SWINBURNE UNIVERSITY OF TECHNOLOGY

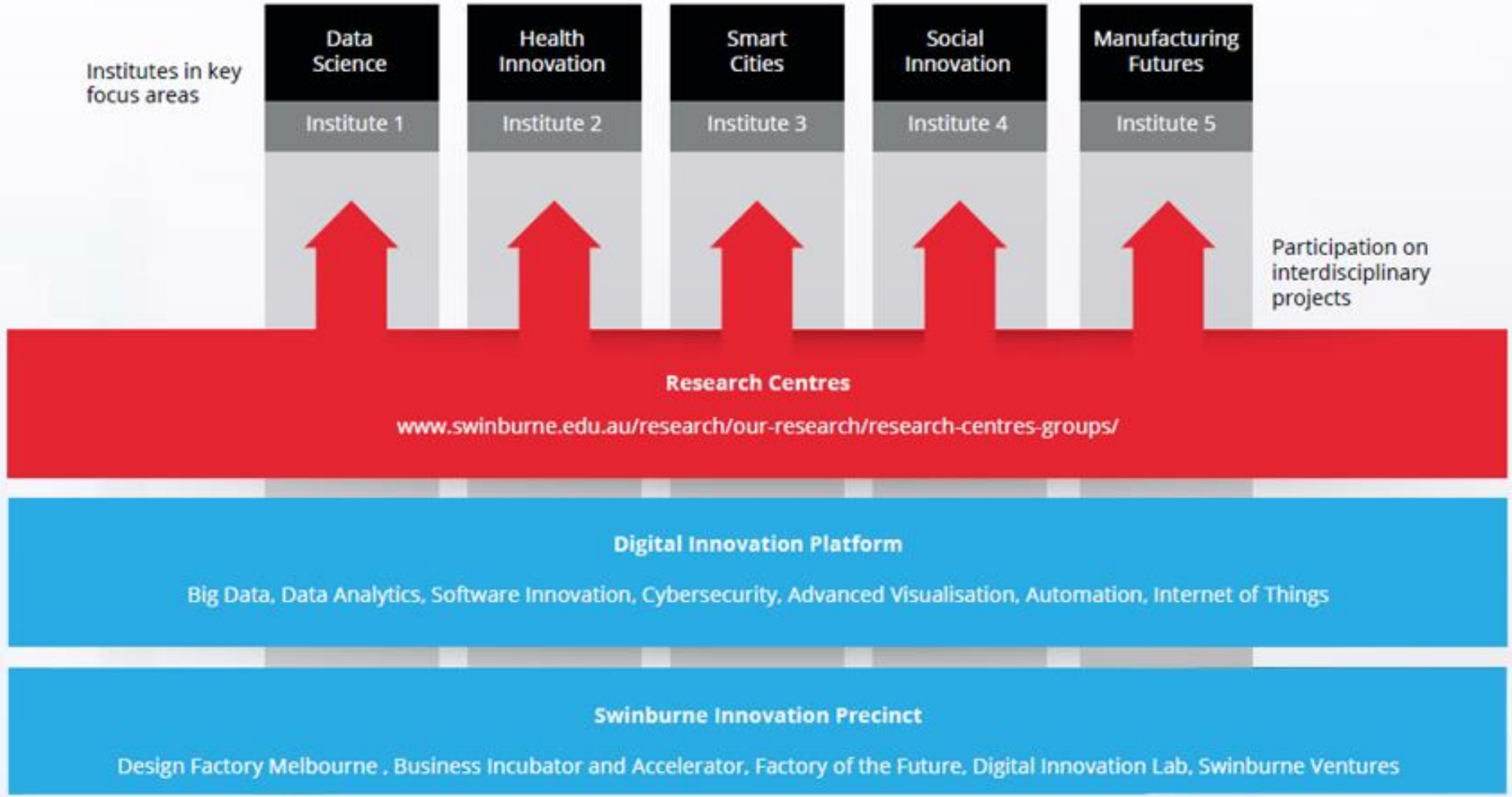
Next generation carbon based materials

Professor Bronwyn Fox

February 2018

Overview of the Swinburne Research Ecosystem.

We are focused on collaborative interdisciplinary research in high impact areas built on advanced capabilities and excellence in select discipline areas.



Manufacturing Futures Research Institute - Highlights from the first year:

- Graphene certification centre (CRC-P)
- Graphene Supercapacitor (CRC-P)
- Asahi Industry 4.0 Partnership
- Ford University Research Project
- PhD project with Boeing and University of Stuttgart
- Digitalization of the Factory of the Future – Siemens
- Airspeed/DMTC Project
- Established strategic partnerships with German Industry 4.0 consortiums including LNI4.0 and ARENA 2036

Swinburne's core strength is our ability to creatively solve real world problems by bringing together multidisciplinary teams.

