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Commercialisation Strategies for Graphene: From Wonder Material to Engineering Material

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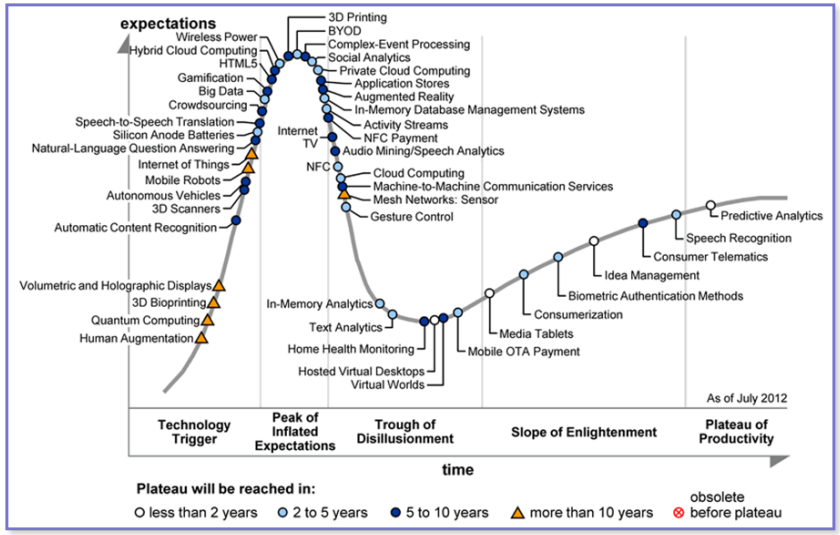
Outline

- Beyond the hype: a commercialisation strategy for graphene
- Graphene at Manchester
- How to partner with the National Graphene Institute



Source: Gartner

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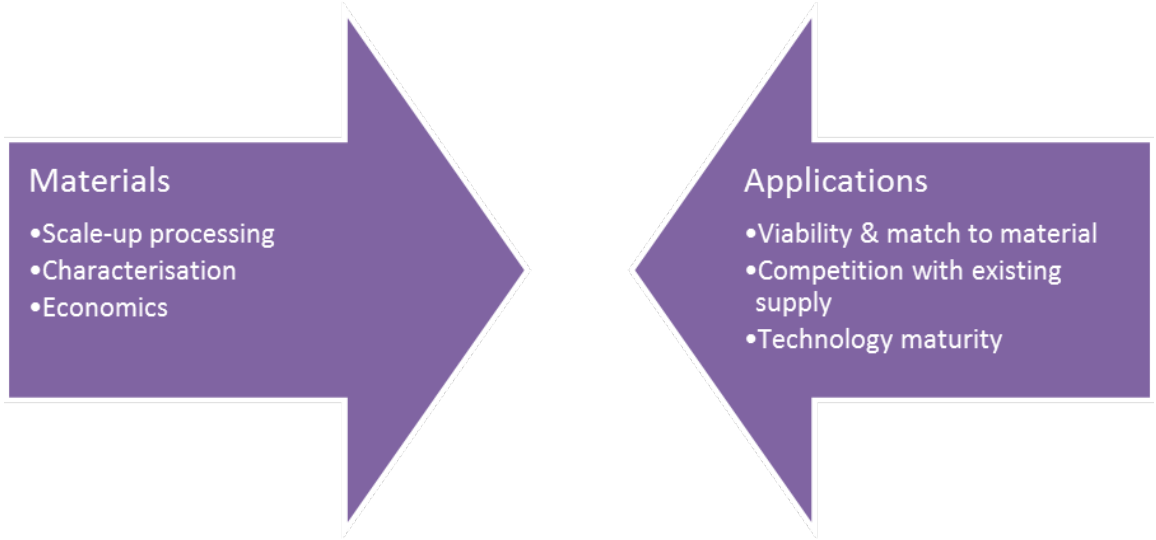
Challenges: From 2NP to GVA

- Staying internationally competitive
- Moving from Science to Engineering & Manufacturing
- Developing scalable manufacturing processes for graphene & intermediates
- Establishing commercial applications where graphene substitutes for other materials or enables transformative approaches
- Capturing supply chain value in the UK – and encouraging inward investment



