Report on First Australian – EU Graphene Workshop, 2018

Date and location: 17-19 October 2018, Adelaide and Sydney, Australia

Chairs:

Australia – Prof Dusan Losic (University of Adelaide)
Dr Katie Green, Dr Adrian Murdoch, Dr Michael Seo (CSIRO – Commonwealth Science and Industrial Research Organisation)

EU – Dr Ken Teo (AIXTRON)

Summary: This workshop aims to foster information exchange and collaboration between Australian organisations and partners of the EU's Graphene Flagship project with respect to Graphene and related materials (GRM). The programme was organised between two different cities (Adelaide/Sydney) over 3 days, with various site visits, to maximise the exposure of the participants to graphene activities performed in Australia. The workshop featured diverse research topics on GRM with 26 scientific presentations, 1 industry roundtable session, 1 working group session, 4 open discussions, 1 poster session, lab tours and social events. About 50 participants were present, including 10 industrial delegates from Australian graphene companies.

Organised by:

Sponsored by:

Adelaide, 17 October 2018

Figure 1: ARC Graphene Enabled Transformation Hub laboratory at University of Adelaide (left) and visit by the EU Graphene Flagship delegation (right)

The Australian Research Council's Graphene Enabled Industry Transformation Hub, a partnership between 4 Australian universities and industrial collaborators, is based at the University of Adelaide. The participants were given a tour of the Hub's laboratories and introduced to its research, which included graphene production by exfoliation and graphene-use in composites, foams, fire-resistant paints and fertilizers. The participants also visited Silanna Semiconductor which featured an advanced laboratory with a multi-cluster molecular beam epitaxy system for III-V semiconductor and novel oxide deposition 6-inch wafers; these facilities are used to produce devices such as UV LEDs and power transistors. This was followed by a tour of the Adelaide University's state-of-the-art 3D printing lab for rapid prototyping with the largest 3D printer in the Southern Hemisphere.

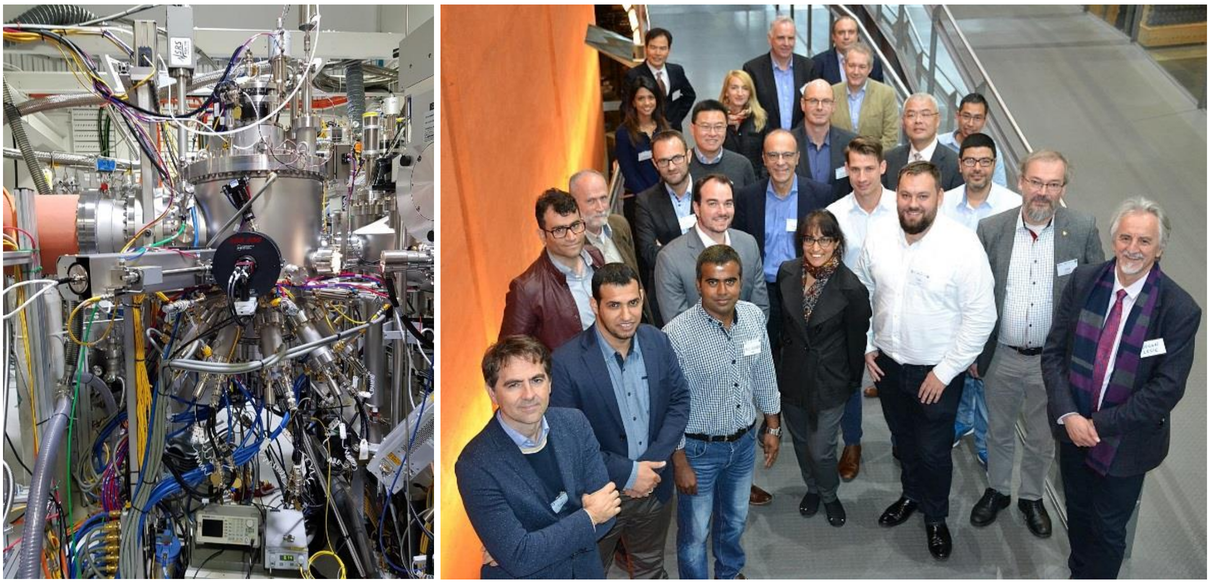


Figure 2: Advanced MBE facilities at Silanna Semiconductor (left) and workshop participants at the National Wine Center of Australia (right).