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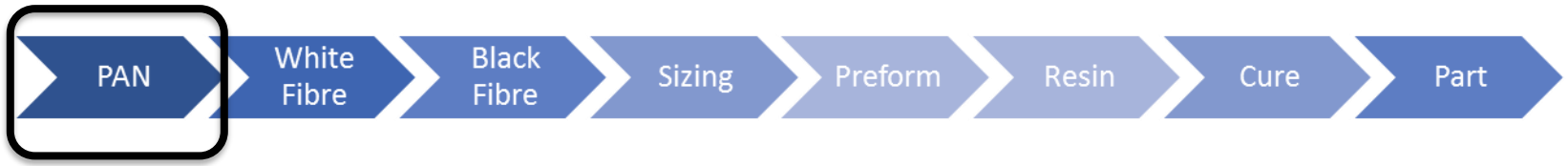
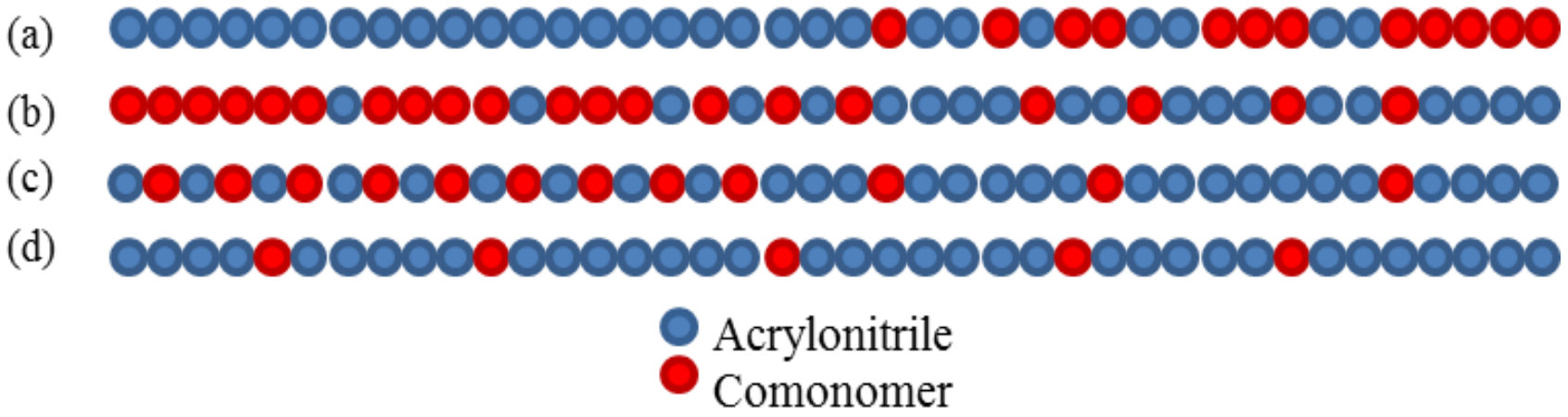
Digitalization of the Factory of the Future

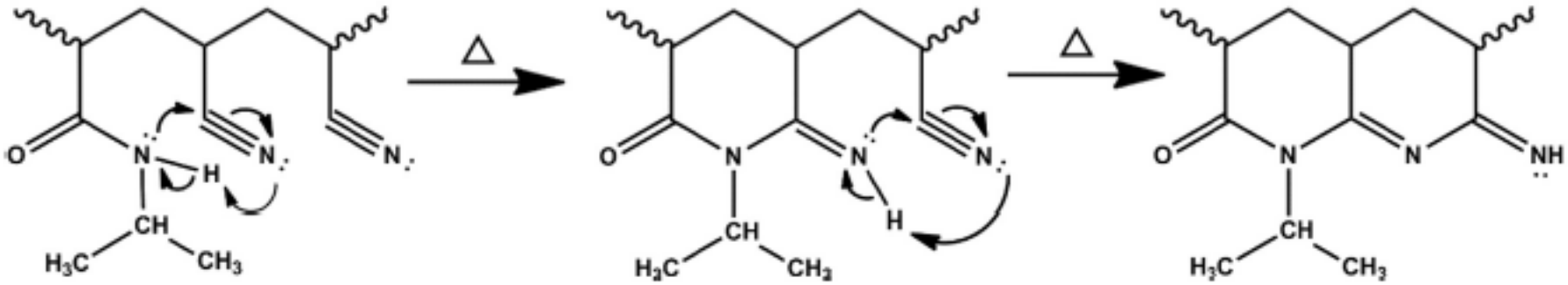
- Swinburne's Advanced Manufacturing and Design Centre has just won access to technology from industrial giant Siemens with an estimated value of $135 million.
- The grant is the largest of its kind ever awarded in Australia and will allow researchers to design and develop products in a virtual environment without having to build physical prototypes. This will also help train future Australian engineers and other students in cutting edge manufacturing skills they are likely to need as manufacturing becomes digitised.
- The fully digitalised Swinburne 'factory of the future' "will set an Industry 4.0 benchmark and provide an environment for workforce transformation that is in line with the most advanced economies in the world," says Swinburne DVCR Aleksandar Subic.