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Strategy: International Leadership

- Focus on international leadership in:
  - Core research
  - Specified materials processes
  - Specified applications
  - Industrial Strategic Partnerships
  - Graphene Industry Group
  - IP management and aggregation, fostering Open Innovation
  - Venture Finance
- Graphene science, engineering and manufacturing
- Dual material and applications approach
- Work closely and openly with Graphene research groups, industry, and other stakeholders across the UK and beyond

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Graphene at Manchester

Physics
- Fundamental properties
- Novel 2D materials and heterostructures

Materials
- Process routes
- Characterisation
- Standards

Electronics
- Sensors
- Semiconductor devices

Chemistry
- Composites
- Membranes, barriers and coatings

Life Sciences
- Sensors, drug delivery
- Tissue engineering
- Nanotoxicology

Business School
- Technology innovation

Commercialisation
- IP management
- Venture Finance
- Business incubation

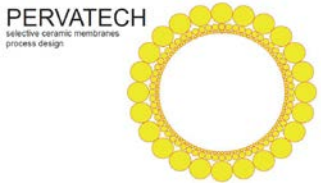
Spinouts
- 2-Dtech
- Graphene Industries

Industry Partners

THALES

SHARP

syngenta



Strategic Partner

Project Partners: Graphene-based membranes

Project Partners: Electrochemical Energy Storage

Project Partners: Other

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Graphene-based membranes

- Molecular Separations
- Ionic Conductors
- Sensors
- Barriers

CROWN
Brand-Building Packaging™

- Crown is working with the National Graphene Institute to improve its food packaging products and customer experience through the use of graphene-based membranes as barrier materials

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Batteries and Supercapacitors

- Supercapacitors: energy bottle-neck (3-5 W h kg^{-1})
- Batteries: power bottle-neck (10^3 W kg^{-1})

- SHARP is working with the National Graphene Institute to explore the benefits of graphene in electrochemical storage devices.
- One of the biggest hurdles that graphene currently faces is its cost in manufacture, in particular in terms of the cost and performance comparison to the low cost materials that graphene would likely replace.
- SHARP is excited to be part of a project that is looking to produce graphene on a cost competitive scale.

SHARP

0.2 Ah

20Ah

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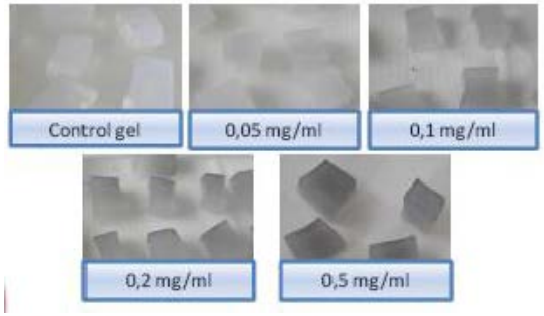
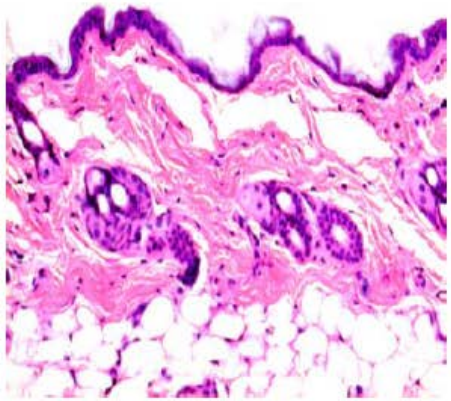
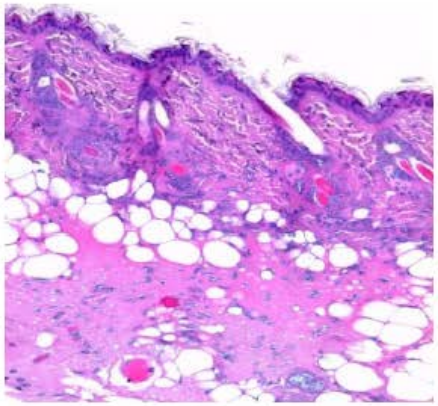
Drug Delivery



