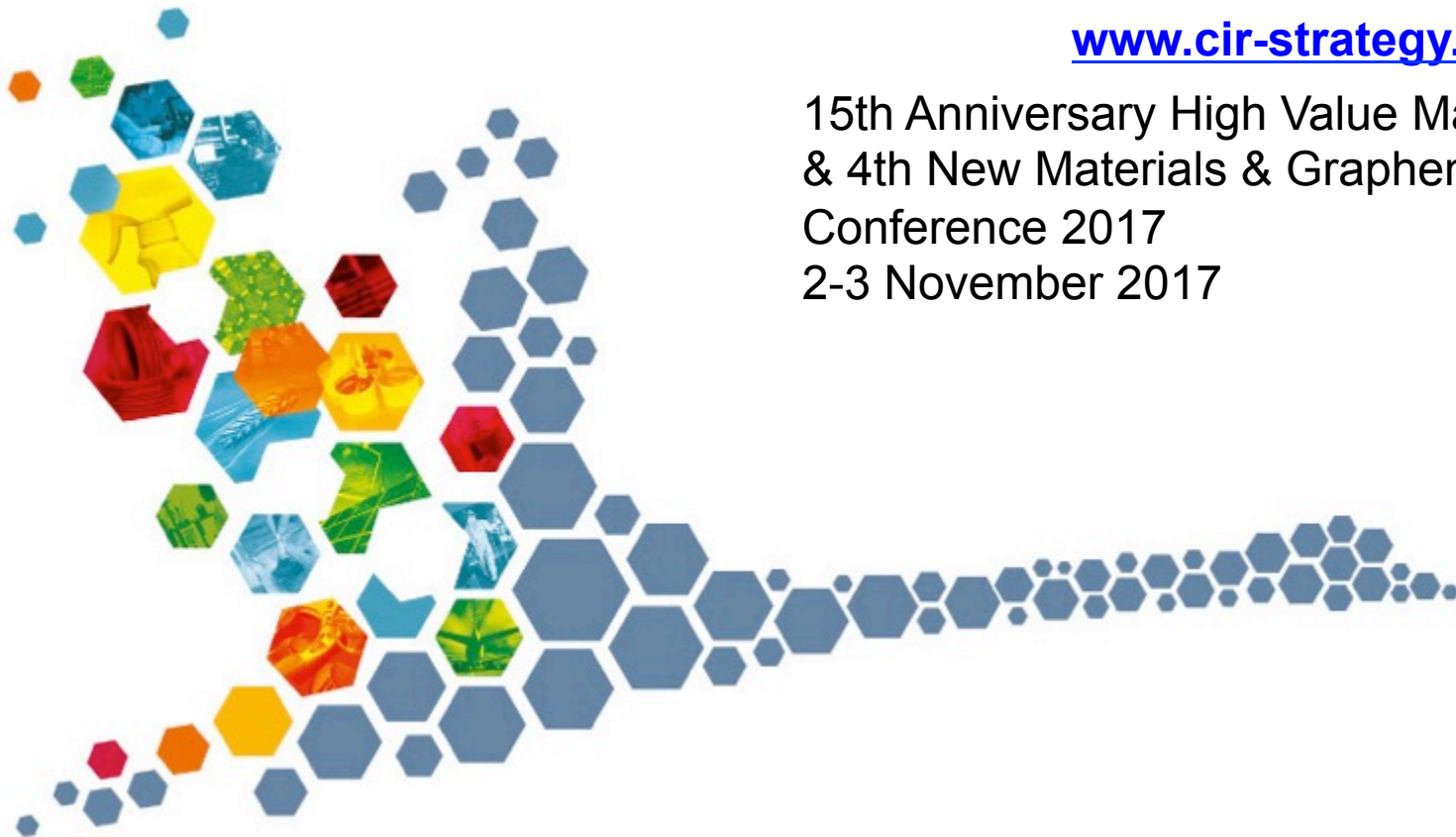


www.cir-strategy.com/events

15th Anniversary High Value Manufacturing
& 4th New Materials & Graphene
Conference 2017
2-3 November 2017