Carbon Fibre Composite Manufacture

Source: SGL ACF

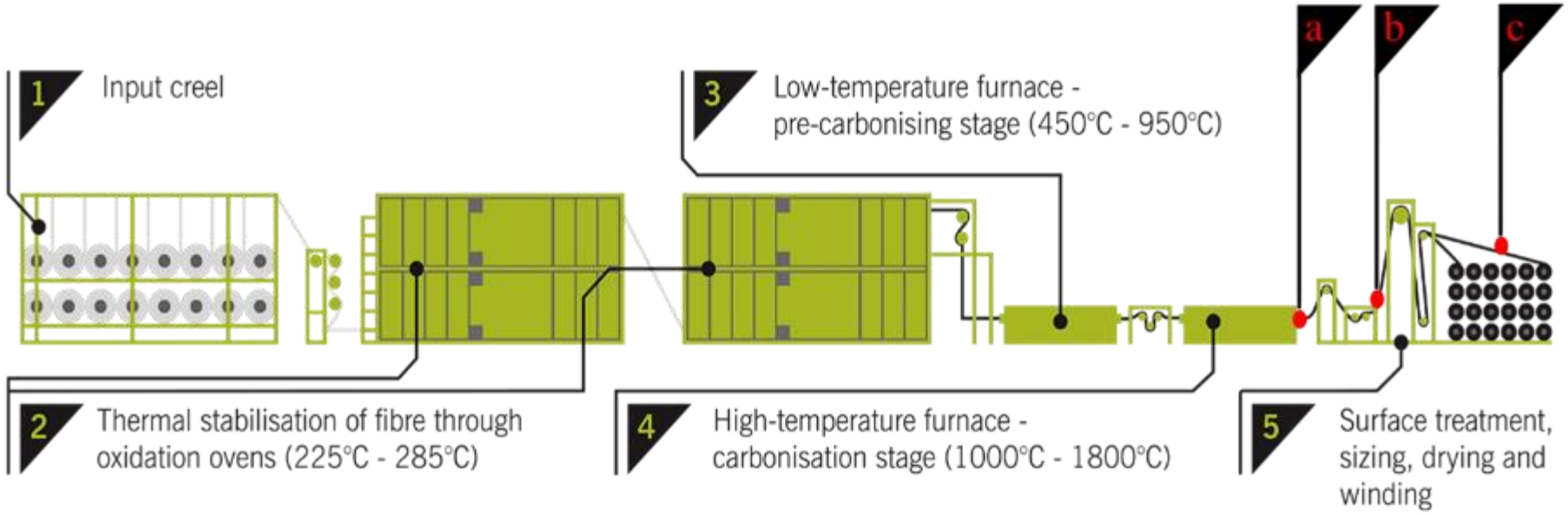






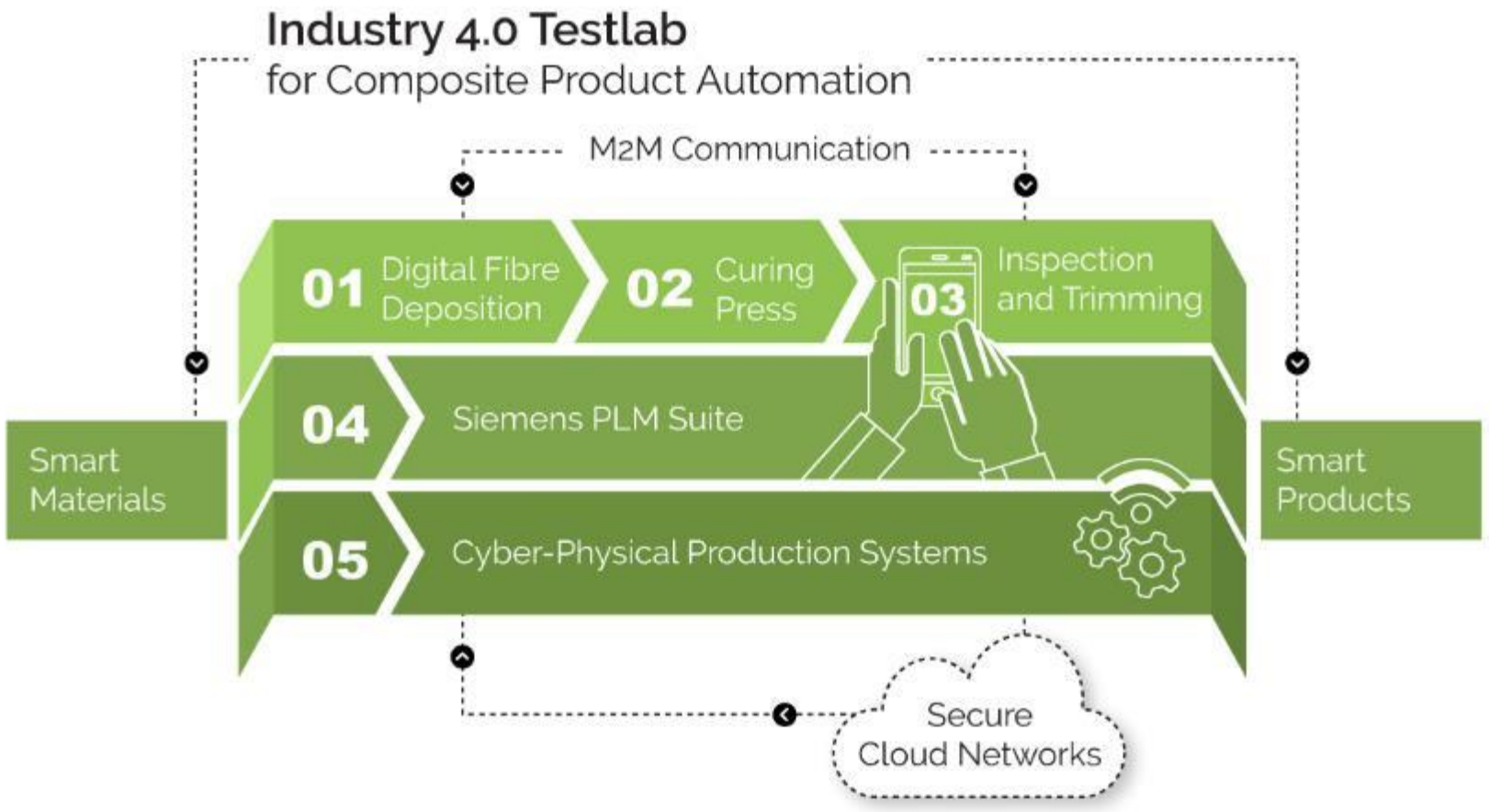
Scheme 2. Cyclization of p(AN-co-NIPAM).

PAN → White Fibre → **Black Fibre** → Sizing → Preform → Resin → Cure → Part



Industry 4.0 Testlab

Industry 4.0 Testlab for Composite Product Automation



Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

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Graphene Certification Centre

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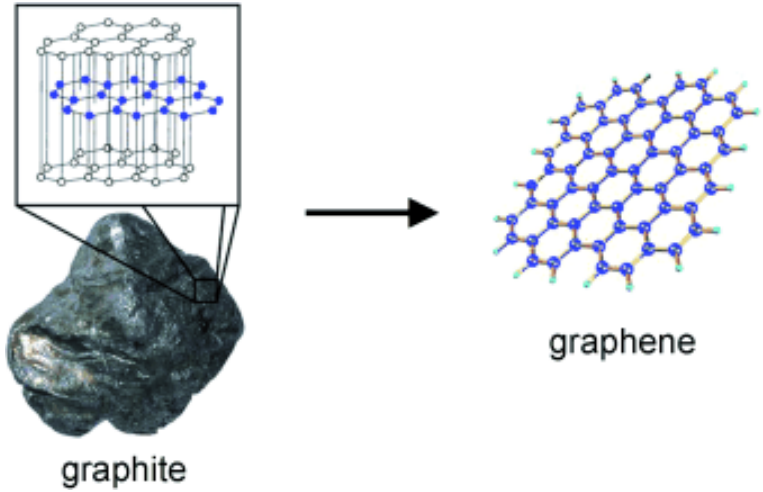
Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Programme

Graphene Supply Chain Certification

- Key challenges – scale de-risking supply chain
- Imagine Focusing on high volume applications
- 1st product release: imgne X-3® with Geofabrics (Aust)
- Global geosynthetics sector will be $18B market by 2018*
- Certification and licensing business model



"When Graphene becomes price competitive……it could significantly disrupt the manufacturing and infrastructure industries"
The Fourth Industrial Revolution (2016)
by Prof Klaus Schwab

