www.graphene.manchester.ac.uk

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Graphene@Manchester

GRAPHENE - Beyond the sticky tape

The Route to commercialisation…

James Baker

Graphene superlatives

- thinnest imaginable material
- strongest material ever measured (theoretical limit)
- stiffest known material (stiffer than diamond)
- most stretchable crystal (up to 20% elastically)
- record thermal conductivity (outperforming diamond)
- highest current density at room T (million times of those in copper)
- highest intrinsic mobility (100 times more than in Si)
- conducts electricity in the limit of no electrons
- lightest charge carriers (zero rest mass)
- longest mean free path at room T (micron range)
- most impermeable (even He atoms cannot squeeze through)
- ……?

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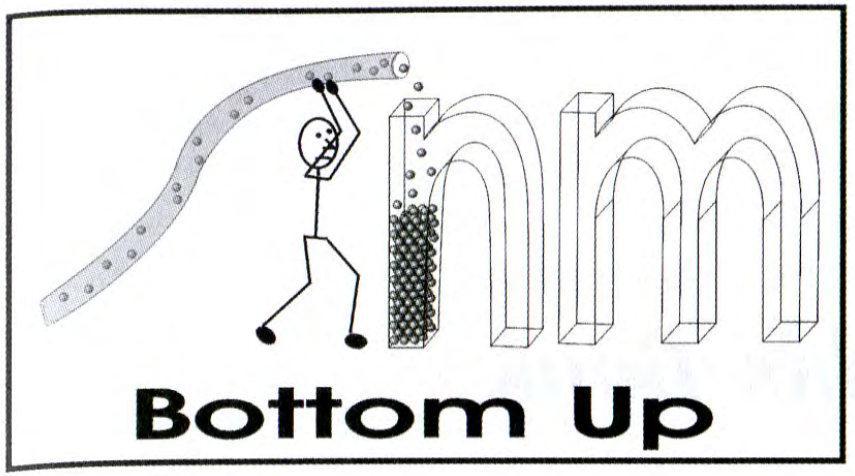
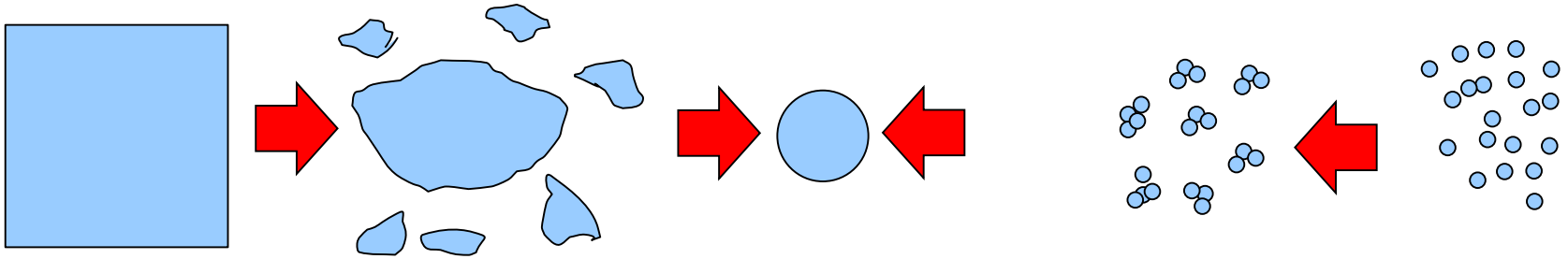
How to make graphene



Production by removing elements from a large starting material.

Assembly of a nanostructure from smaller elements.