The workshop in Adelaide continued at the National Wine Center of Australia. The scientific program with 11 presentations and 1 open discussion covered the objectives of the ARC's Graphene Hub and EU's Graphene Flagship, bulk GRM production, functionalisation and properties, and GRM application in composites. Topics of note from the Australian speakers included industrial production of GRM at First Graphene and launch of fire-retardant graphene-based paint, and a Vortex Fluidic Device for high quality, lab-scale graphene production by 2D Fluidics/Flinders University. The EU speakers provided a broad overview into controlled production of graphene flakes of deterministic flake size, layers and oxygen content and use of such material as protective coatings and composites. The open discussion exposed new collaborative opportunities to be explored between the University of Adelaide (Hub graphene) and EU flagship teams on graphene production, functionalisation and protective coatings.

The evening activities included a BBQ dinner at the University of Adelaide, followed by a poster session from the postdocs and students based at the ARC Graphene Hub.

Figure 3: Pre-dinner drinks and discussion amongst workshop participants at the National Wine Center (left) and evening poster session/dinner at the University of Adelaide

Sydney, 18-19 October 2018

Figure 4: From 18-19 October 2018, the workshop was hosted by CSIRO (left) in Sydney (right).

The participants moved to Sydney for day 2 and the workshop continued at CSIRO Eveleigh. The program continued with a plenary session in which the EU's science and technology roadmap was introduced, followed by talks which dealt with commercialisation of GRM in Australia. Of note was the presentation by Imagine Intelligent Materials which covered the application of GRM for large area sensing in civil structures. The workshop then split into 2 parallel streams covering fundamentals of 2D materials and energy/membrane applications. In the fundamental session, the latest theoretical developments on graphene heterostructures and 2d materials and their plasma engineering were presented by EU and Australian speakers. Noteworthy was the topic on GRM quality and its certification which raised further discussions in the industry session. In the energy/membrane session, the EU's work with respect to GRM integration into Si anodes for Li-ion batteries and into supercapacitors was discussed. Monash University introduced their work in the development and qualification of a membrane filter based on GRM. Of interest also were micro-supercapacitors and solid source growth of graphene with Ni-Cu catalysts by the University of Technology, Sydney. The final formal session of the day was an industrial roundtable chaired by CSIRO; representatives from all the major commercial players in Australia participated including Imagine Intelligent Materials, Archer Exploration, MRC Minerals and Ionic Industries. The challenges and opportunities with introducing GRM to the market in Australia were discussed, and perspectives from EU's experience in this area were shared. The problem of quality control, standards and certifications was raised as very critical barrier from Industry perspectives and collaboration in this area is noted as one of priorities.

Figure 5. The worksop participants in CSIRO Eveleigh in Sydney on 18 October 2019 (top) and industrial roundtable with delegates from Australian graphene companies discussing opportunities and challenges for the future of graphene in industry

Following this, the delegation departed for Circular Quay for a dinner cruise of Sydney Harbour.

Figure 6: Pre-dinner drinks (left) and workshop dinner (right) onboard the cruise of Sydney Harbour

Figure 7: Workshop dinner at the bow of the ship; discussions ensued whilst touring Sydney Harbour

Figure 8: The cruise included sights of Darling Harbour, the iconic Sydney Harbour Bridge (left) and Opera House (right). After the dinner cruise, the participants continued discussions at the Opera House.