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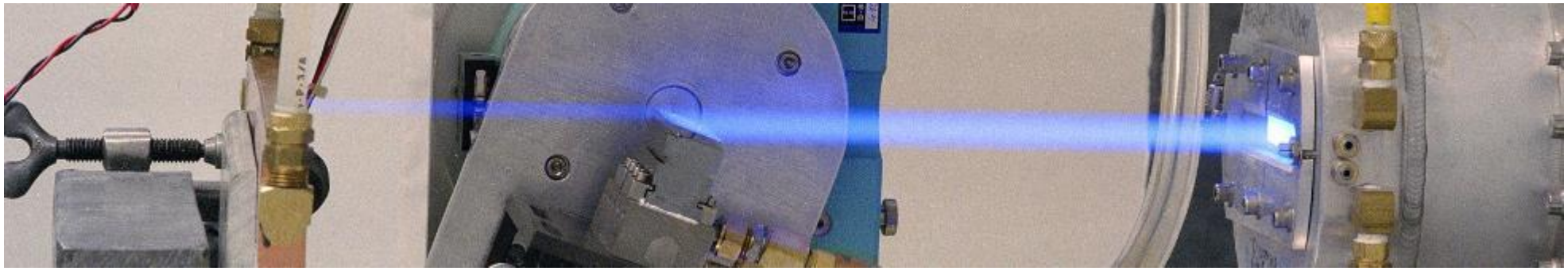
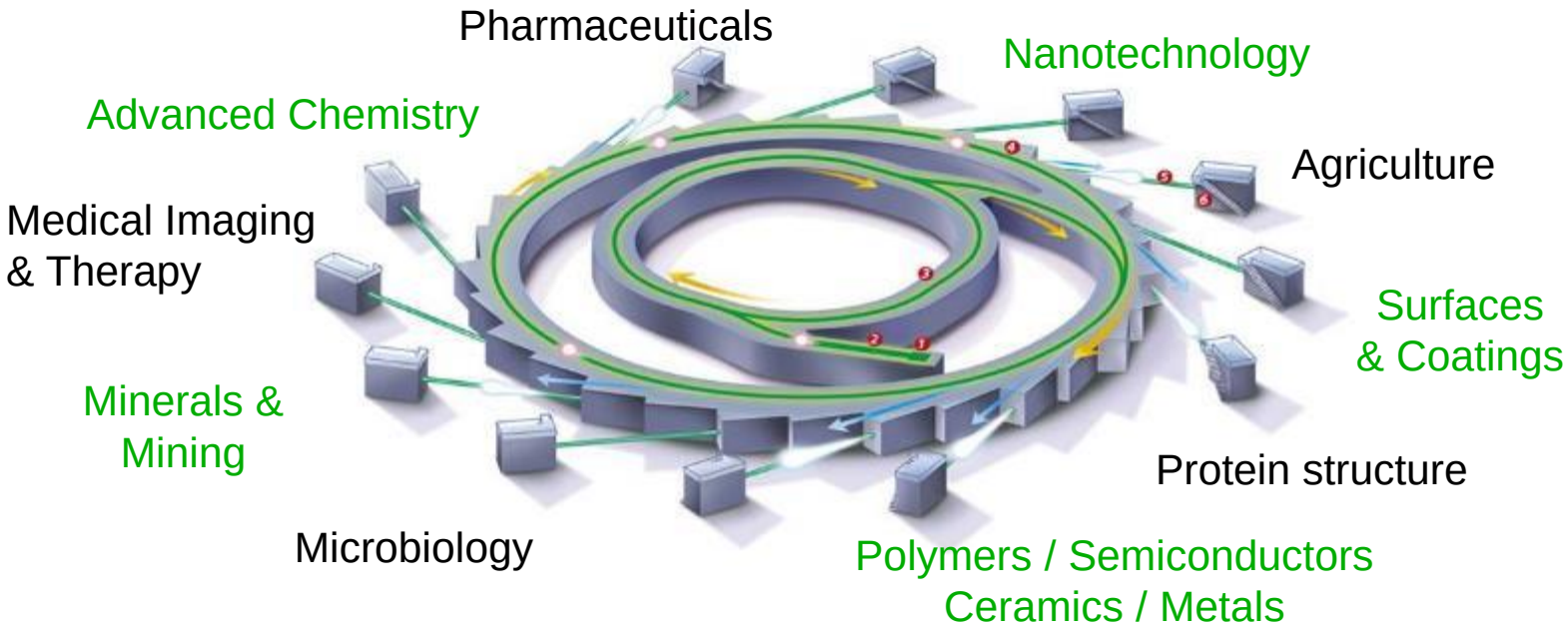
What is the Australian Synchrotron?

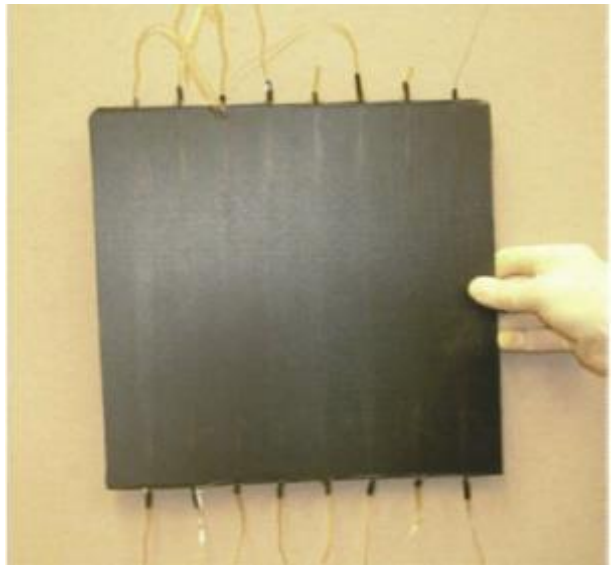
An accelerator-based generator of beams of intense light (infrared to x-rays)