Thomas Swan & Co. Ltd.
Leaders in performance and speciality chemicals

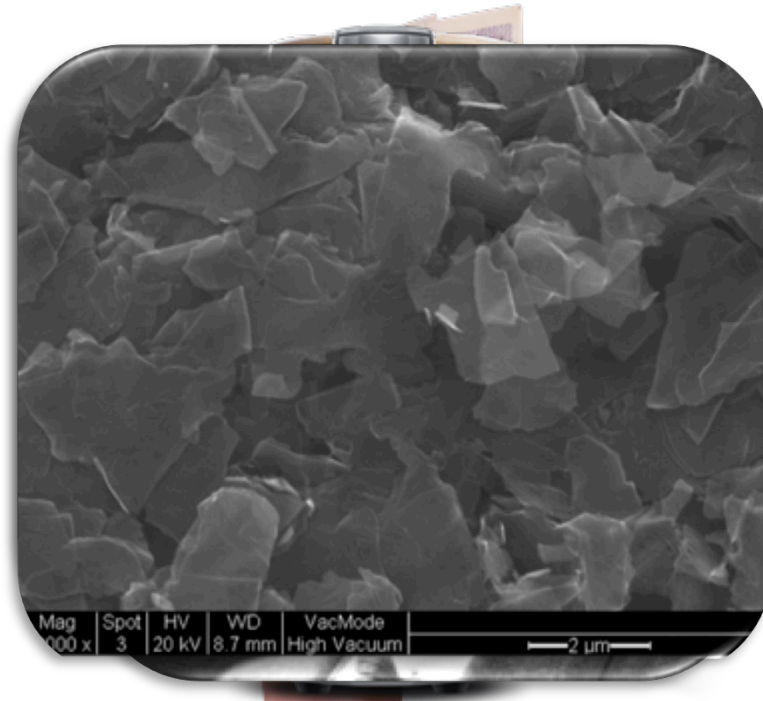
4th Graphene New Materials
15th HVM Conferences
Cambridge, 2-3rd November 2017

Harry Swan, Managing Director
Thomas Swan & Co. Ltd.

From Concord to Composites, our Graphene Story

Our Graphene Story...