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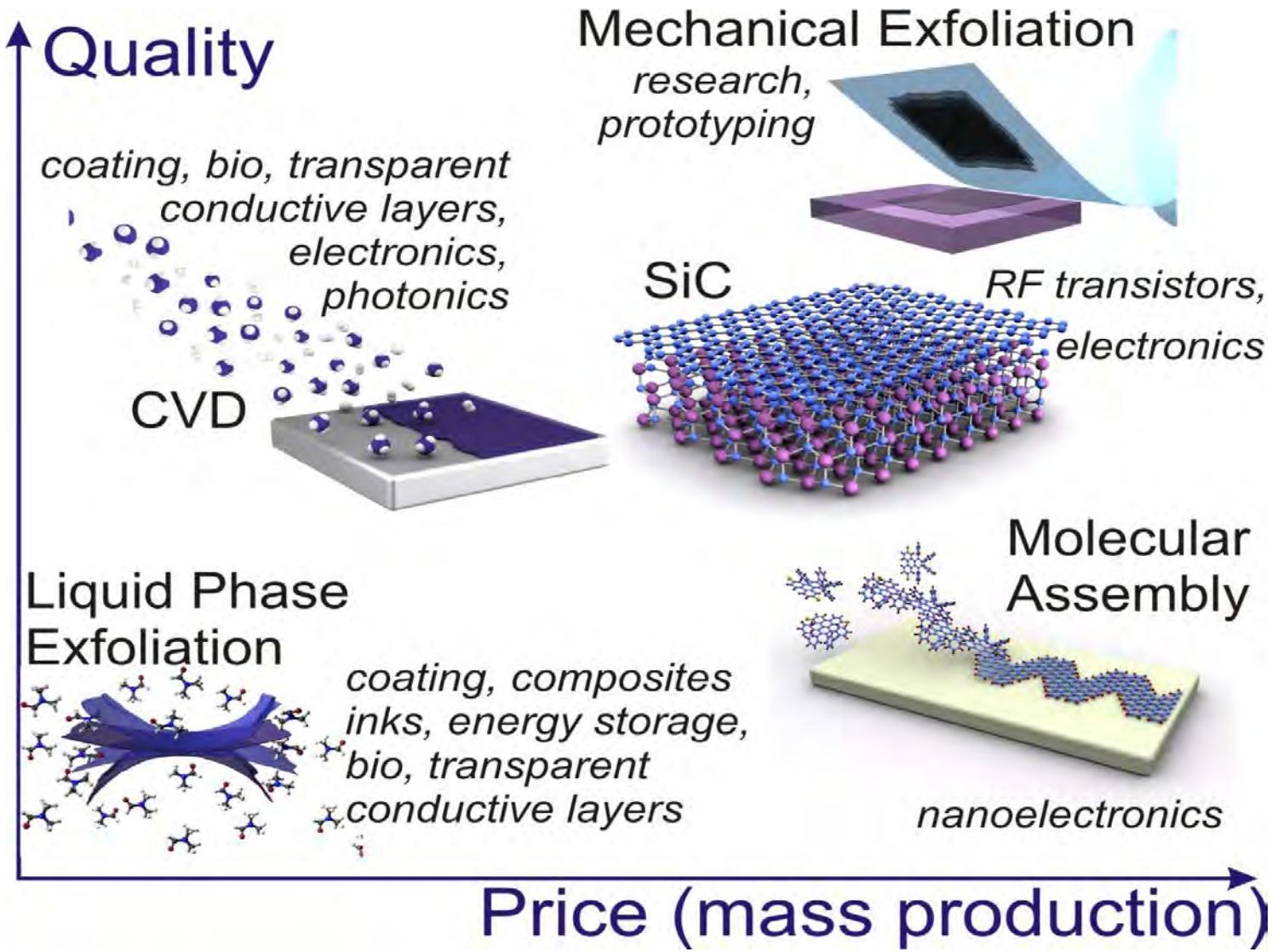
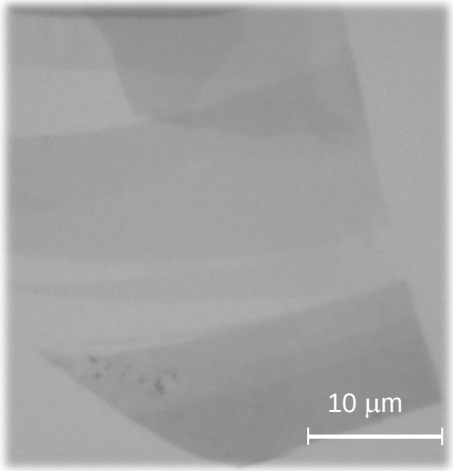
Producing graphene