Smart graphene-coated carbon fibre preforms

- The incorporation of carbon nanomaterials into structural composites as sensors has been studied due to their high surface area and mechanical and electrical properties.
- Enhancing interfacial bonding between fiber and matrix
- Capable of damage monitoring and detecting impact often referred to as structural health monitoring (SHM)
- Graphene nanoplatelets (GNPs) are one of the suitable nanoparticles for this application due to their high sensitivity to strain.



Advanced Carbon Materials from Brown Coal

Opportunities for brown coal

- Brown coal represents a significant resource for the manufacturing of carbon materials.
- The potential carbon materials include but not limited to carbon fibre, graphene and its derivatives, mesophase pitch, activated carbon, artificial diamond etc.
- Applications of these carbon materials include manufacturing of lightweight structures for mass transport, energy storage and conversion devices and selective adsorption systems for purification and emission control.

Advanced Carbon Materials from Brown Coal

- Early studies on the utilisation of Victorian Brown coal for the production of carbon materials was reported by the researchers at CSIRO Division of Coal and Energy Technology in 1993.
- Pang developed fullerenes with high yield from brown coal from the Bacchus Marsh, Yallourn, Loy Yang and Morwell mines using electrical arc method [1].

Fuel Processing Technology, 34 (1993) 147–155
Elsevier Science Publishers B.V., Amsterdam

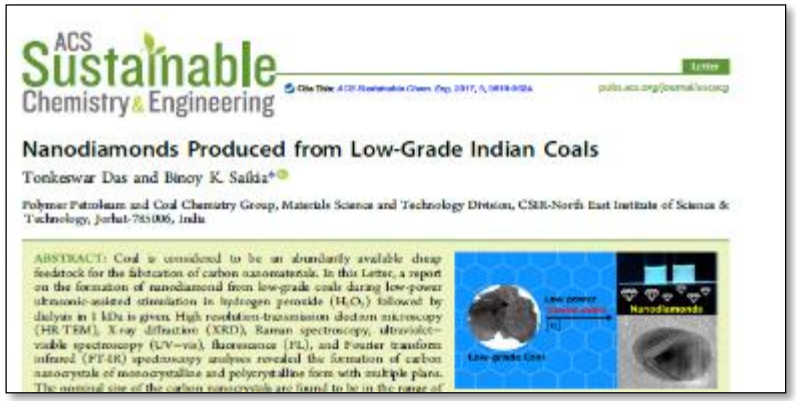
Fullerenes from brown (lignite) coal*

Louis S.K. Pang

CSIRO Division of Coal and Energy Technology, P.O. Box 136, North Ryde, NSW 2113 (Australia)

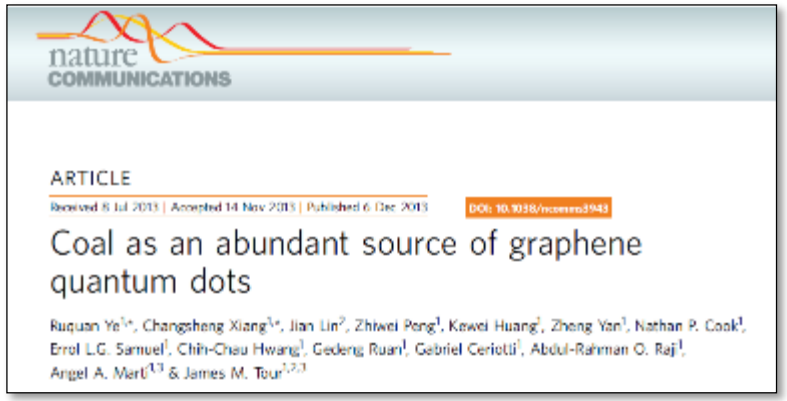
Advanced Carbon Materials from Brown Coal

Coal in general possesses abundant polyaromatic structures that are somewhat similar to sp2 bonding characteristics of carbon materials. Hence it is expected that coal can be a potential precursor material for the low cost manufacturing of high value carbon.