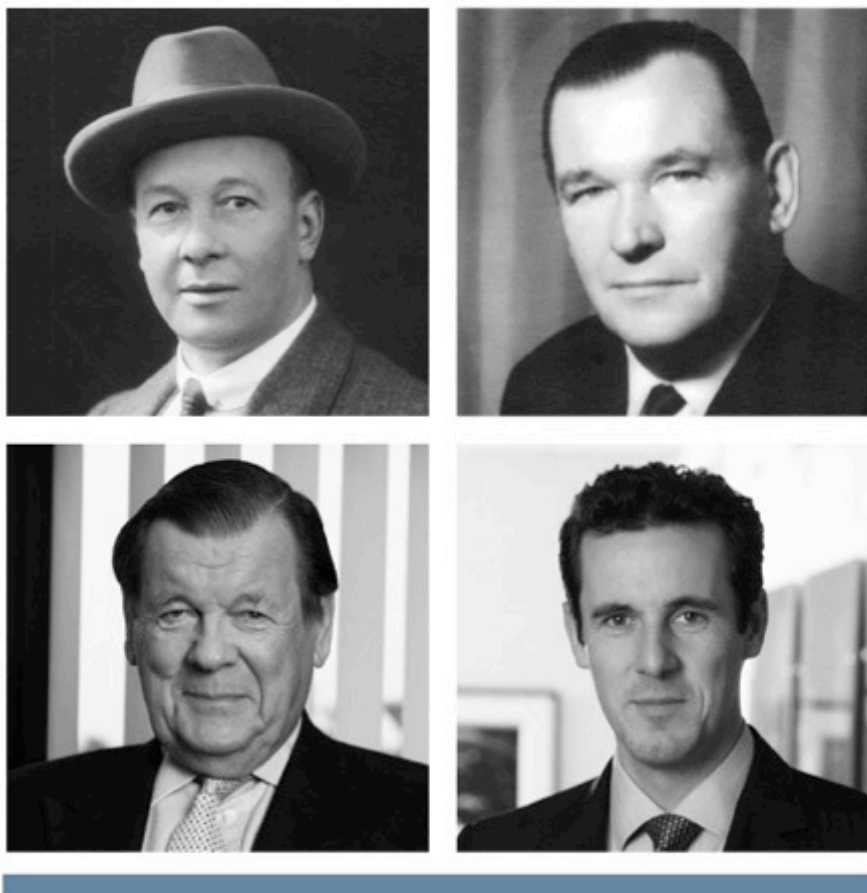
Overview



Thomas Swan & Co. Ltd.



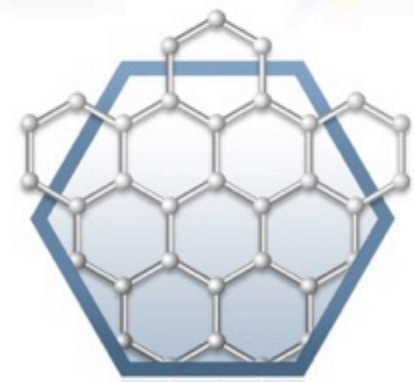
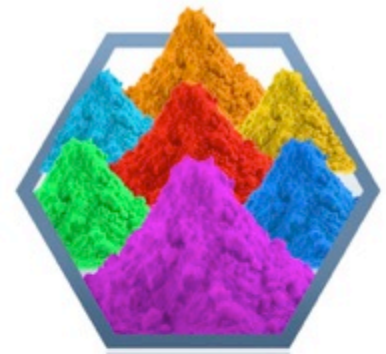
History