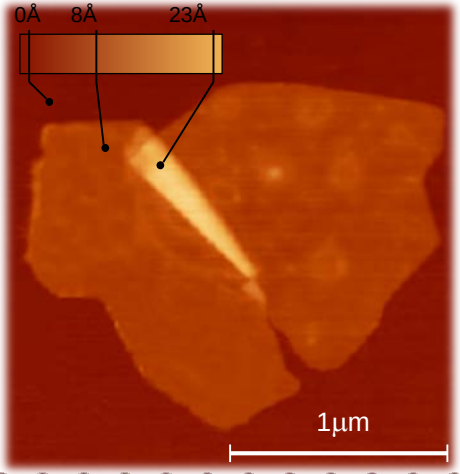


Beyond graphene: other 2D materials



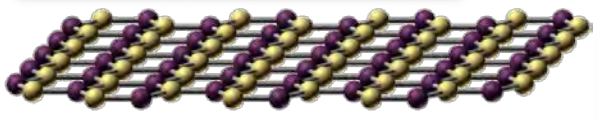
2D boron nitride

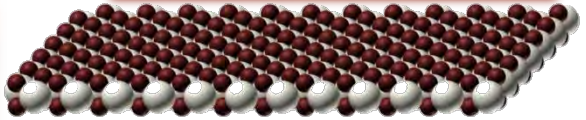
2D $NbSe_2$

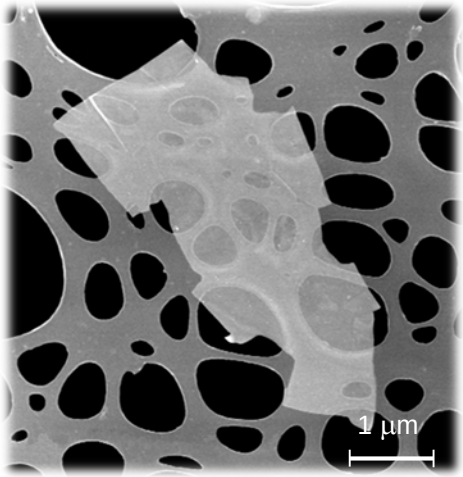


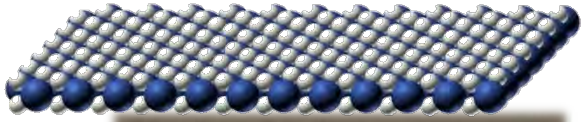
From 3D systems

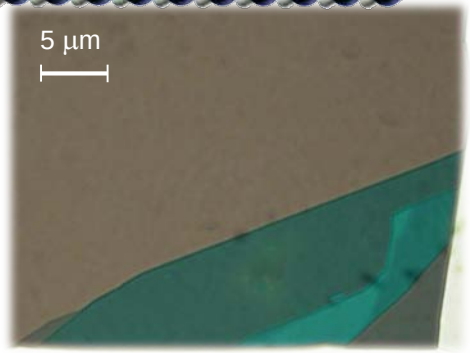
Beyond Graphene











Novoselov et al., PNAS (2005)