ACS Sustainable Chemistry & Engineering

Nanodiamonds Produced from Low-Grade Indian Coals

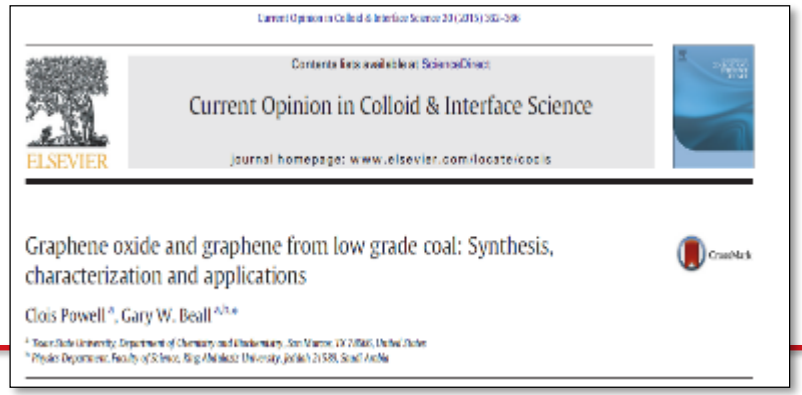
Tonkeswar Das and Binoy K. Saikia*


nature COMMUNICATIONS

ARTICLE

Coal as an abundant source of graphene quantum dots

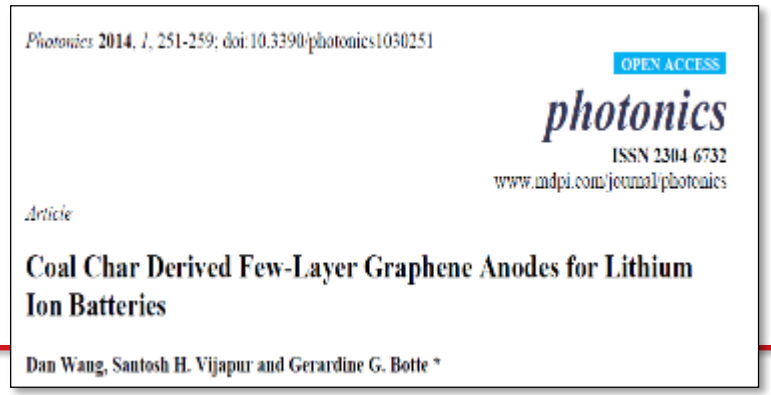
Ruquan Ye, Changsheng Xiang, Jian Lin, Zhiwei Peng, Kewei Huang, Zheng Yan, Nathan P. Cook, Errol L.G. Samuel, Chih-Chau Hwang, Gedeng Ruan, Gabriel Ceriotti, Abdul-Rahman O. Raji, Angel A. Martí & James M. Tour


Current Opinion in Colloid & Interface Science

journal homepage: www.elsevier.com/locate/cocis

Graphene oxide and graphene from low grade coal: Synthesis, characterization and applications

