate and fast manufacture, LED method to stick onto glass, OLED large area
What have we learnt - customers never ask for what you can do, large companies often ask for adjustments or too large a scale, you have to fit in with their existing technology, will need to apply to different substrates, need to answer real world issues form production engineers, 3 years from first seeing to proof. Focus, focus, focus.

Toby Middlemiss and John Bexkens
Applications for coatings - hardness correlates with sp2 and sp3 bonding
Cutting tools - carbide coatings via CVD, very high microhardness
Technology - plasma: fast, graphite, ceramics, crystalline or hot filament: very smooth, slow, ZrO, composites, nano crystalline, high precision, good coefficient of friction
Graphene challenges are the same that DLC has had to overcome
Carbon based coatings - metal doped: less hard, good friction, amorphous+H: hard dense, High C, polycrystalline
C crystalline structure
DLC amorphous dense, hard, wear resistance
Big challenge is to find applications and tweak coatings
Racing- surface coating helps prevent wear and reduce friction
Automotive - stop start function gives low lubrication regimes
Design larger machines - to coat large components, reduce cost
New market has evolved - designers like colour, watches functional interior coating, decorative outer coating

Tony Anson

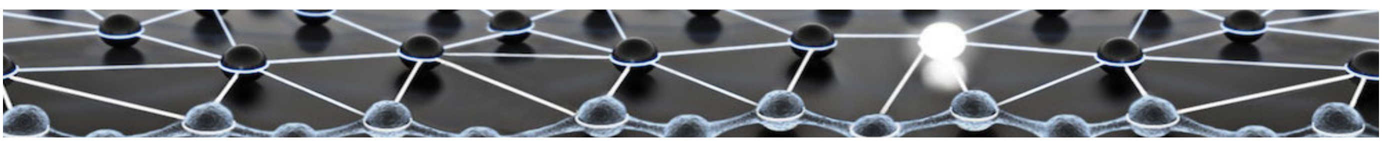




DLC in medical field - spans academic and spin outs, DLC is generic terminology can get different properties from different production methods
Adding value - coat to add performance, protect from toxins, reduce allergic response
DLC inside plastic bottles of soft drinks as a diffusion barrier, density allows thin films which increase shelf life
Methods - spraying, thermal, dipping, lasers, PVD, CVD
Applications - watches vary thickness to achieve different hues, Ilirazov technique screws into body act as path for bacteria DLC can provide barrier, catheters low friction required DLC can be used without lubricant also prevents infection, knee implants with large surface area which causes protein growth and leads to infection DLC coating protects form metal allergy, prevent migration of ions though system
Polymer precursors are toxic
Metallic biomaterials can be toxic/thrombogenic
PECVD to deposit DLC C/H carrier gas and plasma to deposit carbon coating
Inert materials with semi-functionalisation - reduce infections
New surgical instrument - Al saves cost compared to Stainless steel, and coating allows use of Al

Gavin Farmer
Materials selection - compromise, always limited by properties of materials, for nano you can optimise for properties you want by adding nano with extreme properties to base material
Diamond - interesting properties combination, other properties are extremes
Where - metal plating, polymer coating, improving mechanical properties
Plating and anodising - double durability, wear improvement, friction reduction
Thermal interface materials - boost thermal conductivity, introduce at interface
What - nanodiamonds from thermal detonations, shockwave transforms to diamond with tight size range, produced with surface chemical functionalised groups but random, and agglomerate if not strongly functionalised, chemistry to convert functionalisation to required can produce stable dispersion after mechanical agitation
How - need to sit down with customer and discuss and help application, cooperative approach
Dispersion base projects good as use of material is more efficient and can achieve similar properties often, good property improvement with small weight percents <1%
Case studies - electroplating eventually fail by corrosion due to cracks, electroless nickel property increase at very low loading due to hardwearing nanoparticles in coating, PTFE can make crack structure much finer

Panel



Can by-products be valuable, using your waste stream to add value - CNT by products have shown better markets, also true for hydrogen production form methane
CVD - pre Si layer used before C