High Quality

Different From 3D Precursor

2D $Bi_2Sr_2CaCu_2O_x$

2D MoS_2

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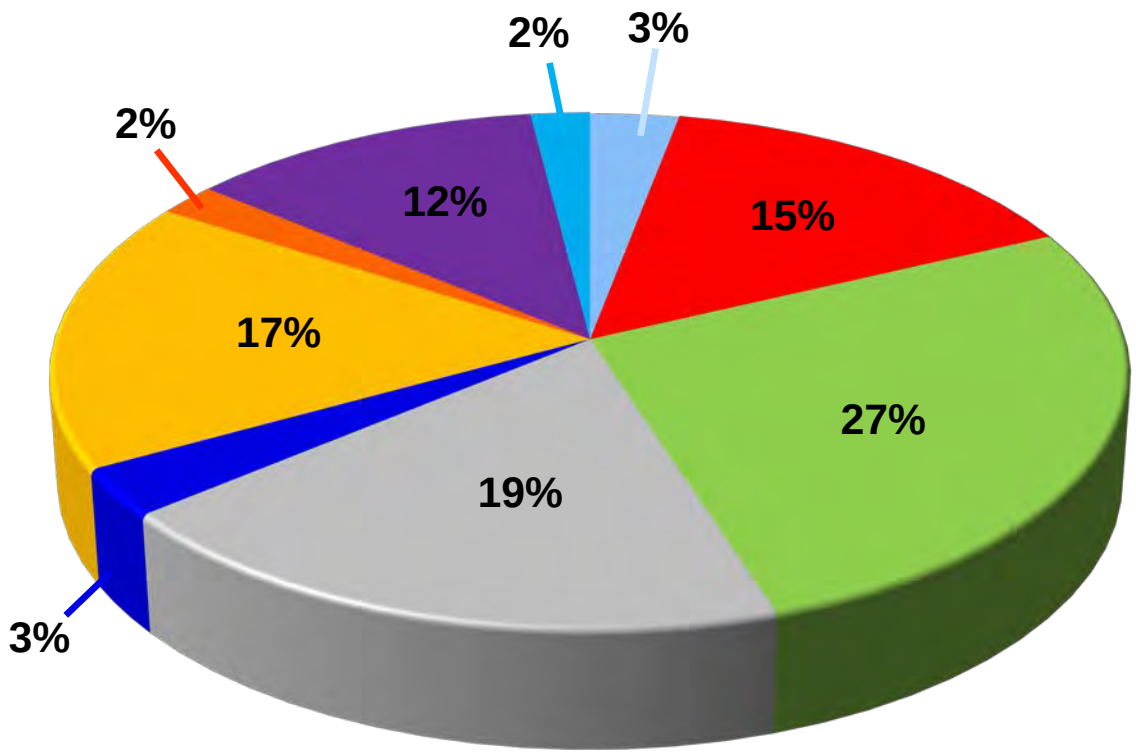
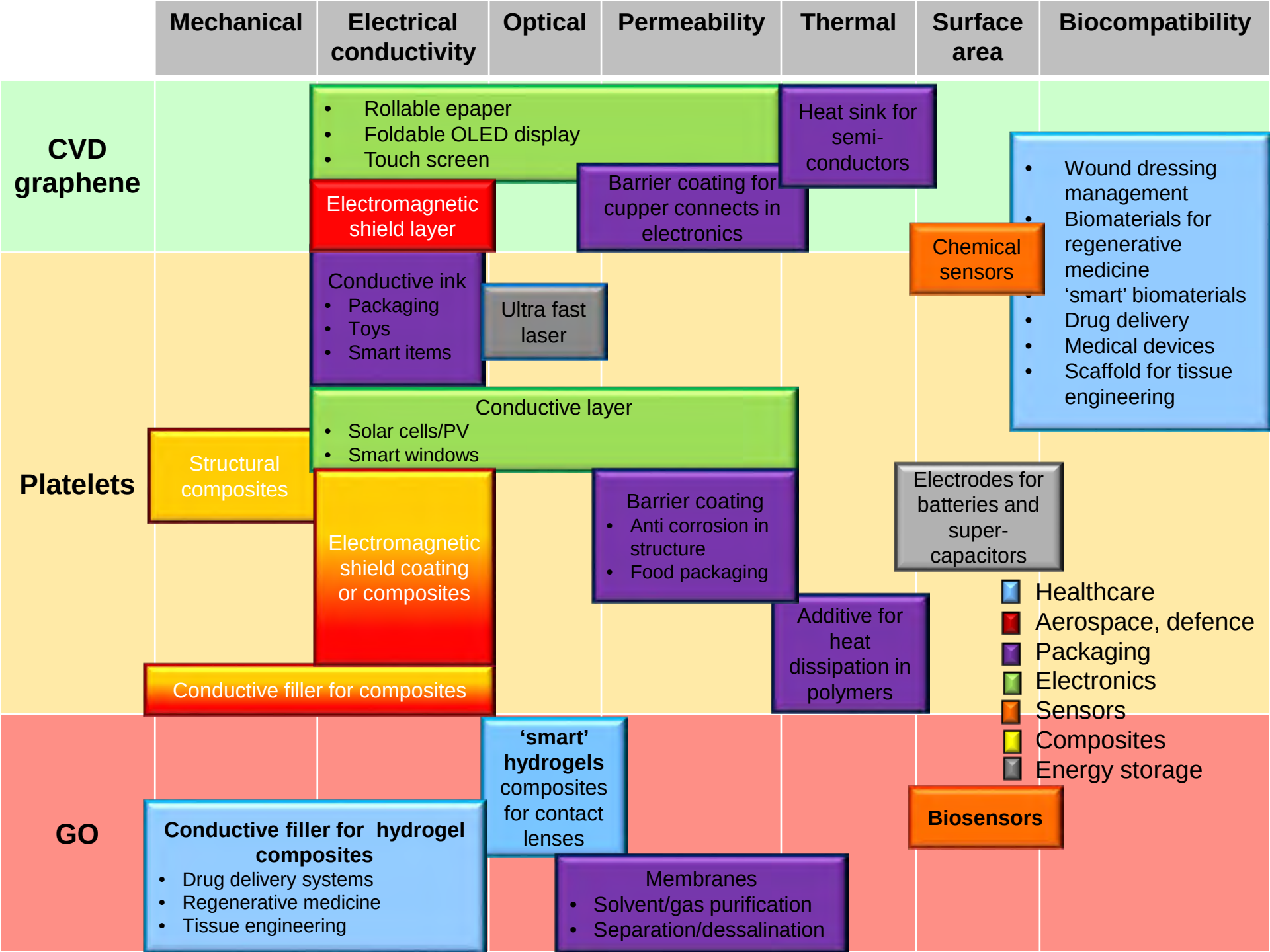
Application sectors