The final day of the workshop, 19 October 2018, began with topics covering Graphene immunology and biomedical applications. Also of interest was CSIRO's pioneering work with graphene growth using renewable precursors (also known as GraphAir) and the application of graphene membranes as anti-fouling filters. An overview of wafer scale and roll to roll chemical vapour deposition (CVD) graphene technologies in the Flagship was also covered. The formal program ended with a networking lunch where the participants discussed areas of future collaboration. In this first workshop, the Australian and European participants identified several common challenges that could be addressed in the future through collaborative efforts. Key topics and problems included graphene production, graphene functionalisation, standardisation and quality control, application in areas of composites, protective coating, mass production of graphene using CVD, graphene membranes for water purification and graphene materials for energy storage and production. To foster joint collaboration, Australian researchers are interested in exploring available funding opportunities from both sides, such as support for student and postdoc exchange, small and large collaborative grants and industry linkage grants. Two Australian graphene companies, namely Talga and First Graphene are already very active in Europe collaborating with Flagship research teams and exploring commercial opportunities in the European market that other Australian companies would like to follow.

Following lunch, the participants were taken to CSIRO Lindfield for a visit of the labs.

Figure 9: Visit to the labs of CSIRO Lindfield. Besides the Graphene labs, the participants also saw the advanced material deposition capabilities offered by the thin film lab (left). In particular, high precision gold electrostatic drivers were fabricated at this facility for the Laser Interferometry Gravitational Observatory (LIGO); gravitational waves were observed with these detectors, recognised by the 2017 Nobel Prize being awarded for this work.

A tour was provided of the graphene lab which housed the GraphAir reactor as well as a plasma CVD reactor for graphene production. The membrane testing equipment was also shown to the visitors. The site visit also included introduction to advanced research activities in the sensor lab, superconducting devices lab and thin film lab.

The EU delegation expresses their thanks to the Australian organisers for their hospitality and meticulous planning which has made this workshop a stunning success. The highly informative scientific and industrial contribution by the speakers are appreciated. All generous sponsors, without whom this workshop and activities would not be possible, are also gratefully acknowledged. The Australian workshop organisers thank the EU delegation for making the long trip to Australia and their willingness to share their experience and collaborate with Australian researchers and companies. The EU delegation acknowledges the support of the European Science Foundation and GrapheneCore2 Grant Agreement 785219.

The workshop organisers agreed to hold the next workshop in Helsinki as part of the Flagship's Graphene Week in 2019.

FIRST
AUSTRALIAN - EU
GRAPHENE WORKSHOP

17th October – 19th October 2018
Adelaide and Sydney
Australia

Organised by:

ARC Research Hub for Graphene Enabled Industry Transformation

CSIRO

Graphene Flagship

Sponsored by:

The University of Adelaide
Centre for Materials in Energy and Catalysis
Faculty of Engineering Computer and Mathematical Sciences

University of South Australia

Australian Graphene Industry Association

First Graphene — Australia's leading graphene company

Archer Exploration

Talga — unearthing tomorrow

MRC Mineral Commodities

The Graphene Enabled Industry Transformation Hub is an initiative of the Australian Research Council

Australian Government
Australian Research Council

The First Australian-EU workshop on Graphene and Related Materials (GRM) will be held on 17 October 2018 and 18-19 October 2018 in Adelaide and Sydney respectively. Co-organized by the Australian Research Council (ARC) Hub for Graphene Enabled Industry Transformation, Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the European Graphene Flagship project, this workshop provides a platform for discussing the common challenges in moving graphene from research labs to commercial products and identify opportunities for future collaborations

WORKSHOP SPEAKERS

Organising Committee

DELEGATIONS

Organising Team

EU	Dr Ken Teo
UA	Professor Dusan Losic
CSIRO	Dr Katie Green, Dr Adrian Murdock, Dr Michael Seo

Flagship delegation

Name	Role/topics covered
Jari Kinaret	EU Graphene Flagship Director
Andrea Ferrari	Flagship Science & Technology Officer, Science & Technology roadmap
Vladimir Falko	2D electronic hetero-structures
Vittorio Pelligrini	Energy storage and conversion
Costas Galiotis	Preparation, performance and application of composites using GRM
Ian Kinloch	Bulk GRM production, functionalisation, characterisation
Julio Gomez	Functional and protective coatings using bulk GRM
Lucia Delogu	Graphene in Immunology
Nishad Karim	Science writer for workshop
Ken Teo	Chair of workshop, CVD graphene production