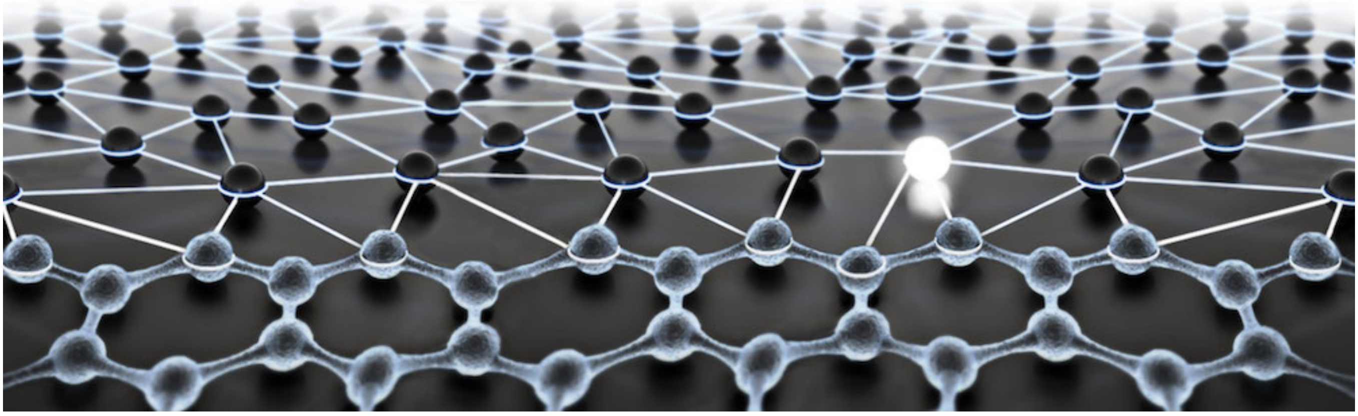
Session 3

Ian Walters

Pristine graphene via CVD barrier is quantity, Top down is nano graphite not graphene, 2014 still don't have mass production, lifecycle analysis required
Credibility issues in terms of quantity produced and purity
Nanographite masquerading as graphene, not the same characteristics
Graphene ink is not real, high conductivity comes from adding Ag
Top down causes defects, large holes help make area claims bigger
Automated large volume process produces graphenes, Stone-Wales defect, 3D microscopy
Precious metal doped surfaces, engineer surface to match end use
Intercalates Li-S battery, sulphur shoved in very hard which prevents sulphur poisoning

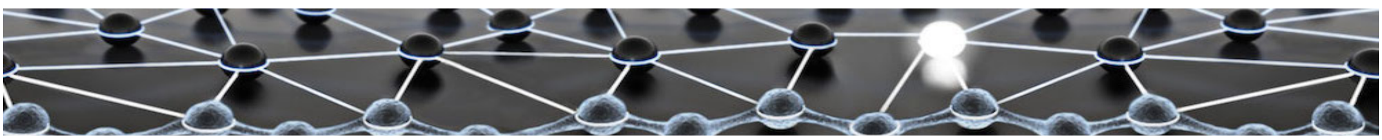
Growing CNT on graphene, high volume nanocarbon, discharge on edge of graphene and dangling bonds causes CNT to grow on edge, don't know exact mechanism
Bendable ITO replacement, not as good but are uses
Major players are risk adverse, don't reach to market need wait for TSB ask

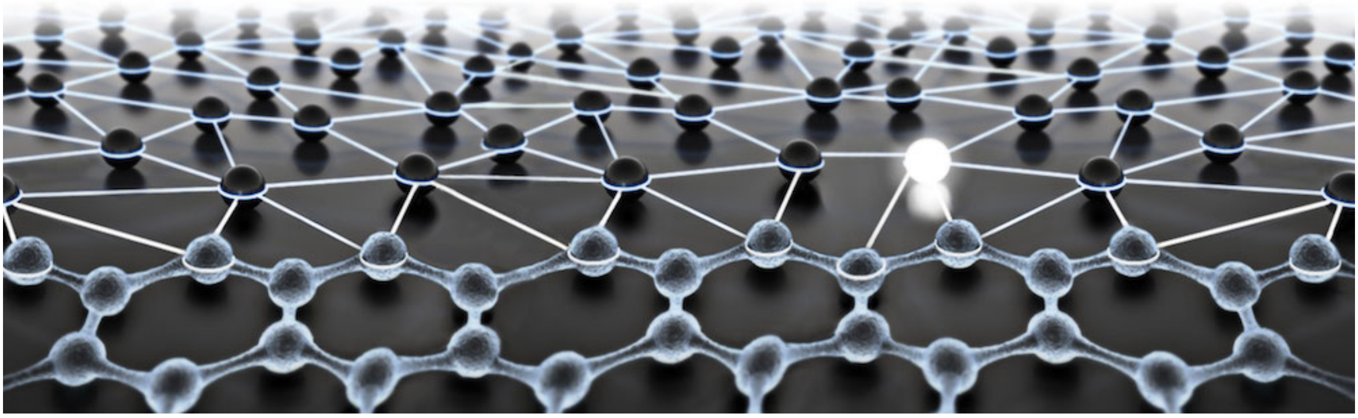
Emma Kendrick
Sharp R&D - health and medical: point of care devices, lab on chip, Energy and environment: home energy management, energy storage, PV-T field trial, Displays and Embedded systems, Systems and devices: lasers and LEDs
Carbons currently used, substitute for graphene in future
Energy storage market - automotive, portable application, appliance and diy, stationary industrial, need to determine sensible target market you need to focus, difficult to displace current technologies, need to better and at a lower cost, emerging markets are easier very hard to displace existing
Stationary application - cost over lifetime is very important, storage need to match lifetime of device, lead acid lifetime cost is lower than lithium ions, want to replace lithium with low cost and better lifetime than lead
Battery operation - lithium moves through electrolyte, stack anodes and cathodes with conductive additives such as carbon black, electrode drying is important for adhesion then compress for energy density