- Healthcare
- Aerospace & defence
- Electronics, optoelectronics and semi-conductors
- Energy Storage
- Automotive
- Plastics, composites
- sensors
- coating, packaging and paints
- telecommunications

Source: Future Markets


Mechanical
Electrical conductivity
Optical
Permeability
Thermal
Surface area
Biocompatibility
CVD graphene
Platelets
GO
Rollable epaper
Foldable OLED display
Touch screen
Heat sink for semi-conductors
Electromagnetic shield layer
Barrier coating for cupper connects in electronics
Chemical sensors
Wound dressing management
Biomaterials for regenerative medicine
'smart' biomaterials
Drug delivery
Medical devices
Scaffold for tissue engineering
Conductive ink
Packaging
Toys
Smart items
Ultra fast laser
Conductive layer
Solar cells/PV
Smart windows
Structural composites
Electromagnetic shield coating or composites
Barrier coating
Anti corrosion in structure
Food packaging
Electrodes for batteries and super-capacitors
Additive for heat dissipation in polymers
Conductive filler for composites
Healthcare
Aerospace, defence
Packaging
Electronics
Sensors
Composites
Energy storage
'smart' hydrogels composites for contact lenses
Biosensors
Conductive filler for hydrogel composites
Drug delivery systems
Regenerative medicine
Tissue engineering
Membranes
Solvent/gas purification
Separation/dessalination

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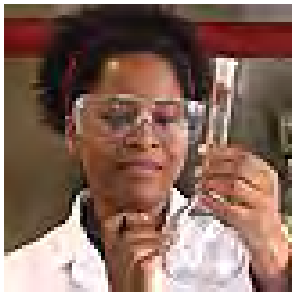
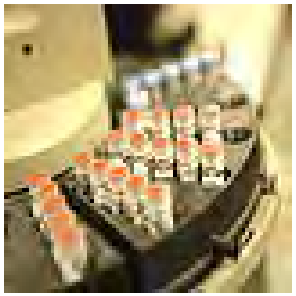
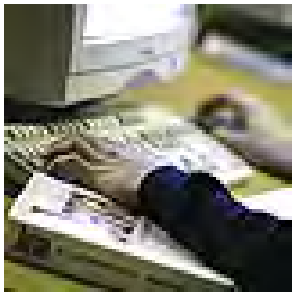
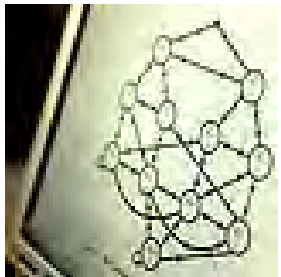








Physics
Fundamental properties
Novel 2D materials and hetero-structures

Spinouts
Graphene research
2-Dtech
Graphene Industries

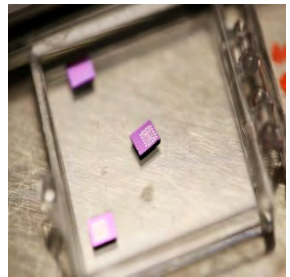
Materials
Process routes
Characterisation
Standards

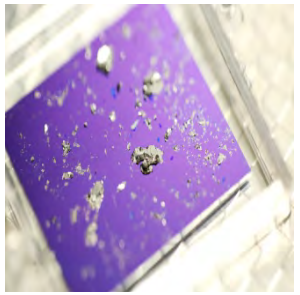
NGI Capabilities

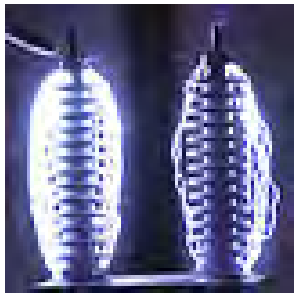
Life Sciences
Sensors, drug delivery
Tissue engineering
Nanotoxicology