Australian Delegation

Name	Organisation
James Galvin	Archer Exploration
Mohammad Choucair	Archer Exploration Ltd (biosensors)
Jun Hong	Archer Exploration
Katie Green	CSIRO
Tim Laan	CSIRO
Michael Seo	CSIRO (CVD membranes)
Adrian Murdock	CSIRO (Graphene applications)
Craig McGuckin	First Graphene Ltd (GRM production and applications)
Kasturi Vimalanathan	Flinders University (graphene production)
Phil Aitchison	Imagine Intelligent Materials Ltd
Grant Mathieson	Imagine Intelligent Materials Ltd
Simon Savage	Ionic Industries Ltd (Membranes)
Mainak Majumder	Monash University - ARC Dep Director - (membranes, supercapacitors)
Michael Fuhrer	Monash University - Director ARC Centre of Excellence FLEET
Nunzio Motta	QUT (energy)
Surinder Ghag	MRC
Namita Roy-Choudhury	RMIT
Kostya Ostrikov	QUT (CVD/PECVD graphene growth)
Han Lin	Swinburne University (energy storage)
Lachlan Hyde	Swinburne University (graphene characterisation)
Martin Phillips	Talga Resources
Deepak Dubai	The University of Adelaide
Yan Jiao	The University of Adelaide
Dusan Losic	The University of Adelaide - Chair/ARC Hub Director (emerging applications)
Md Nine Julker	The University of Adelaide (multifunctional and protective coatings)
Michael Gilbert	The University of Adelaide - ARC Graphene Hub Manager
Stan Skafidas	The University of Melbourne - ARC Hub Dep Director (neuro-engineering)
Dan Li	The University of Melbourne (graphene properties)
Yuan Chen	The University of Sydney (biomedical applications)
Jun Ma	University of South Australia - CI Graphene Hub (composites)
Sean Li	UNSW (graphene composites)
Rakesh Josh	UNSW (membranes)
Francesca Lacopi	UTS (CVD graphene and energy)
Cam Coghlan	The University of Adelaide
Diana Tran	The University of Adelaide
Tran Tung	The University of Adelaide
Mahmoud Moussa	The University of Adelaide
Nathan Stanley	The University of Adelaide

PROGRAM

Day 1 – Adelaide – Wed 17th October 2018

0900	Meet at The University of Adelaide
	Graphene Lab/Uni Adelaide tour including 3D printing lab, Silanna micro-fabrication

1000	Walk to the National Wine Centre
1030	Coffee Break

Graphene Research Goals and Objectives (Chair: Dr Ken Teo)		
1045	Welcome from Deputy Vice-Chancellor (Research) - UA	Professor Mike Brooks
1100	Meeting overview and objectives	EU and Australian Chairs
1110	EU Graphene Flagship	Prof Jari Kinaret
1130	ARC Graphene Hub	Prof Dusan Losic
1150	Participant (name, affiliation, role) introductions	All

1210	Lunch

Bulk GRM, Production, functionalisation, properties (Chair: Prof Dusan Losic)		
1300	Bulk GRM production, functionalisation, characterisation	Prof Ian Kinloch
1320	Industrial production of GRM and applications	Mr Craig McGuckin
1340	New concepts for scalable graphene production	Dr Kasturi Vimalanathan
1400	Functional and protective coatings using bulk GRM	Dr Julio Gomez
1420	Multifunctional coatings	Dr Md Julker Nine
1440	Discussion on collaboration topics	All

1500	Coffee break

Composites		
1520	Preparation, performance and application of composites Incorporating graphene and related materials	Prof Costas Galiotis
1540	Graphene polymer composites: current progress and applications	Prof Jun Ma
1600	Composite products	Prof Sean Li

1800	Poster session (one slide intro per poster) (Chair: Dr Kasturi Vimalanathan) Dinner – "Aussie" Barbeque at The University of Adelaide