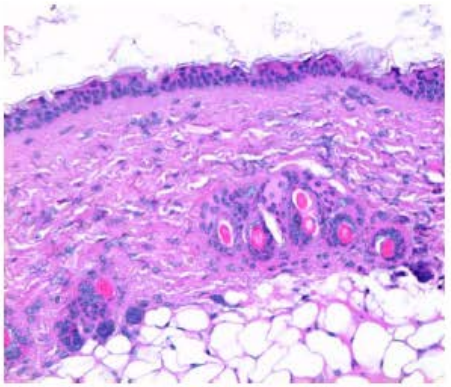
Graphene-based Electroresponsive Hydrogels are Safer



Blank gel



MWNT gel



Graphene gel

- Gels were implanted subcutaneously and electrically stimulated for 5 mins
- Significant inflammation for MWNT hybrid gels due to gel heating during stimulation

Servant *et al., submitted*, 2013

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Graphene Materials and Characterisation

- Process & characterisation tools, techniques and standards are critical to the adoption of graphene as an engineering material

- Bluestone has established its European operation alongside the National Graphene Institute in the UK
- With its long term commitment and cooperation with the National Graphene Institute, Bluestone will have access to a critical mass of world-class research talent, facilities and resources, located at the home of graphene

BGT BLUESTONE GLOBAL TECH

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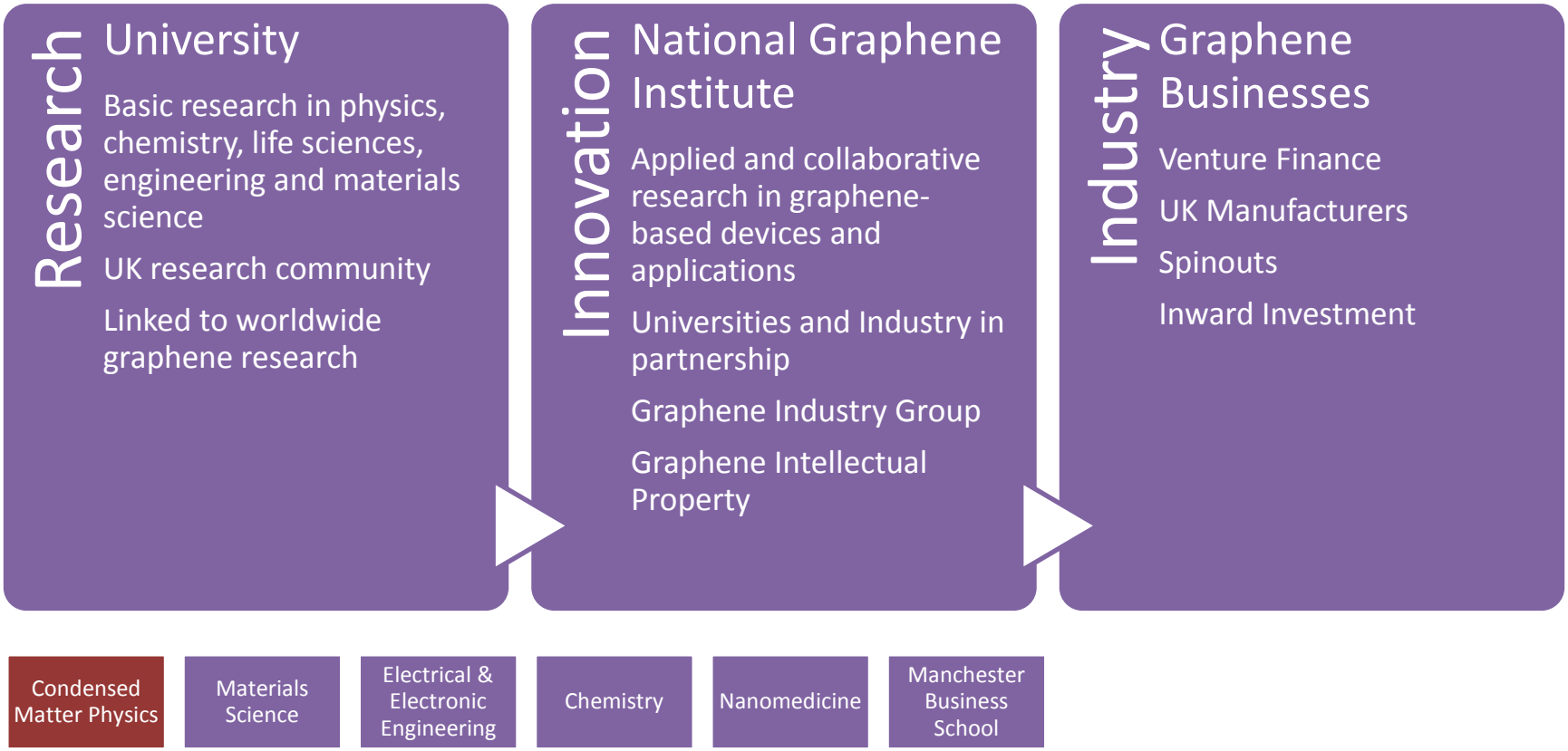
National Graphene Landscape