Electrode formulation - 3D electronic and ionic conductivity, porosity/morphology, energy density and adhesion
Cathode composites - super fine Cblack dispersion and additional carbon species to give conductivity, could use graphene in this place, can optimise cycle life and capacity
Carbon use - promote electronic conductivity of poor conductors, could use graphene instead
Anodes - graphite or hard carbon gives higher capacity but more cycle losses, graphite could replace
Carbon anode - reproducible and reasonable results
LIB replacement - cost of battery cathode is over 50% (high cobalt cost), try to replace Li with Na which is more abundant, by reducing cost aim for low cost applications
Sodium ion battery - building new battery technology

Ravi Sundaram
Upscale considerations for a bottom up approach
Nanotechnology tools sector - fabrication: plasma and CVD UHV ULT and characterisation
Challenges - reducing production costs, use other 2D materials
Scalable - CVD broad, MBE niche for example spintronics
Cluster tool - make, test and assemble, not scalable but valuable in lab, lots to learn from III-V
PECVD - showerhead technology gives uniform deposition, wide temp range for different materials, precursors for 2D are dangerous so need safety, dual frequency plasma heads, plasma damages atomically thin layers, want to create plasma remotely in very controlled way for thin films
CNT - lots of experience, can grow aligned over large area,
ALD - adding layers is important
Gas valves - need control of gas flow, quick pulsing required
Characterisation - inline characterisation for upscaled production line, integrated for quality control
Graphene - holy grail is to grow on dielectrics not copper so can be used in semiconductor industry and transfer process is challenging, plasma might be the way to go, Si substrates might not be
MoS - need to guard against HS
High volume production - long term tool reliability, temperature control, chamber contamination, automated diagnostics for preventative diagnostics, precursor supply, substrates
Summary - reliability, end users, automation, experienced company



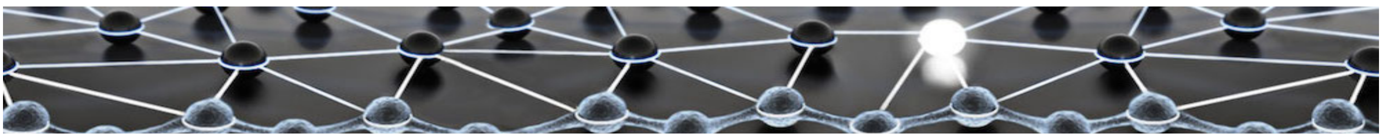


Paul Ladislaus
Departments - custom manufacture, advances materials, performance chemicals, good diversity, SME with large company facilities
SWCNT manufacture - installed plant 500Kg/year, in house measurement facilities, quality control team
Graphene - conductive inks, supercapacitors and batteries, barriers,
Trinity college collaboration - graphene wafers, liquid phase exfoliation, ambient conditions no ultrasonics, can use range of solvents, patented process rotor stator ie graphene in blender, pilot scale 1g/day, scale up parameters are available
Characterisation - confident making good number of layers <5 and low impurities, batch to batch repeatable
Currently commercially available product, scalable route to pristine graphene nanoplatelets

Panel
How do we quality assure - Ramen can be put inline but it is a challenge in large chamber size, to get all information out you need tightly focused beam
Price drop in graphene - product in isolation is not only problem need to consider scale up, can do simple
Why grow on Cu - for catalytic properties, could use benzene/phenyl for a gaseous low T synthesis for sp2

Session 4

Nabil Zahlan
Technology push and market pull coming together to create value, adding value to the UK economy in this case
TSB arm is graphene special interest group
KNT have consolidated recently,
Innovation with chemistry to improve UK economy - published strategy in June last year, Dept BIS identified priority sectors, many need and opportunities uncovered, potential need that graphene can fulfil
Novel materials creation is key area to pursue
Why is graphene not being applied - Where is it on the journey? Reached prototype stage with lab demonstrations. Will fundamental properties translate?
How to get to commercial products? - value chain in uk: science, material understanding, enabling capacity, and raw material > need to combine all in network but application development is not happening