Day 2 - Sydney - Thurs 18th October 2018

Travel to Sydney in morning (own arrangements)

1230	Lunch

Plenary (Chair: Prof Michael Fuhrer)		
1300	Roadmap to applications: graphene & related materials	Prof Andrea Ferrari
1320	Graphene research and translation	Prof Dan Li
1340	Commercialisation of graphene in Australia	Mr Phil Aitchison

Concurrent Session 1: Fundamentals of 2D materials (Chair: Dr Lachlan Hyde)		
1400	Moiré superlattices and minibands for Dirac electrons in graphene heterostructures	Prof Vladimir Falko
1420	Graphene and 2D materials from theory to applications	Prof Michael Fuhrer
1440	Plasma engineering of graphene and 2D materials	Prof Kostya Ostrikov
1500	Graphene materials quality certifications	Dr Lachlan Hyde
1520	Discussion on collaboration topics	All

1530	Coffee break

Concurrent Session 2: Energy applications (Chair: Prof Francesca Lacopi)		
1400	Graphene-based electrodes for high-power Li-ion batteries	Prof Vittorio Pelligrini
1420	Graphene for membrane and energy applications	Prof Mainak Majumder
1440	Energy and supercapacitors	Prof Francesca Iacopi
1500	Energy storage	Dr Han Lin
1520	Discussion on collaboration topics	All

1530	Coffee break

Commercial Session (Chair: Dr Adrian Murdock)		
1545	Industry roundtable Commercialisation challenges Market trends 5 min each then 15 minutes discussion	Mr Chris Gilbey, Imagine Intelligent Materials Mr Simon Savage, Ionic Industries Dr Mohammad Choucair, Archer Exploration Dr Lachlan Hyde, CRC-P Dr Adrian Murdock, CSIRO Mr Phil Aitchison, Imagine Intelligent Materials Dr Surinder Ghag, MRC Mr Martin Phillips, Talga Mr Michael Gilbert, Graphene Hub
1700	Close	

1830 Ship dep 1900	**PLEASE ARRIVE AT WHARF BY 6:45** **Captain Cook Cruises - Starlight Dinner** MV Sydney 2000 Three course Contemporary Australian a la carte dining Departs: 7.00pm Wharf No.6 Circular Quay Returns: 9.30pm Wharf No. 6 Circular Quay

Day 3 - Sydney - Fri 19th October 2018

Biomedical Applications and CVD graphene		
0830	Welcome to CSIRO	Dr Cathy Foley
0840	Graphene for neural engineering	Prof Stan Skafidis
0900	Graphene and immune cells	Dr Lucia Delogu
0920	Biomedical applications	Prof Yuan Chen
0940	Water filtration	Dr Michael Seo
1000	Graphene Based Filtration	Dr Rakesh Joshi
1020	Graphene growth by chemical vapour deposition and integration challenges	Dr Ken Teo

1040	Coffee break and collaboration working group discussions

1140	5 minute update per working group Coatings, Composites, 2D fundamentals, Energy, Bio, CVD	(Various leads)
1200	Next steps and close of meeting	EU and AUS Chairs

1230	Networking lunch

CSIRO Lab Tour	
1330	Bus to CSIRO Lindfield for lab tour, 15 delegates maximum
1530	Leave CSIRO Lindfield
1700	Sydney / Airport

FAQS - DIRECTIONS AND MAPS

Contacts

	Contact	Email	Mobile
EU	Ken Teo	k.teo@aixtron.com	+44 7824 690202
Adelaide	Michael Gilbert	michael.gilbert@adelaide.edu.au	+61 414 710 540
Sydney	Katie Green	katie.green@csiro.au	+61 407 772 811

Suggested Accommodation

Adelaide	Sydney
Holiday Inn Express 30 Blyth Street Adelaide SA 5000 Australia Tel: +61 8 8112 3000	**Travelodge Wynyard** 7-9 York St Sydney NSW 2000 Australia Tel: +61 2 9274 1222