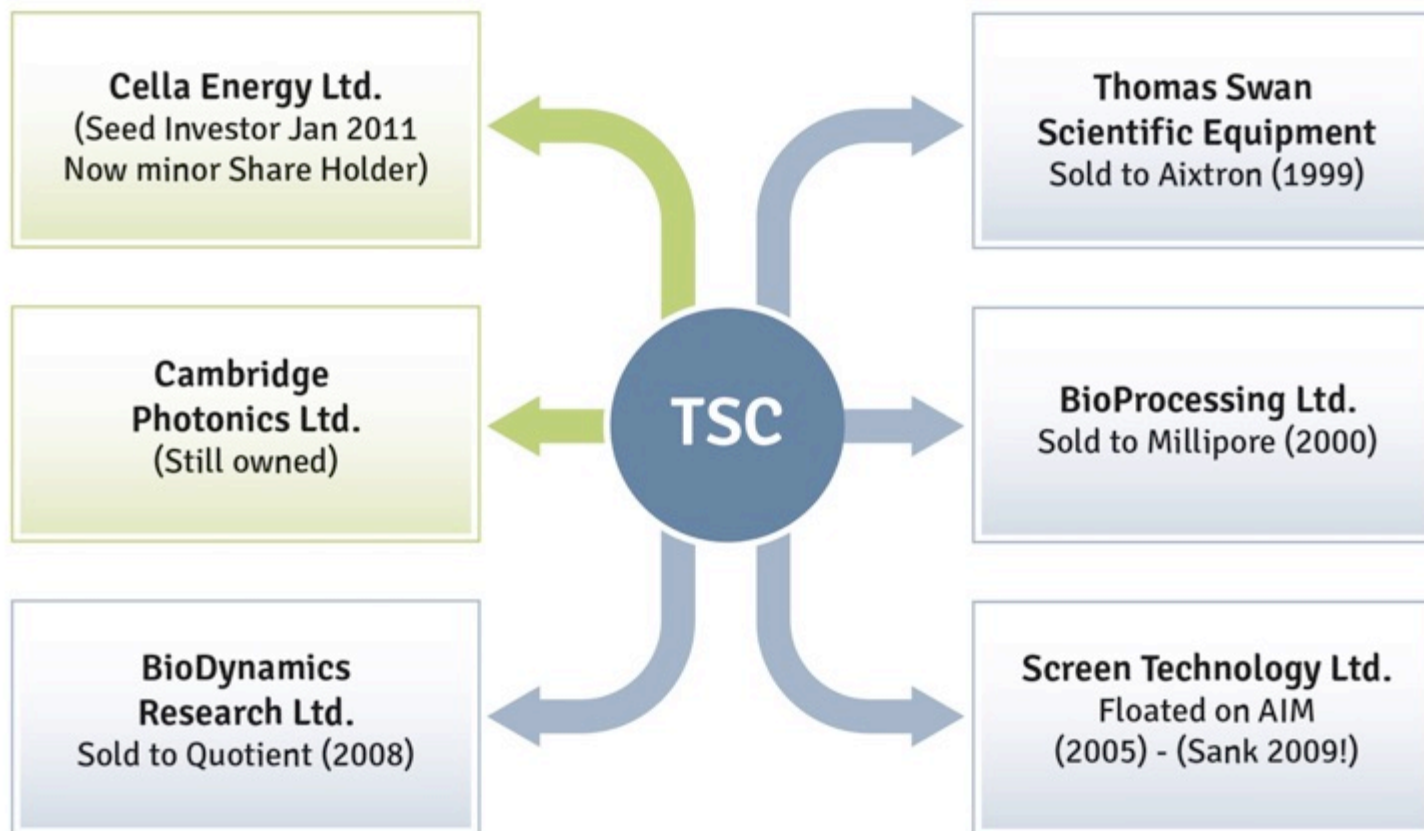


Four generations of Swan family



Core Chemical expertise





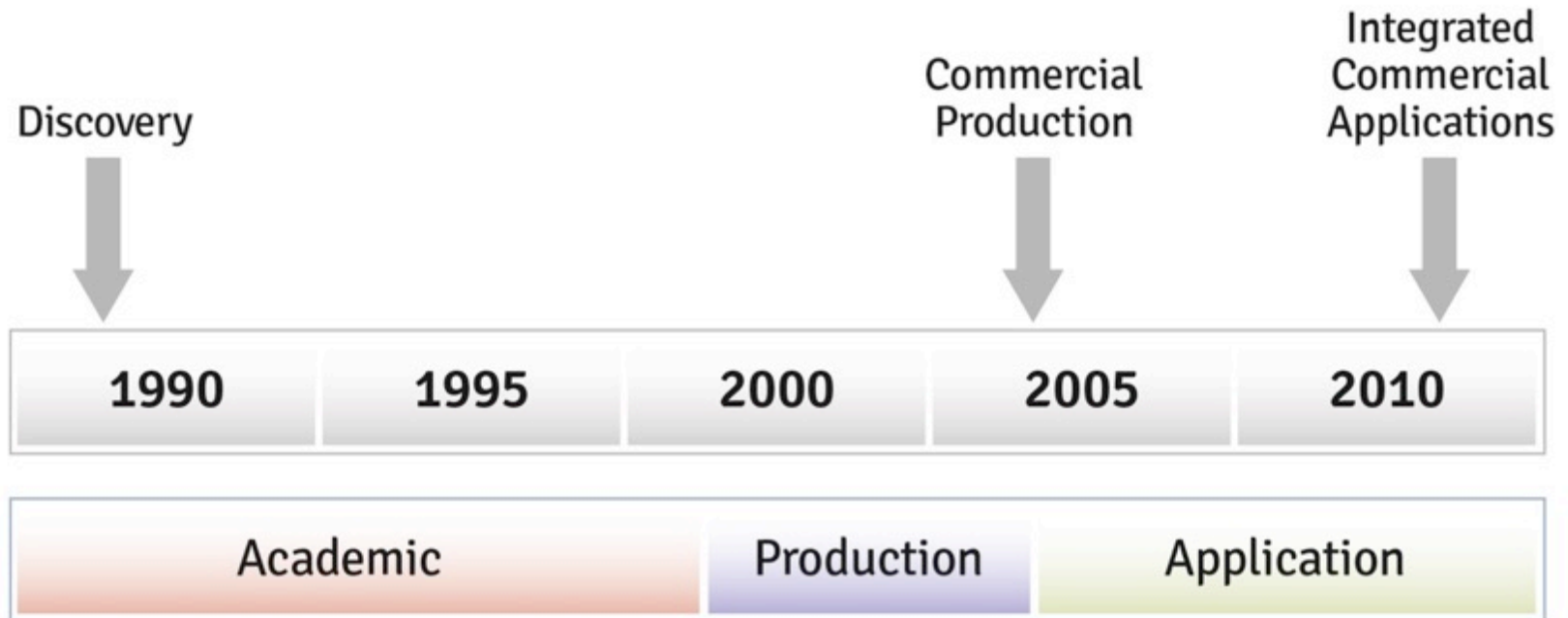
What is Innovation to Thomas Swan?