TSB funding call for feasibility studies - how do we get the application makers involved? study led by application developer, joint with EPSRC as science is still needed
SIG graphene - to serve community, supporting the funding call with advice as second pair of every for proposal, building leadership team, mapping out UK community, website with news and matchmaking capability to connect
We will commercialise together join www.grapheneSIG.net

Alec Reader
Nanomedicine motivation - it is the most important area for exploitation in the uk, market study to look at market sizes
Nano medicine defined - diagnostic and pharmaceutical sides, nano tools and devices
Market - compound growth rate is high and uk is good, good routes to market via NHS and big pharma to use all over world, could do lots for cancer care, good market size and growth rates, very good at high resolution imaging with nanoparticles
Pharma - Biomedical catalysts - work is being done here
Lots of talk but need real momentum, uk life science strategy is strong, we are leaders but we are not doing enough, we have many initiatives but slow take up in governmental circles
Companies taking this up especially SME, and global pharma taking an interest
Devices - Point of care diagnostic companies, doing quite well spinning out from universities
Regenerative medicine - SMEs again
Problem is lack of enthusiasm
Future prospects - will see significant growth, lots is already in clinical use, lots of patents coming to the end of their period in pharma so mergers and acquisitions are common, nano are beginning to be patented so could be new growth area for patents
Summary - wonderful opportunity in Uk we are already world leaders but we need to commercialise to benefit, hope recommendations to UK government will be taken up, will miss a trick if we don't do something quickly in this space

Tom Taylor
Odd one out from various graphene applications - the only one on the market (innovation) is from abroad all the others are UK and are inventions
UK is a good place to manufacture - good UK innovations: OLED mask cure for diabetics, biggest application of OLED since discovery in Cambridge. Plastic logic printed on plastic for packaging with lights.
CPI - pilot plant for scale up and innovation research
Innovation centre - catalyse gap between invention (research public funding in universities) and production and commercialisation, gap is seen to be risky so

companies don't invest anymore so government must step in with catapult centres to de-risk step with tax payers money
Valley of death - must invest heavily between TRL 3 and 9
Innovation is market driven, research and science (logical right brain) isn't innovation (left brain connecting with customers), 90% of innovation from customer interaction, need to facilitate science process but innovation is not this process
Research councils fund TRL1-3, spin outs TRL 3-6 fills valley with corpses spend lots of money on equipment but want to invest in knowledge, TRL 6-8 is industrial build
PTAA organic - active transfer on every photocopier lousy mobility but fit for purpose stable to 300C
Need to understand each application individually, doesn't have to be best material just need to be fit for purpose
Survival strategy for VoD - always look to market first what problems do you need help with, look to universities for consulting and knowledge
Deed to define key innovation needs - its not good science going forward it is the market, what do they need help with, what are the underpinning skills needed
Approach - partnership model, using existing strengths, develop national infrastructure
Decide themes, determine platforms and gate applications based on economic models

Peter Zilgalvis
Innovation - boarder: implementation of new or significantly improved
Considered that low hanging fruit has been plucked
State role - needed for social challenges: health and demographics, climate change and energy, education, security and defence
Political background - investment and innovation in digital sphere key drivers of growth and jobs, not yet taking advantage of digital economy opportunities due to segmentation, only 38% of crowd funding is across boarders due to money laundering laws
Bridging innovation gap - potential doesn't always translate, finance access is difficult, market barriers and red tape, innovation happens in clusters which are very important
Europe - needs better coordination of tools, procuring a solution to allow bottom up innovation for answers, not propping up failing companies to save jobs, open access is required but data control is key due to worries of big brother or leaks, individuals can see all accesses to their data allowing them to be an extra control

Panel
Valley of death is it the people causing the problem not the technology - young people will only go where they can see a future, think we have turned a corner and

employment is better, new DTCs are helping compete with other graduates across Europe
Money in not being well invested - funding must be audited but it is still critical to allow innovation not just incremental research, horizon 2020 is better as it emphasises simplification and getting products out, sometimes you do need very many countries, different instruments for different jobs
Pilot plant is good - companies need to do initial tests which would eventually be done by customs but needs to be done now in order to prove to customers so they can buy it and go on to do it themselves, need company large enough to recycle equipment and staff of falling project an put into the next one
Tech city, digital start ups numbers are very low but large amount of attention, young people go into coding not physics - it is a small investment in capital equipment and short turn around, you just need bright minds not lots of equipment, capital investment in equipment is risky as is the project fails the asset looses value, investors want manufacture to be done in Asia which has been recognised as a concern, investment cycles are too short term long term is not seen, shareholders are only concerned with money, government takes risk to allow industry to dabble
Nanomedecine what is missing - you need to get your customers to pay, nhs is too fragmented so no guaranteed reimbursement