Day 1 – Adelaide - 17th October

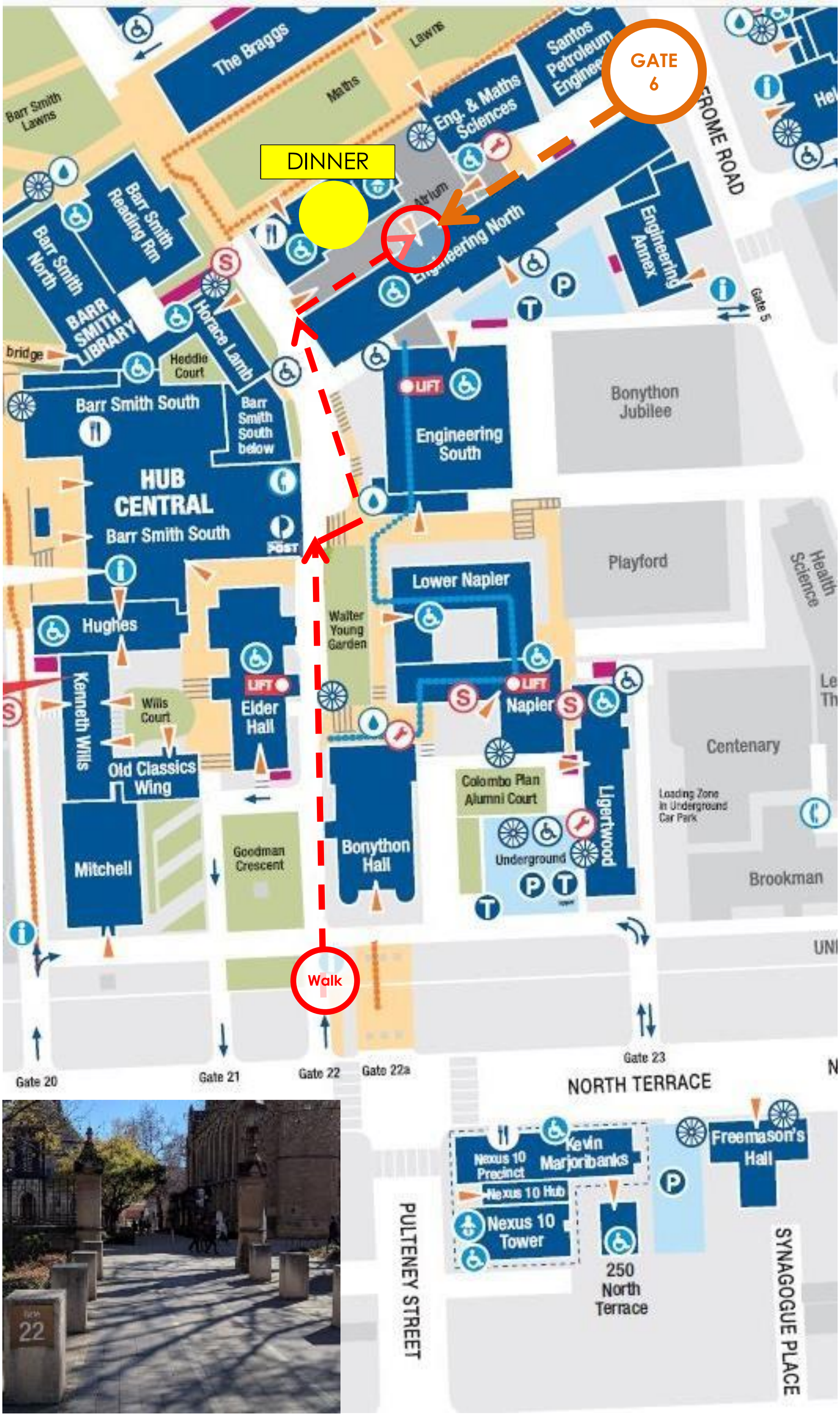
MORNING OPTIONS

Option 1	Option 2
Adelaide Graphene Hub lab tour	National Wine Centre
Arrive 9am	Arrive 10:30am
See Map 1	**See Map 2**
University of Adelaide Engineering North Building	National Wine Centre.
North Tce, Adelaide	Hackney Road, Adelaide
If arriving by taxi that morning, take taxi to **Gate 6, Frome Road** then 30m walk to Engineering North Building **(FOLLOW GREEN LINE ON MAP 2 BELOW)** Or, if walking from Hotel, enter Uni at **Gate 22** on North Tce (opposite Pulteney Street) walk past Bonython Hall then down all the steps – at the bottom, through the glass sliding doors to Engineering North the glass sliding doors on the right **(FOLLOW RED LINE ON MAP 1 BELOW)**	If you are not going to the lab tour, go directly to the Workshop at the National Wine Centre at 10:30am **(SEE MAP 2 BELOW)**

DINNER

1800 - Poster session and "Aussie" Barbeque at The University of Adelaide
Level 5, Ingkarni Wardli Building (Opposite Engineering North Building) **(SEE MAP 1 BELOW)**

MAP 1 - UNIVERSITY OF ADELAIDE NORTH TCE



MAP 2 – NATIONAL WINE CENTRE – HACKNEY ROAD – WORKSHOP VENUE

Day 2 – Sydney - 18th October

Taxi to Adelaide Airport IN MORNING
Domestic Flight to Sydney then taxi to CSIRO
1230 - CSIRO Data 61, Level 5, 13 Garden Street, Eveleigh, New South Wales 2015 **(SEE MAP 3 BELOW)**
The workshop ends at 515pm after which participants can take a taxi (approx. 15min/AUD$20) to their hotel or use the train/T from Redfern station to Sydney city stations (all trains except T4 will head to Central/Town Hall/Wynyard/Circular Quay).
Dinner will be held at 7pm. Location TBA

MAP 3 – CSIRO EVERLEIGH

Day 3 – Sydney - 19th October

0830 – 1230 CSIRO Data 61, Level 5, 13 Garden Street, Eveleigh, New South Wales 2015 **(SEE MAP 3 ABOVE – Same place)**
For those attending the optional tour, a bus will be provided at **1330** to go to CSIRO Lindfield. Return : To City or Airport departing at **1530**