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Partner with the National Graphene Institute

- For Industry
  - Strategic Partnerships
    - Mutual partnerships with strategic (≥5 year) goals – partners create ecosystem supporting commercialisation
  - Project Partnerships
    - Individual projects, typically 1-3 year duration and topic specific
  - Graphene Industry Group
    - Open to all – pilot in Chemical Industries
- For Academic Research
  - Collaborative Research Projects
  - Knowledge Transfer
  - Synergy Grants & EU Flagship

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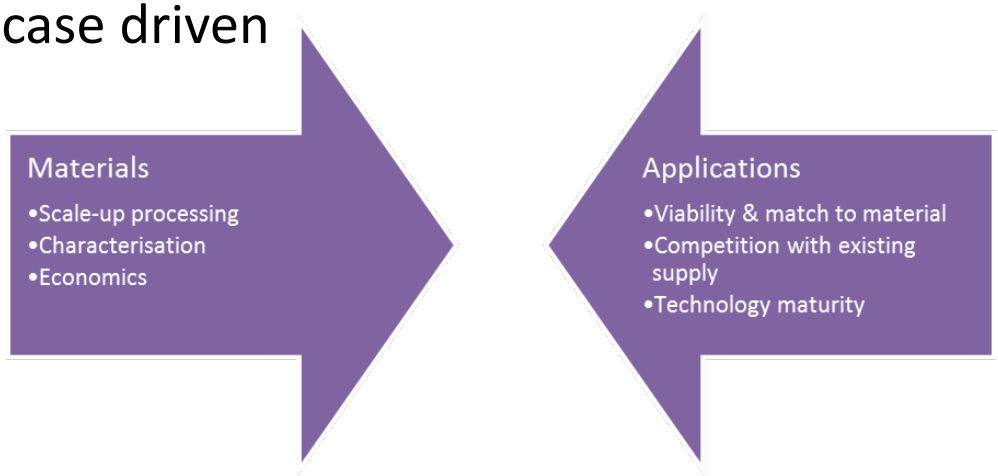
Focus of Partnerships

- Materials
  - Scalable processes and tools
  - Addressing characterisation challenges
  - Standards / metrology for materials and applications

- Applications
  - Substitutional and transformational applications
  - Developing supply chains
  - Market case driven



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EU Graphene Flagship

- 60 Partners, including:
  - Aixtron
  - Alcatel-Lucent
  - Thales
  - Nokia
  - ST Microelectronics
  - Varta Micro Innovation
  - Airbus Operations
  - Oxford Instruments
  - Philips Technology
  - Numerous activities in UK, including IP management

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Summary

- We're beyond the hype – it's time for the transition from science to engineering & manufacturing
- The focus of basic research has shifted to 2D materials
- 'Bridging the gap' strategy focuses on materials and applications
- Graphene at Manchester is great – Graphene in the UK is greater still
- Industry can partner with the NGI to leverage investment and maximise the UK graphene cluster