“Innovation is any new idea, no matter how small or large, that adds value [to the company].”

Platform for Innovation



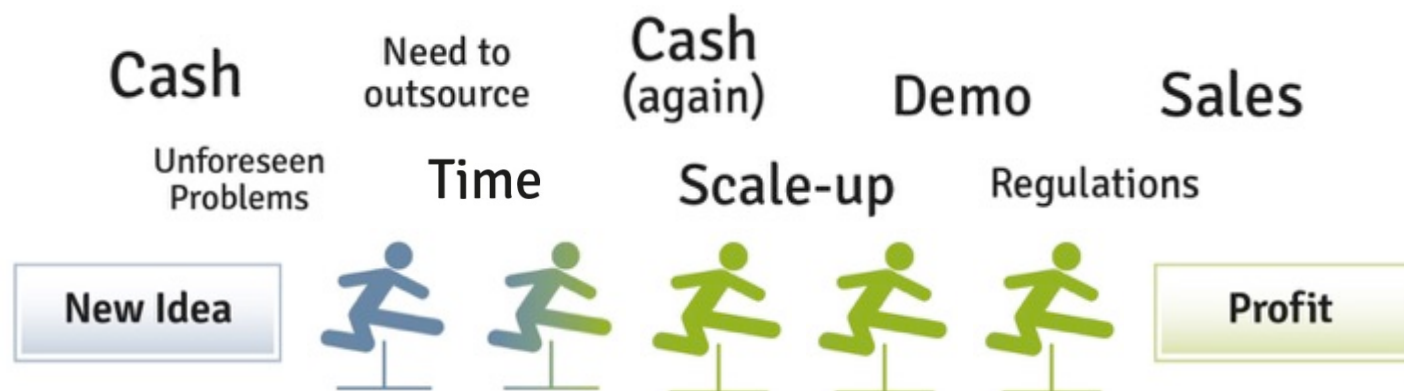
Carbon Nanotubes Application Time Line*



*As written in 2004...!



The Innovation Challenge



Which is why financial support, help to find technical and process solutions, marketing, IP, sales and export advice is so important. We have been helped by, or worked with, all of the following:

- | | | | |
|------|--------------|------|-----------|
| KTN | EPSRC | EU | UKTI |
| STFC | Innovate UK | CIA | Embassies |
| CPI | Universities | OECD | NEPIC |