ABSTRACTS (SPEAKERS)

Graphene Flagship

Jari Kinaret

jari.kinaret@chalmers.se

Department of Physics, Chalmers University of Technology, SE-412 96, Gothenburg, Sweden

Abstract

Launched in 2013, the Graphene Flagship, a Future and Emerging Technology Flagship by the European Commission, represents a new form of joint, coordinated research on an unprecedented scale, forming Europe's biggest ever research initiative. The Graphene Flagship is tasked with bringing together academic and industrial researchers to take graphene from the realm of academic laboratories into European society in the space of 10 years, thus generating economic growth, new jobs and new opportunities. The core consortium consists of ~150 academic and industrial research groups in 23 countries, as well as a growing number of associated members that will be incorporated in the scientific and technological work packages.

This presentation will discuss the Graphene Flagship, its past, present and future. Here, I will focus on the Flagship in the global context. The details of our scientific and technological work will be covered by the other EU workshop participants.

Biography of Presenter

Prof Jari Kinaret is the Director of the Graphene Flagship. He is the Head of the Division of Condensed Matter Theory at the Department of Applied Physics at Chalmers University of Technology. His former roles include Director of Nanoscience and Nanotechnology at Chalmers, as well as Head of the Chalmers Graphene Centre. He is also a member of the Royal Swedish Academy of Engineering Sciences (IVA).

Prof Kinaret is educated at the University of Oulu, Finland, and obtained his PhD from the Massachusetts Institute of Technology, USA, in Physics and Electrical Engineering. His research interests include theoretical studies of graphene-based nanoelectromechanical systems and graphene plasmonics.