Clois Powell, Gary W. Beall


Photonics 2014, 1, 251-259; doi:10.3390/photonics1030251

OPEN ACCESS

photonics

ISSN 2304 6732

www.mdpi.com/journal/photonics

Article

Coal Char Derived Few-Layer Graphene Anodes for Lithium Ion Batteries

Dan Wang, Santosh H. Vijapur and Gerardine G. Botte *

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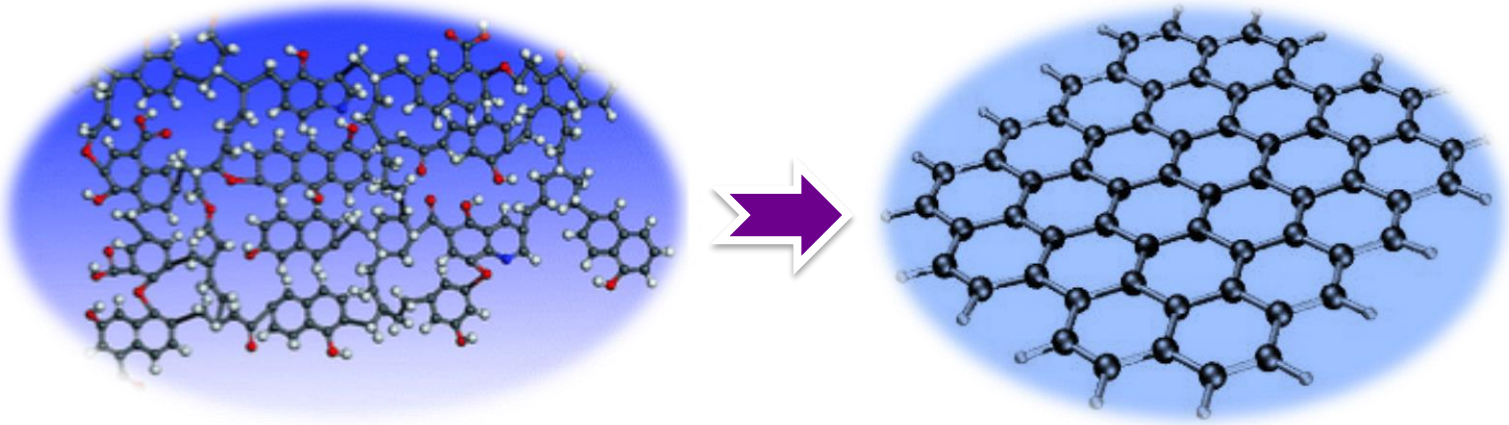
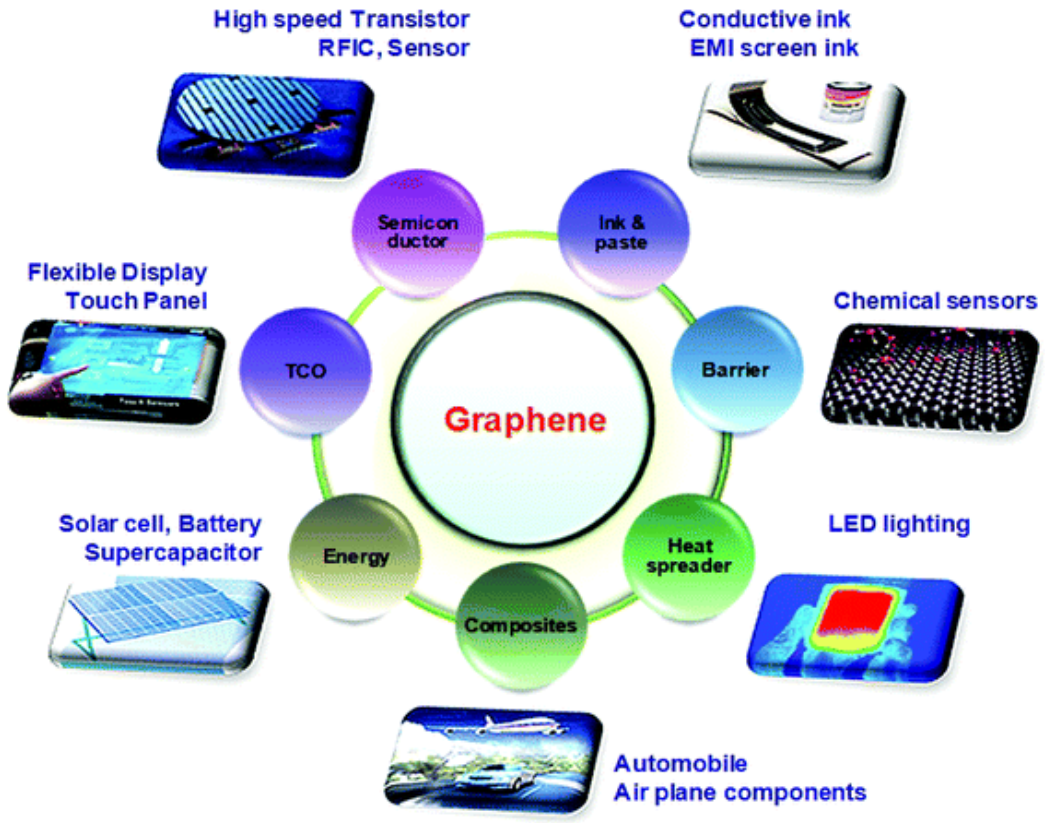
Advanced Graphene Materials from Brown Coal

- Brown coal has relatively lower carbon content and higher moisture content than other forms of coal.
- On the molecular level, small aromatic clusters, high concentration of organic oxygen functional groups, and the presence of inorganic species as ion-exchangeable cations are unique features of these low-rank coals.
- The presence of rich functional groups supports conversion process and enables the creation of carbon nanomaterials with multiple functionalities.



Brown Coal to Graphene

Application areas of graphene



The current cost of bulk graphene is estimated to be US $100 per kilogram. The cost needs to be significantly reduced to be around US $11 per kilogram in order to utilise graphene for market applications.

Advanced Graphene Materials from Brown Coal

- Developing low cost graphene manufacturing technologies holds the key and has been deemed as the most important strategy worldwide.
- Viable technologies to convert brown coal to graphene and graphene oxide materials using a brown coal as a low-cost precursor will benefit brown coal industries.

Manufacturing Futures Research Institute

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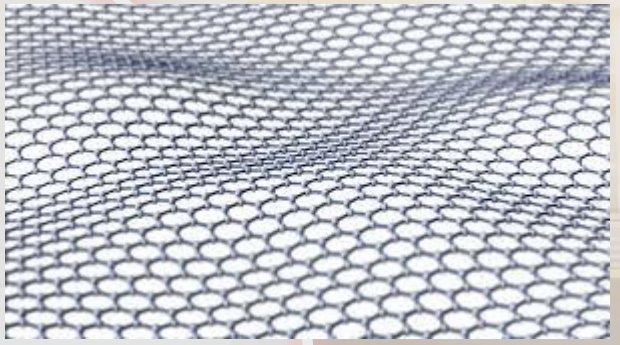
Manufacturing Futures Institute



Industry4.0

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