Failure is a critical part of innovation



<https://www.youtube.com/watch?v=P5elyRVpwmc>

Supercritical Fluids

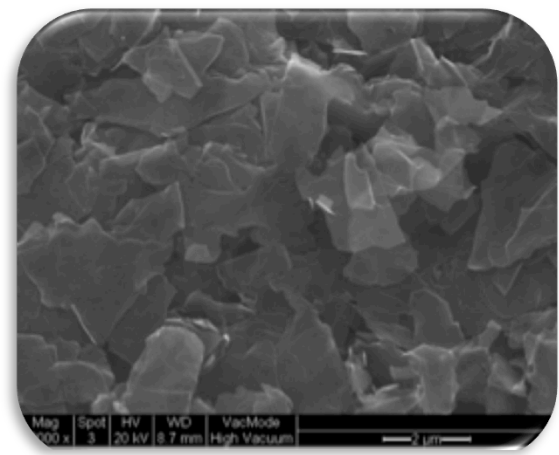
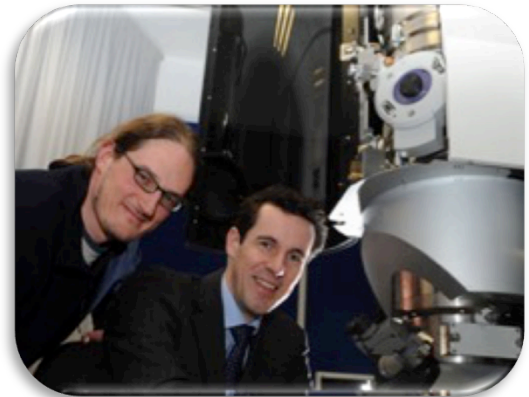
- Launched 2001 as world's first continuous, high pressure supercritical fluid reactor
- Laboratory, pilot plant and commercial scale production
- Potential for faster, cleaner chemistry

FAILED





The recipe for graphene...

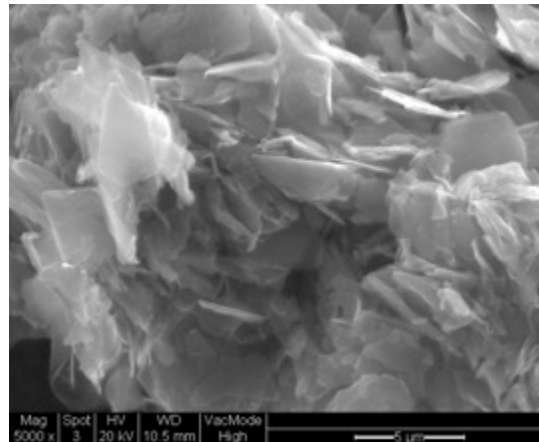
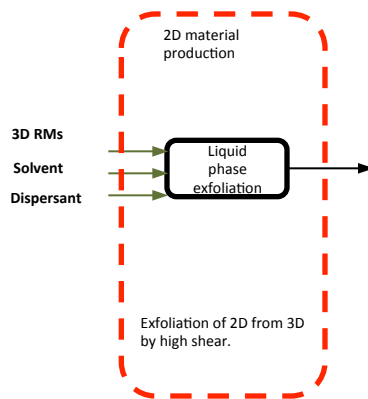




The Direct Liquid Exfoliation Process

We selected a scalable high shear exfoliation route:

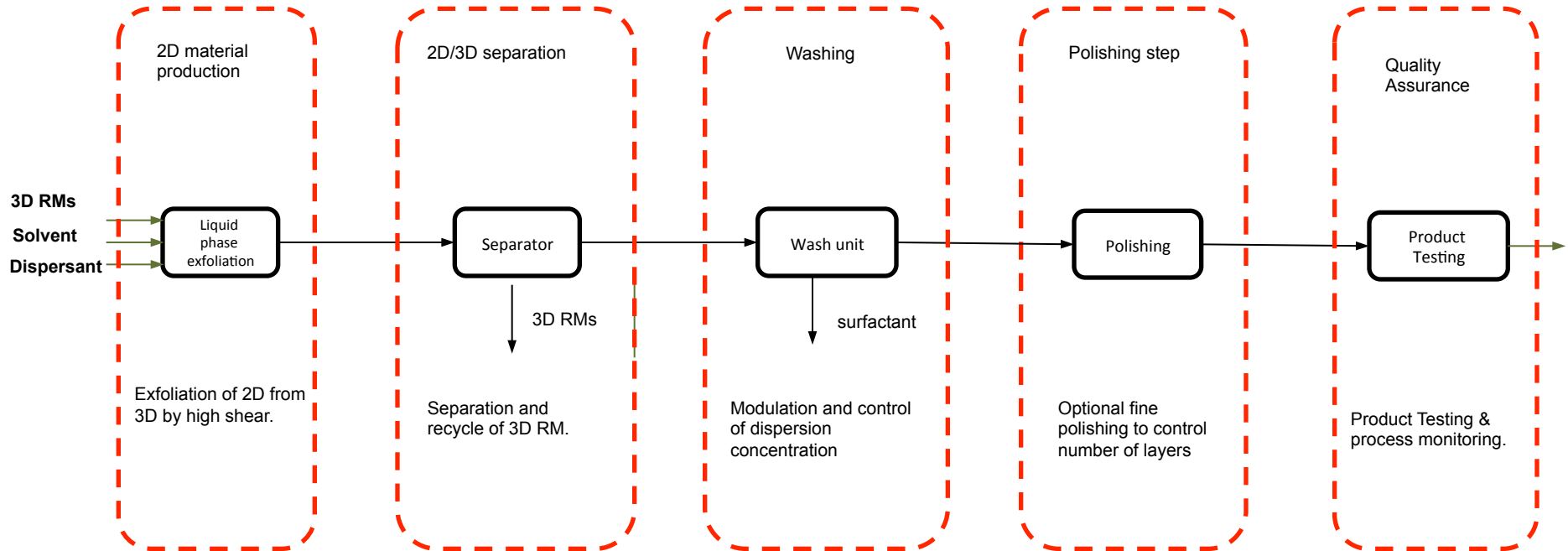
- Ambient conditions.
- No ultra-sonication.
- No aggressive chemistry.
- Range of solvents – including water.
- Range of mineral raw materials.
- Scalable mineral processing.
- Products are stabilised 2D dispersions and powders.



Developed in Collaboration
with AMBER at
Trinity College Dublin.

Full scientific details have been published: Paton, Coleman *et al.*,
Scalable production of large quantities of defect-free, few-layer graphene by shear-exfoliation in liquids
Nature Materials Volume: 13, Pages:624–630 (2014)

The Direct Liquid Exfoliation Process



Tunable process allows for flexible design of 2D Materials products

Patent protected process

The Direct Liquid Exfoliation Process



- Developed with funding support from EU H2020
- Manufacturing capacity for Elicarb[®] Graphene products 20 tonne/yr.
- Ambient processing with no oxidation chemistry – giving pristine, non-oxidised products.
- Flexibility to manufacture range of 2D products including Elinova[®] Boron Nitride and Elinova[®] Molydenum Disulfide.
- Tunability to manufacture range of product grades from few-layer to multi-layer



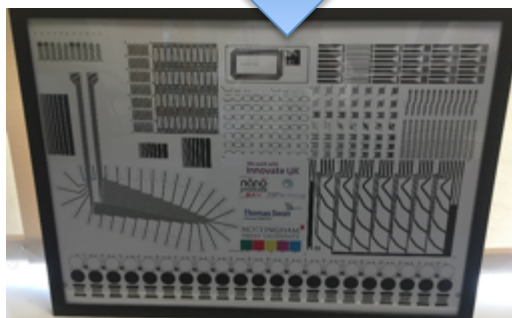
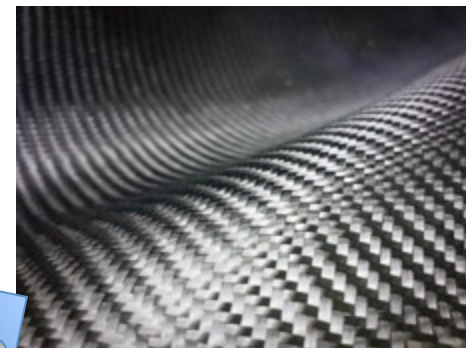
Graphene – the product!