Electronics
Sensors
Semiconductor devices

Chemistry
Composites
Membranes, barriers and coatings







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NGI Industry partners

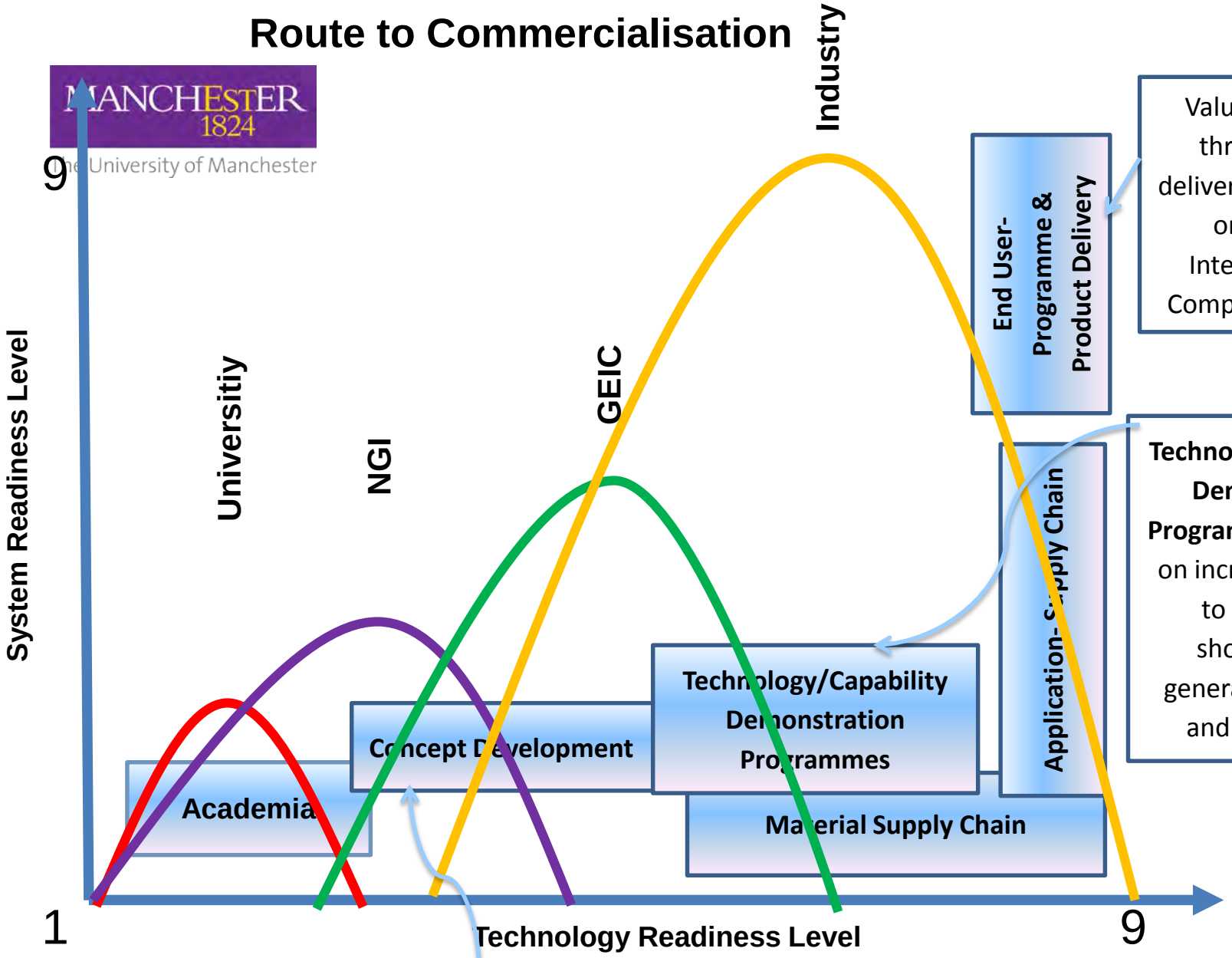
Strategic Partner

Project Partners: Graphene-based membranes

Project Partners: Electrochemical Energy Storage

Project Partners: Other

Route to Commercialisation



Concept Development – focus is on a) increasing the technology development TRL – manufacturing scale up, characterisation and measurement, b) experiment with the art of the possible future applications and concepts and c) provide inputs to Concept Development.