Elicarb[®] Graphene Epoxy Dispersion

15% w/w Dispersion of Elicarb[®] Materials
Grade Graphene in Epoxy Resin



Graphene Applications



2D Product Applications – Mechanical

Elicarb® Graphene platelets improve mechanical properties of polymers with small additive levels.

Results to be published soon in scientific papers.

1% w/w Elicarb® Materials Grade Graphene in epoxy resin

- Flexural strength increases by 22%.
- Flexural modulus increases by 28%.

1% w/w Elicarb® Materials Grade Graphene in laminated carbon composite:

- Flexural strength increases by 15%.
- Flexural modulus increases by 28%.

1% w/w Elicarb® Materials Grade Graphene in polypropylene:

- Tensile modulus increases by 15%.
- Improvements also observed in other thermoplastics and elastomers (EPDM, SBR, PU).

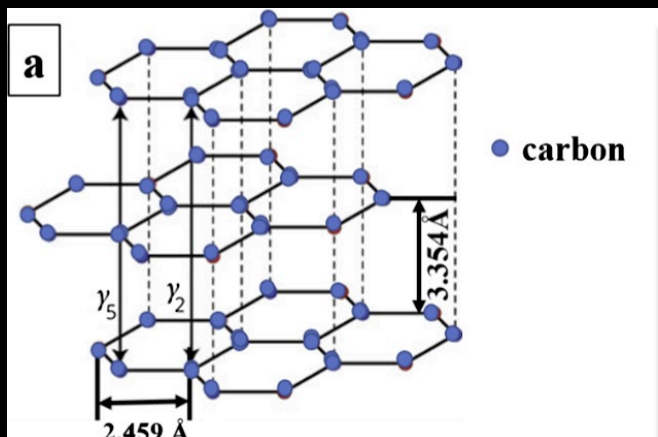


Flexural - 3 point bending

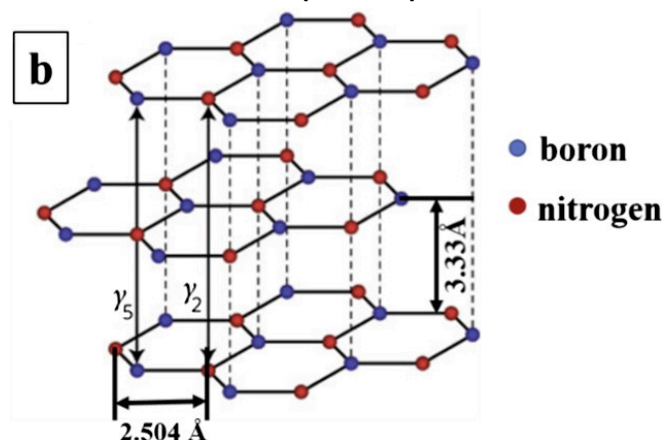


Tensile Testing

Graphite



Boron nitride (h-BN)



Strong bonds within plane, weak bonds between planes

Graphene

- Natural mineral – existing mining industry
- Black powder
- Honeycomb structure of C atoms
- High electrical conductivity
- Chemically inert carbon
- Very high thermal conductivity
- Mechanical strengthening
- Gas and chemical barrier.

2D Boron Nitride

- Chemically manufactured material
- **White powder**
- Honeycomb structure of alternating B and N atoms
- **High dielectric material**
- Chemically inert ceramic
- Very high thermal conductivity
- Mechanical strengthening
- Gas and chemical barrier

Thank you!



We work with
Innovate UK



<http://necomada.eu.gridhosted.co.uk>



<http://www.nano-inspired.eu/>

www.thomas-swan.co.uk