The Graphene Enabled Industry Transformation Hub

Dusan Losic

E-mail address: dusan.losic@adelaide.edu.au

The University of Adelaide, Australia

Abstract

The Graphene Enabled Industry Transformation Hub is co-funded by the Australian Research Council (ARC) and supports the commercialisation of graphene research in a partnership between The University of Adelaide, The University of Melbourne, The University of South Australia and Monash University and five industry partners with total funding of $6 for 5 years. There is also a growing number of "associate" industry partners involved in its graphene research under different investment programs.

The Hub is providing industry with innovative solutions to tackle critical and complex challenges of national significance by leveraging substantial existing and new investments to overcome fundamental scientific barriers and developing fit-for-purpose products with and for our partners, to help their long-term economic prosperity and growth. The industry projects span across a number of fields such as bio-sensing, fire retardants, composites, energy storage, coatings, soil and water remediation, composites, shielding and membranes. The Hub's focus is to conduct high quality translational research for delivery to industry. Already several products have already been developed to the stage of "Proof of Concept" (approximately Technology ready Level 3-4) and licensing of some products has commenced.

Currently the Hub is developing new relationships with commercial clients and has a mix of new commercial funding and extra grant funding to support the new projects. The aim is to quickly leverage the initial ARC support to increase the Hubs critical mass.

Biography of Presenter

Prof Dusan Losic, finished PhD in Nanotechnology at Flinders University in 2003. Currently he is Professor in School of Chemical Engineering, the University of Adelaide where he is leading Nano Research group of 20 researcher and Director of the ARC Research Hub for Graphene Enabled Industry Transformation, involving 30 researchers, 4 Universities and 6 Industry partners.

His multidisciplinary research in Nanoscience and Nanotechnology involves fundamental, engineering and applied aspects across several disciplines including chemistry, material science, engineering, medicine and agriculture focused to use these concepts through engineering new nanomaterials and properties to address concerning environmental (clean water pollution), health (drug delivery, cancer), agriculture (pest control, fertilizers), and energy (storage) problems.

Bulk GRM Production, Functionalisation, Characterisation

Ian A. Kinloch

ian.kinloch@manchester.ac.uk

School of Materials and National Graphene Institute, University of Manchester, UK

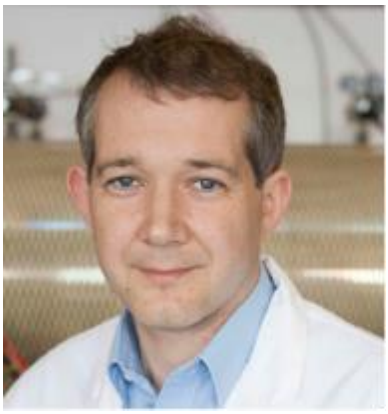
Abstract

In order to successfully translate the intriguing properties of GRM materials from the nanoscale to the macroscale one needs to use the optimal 2D material organised into the ideal architecture. Thus it is vital to develop production and functionalisation routes which can control the thickness, lateral dimensions and surface chemistry of GRMs on sufficient scale for bulk commercial applications. Furthermore, there is a need to develop characterisation methodology which can accurately analyse these properties against standards in order to ensure process stability and supply chain confidence.

This presentation will highlight the routes for the bulk production of 2D flakes developed within the Flagship by both academic and industrial partners. These methods include chemical, high shear (e.g. mixing or milling) and electrochemical exfoliation. Understanding the reaction parameters for all these techniques is found to give control over the morphology of the final material obtained. Successful functionalisation techniques both during and post exfoliation have been developed to control the interface of the GRMs with a range of solvents and polymers. Finally, techniques for both definite analysis and rapid quality control of GRM samples will be discuss

Biography of Presenter

Prof Kinloch is the Deputy Workpackage Leader of the Composites Workpackage within the Graphene Flagship. He holds a Chair in Materials Science at the University of Manchester, having previously been an EPSRC Challenging Engineering Research Fellow. He is Director of Research in the School of Materials and heavily involved in the National Graphene Institute and Graphene Engineering and Innovation Centre. He is Deputy Theme Leader of 2D Materials in the national Henry Royce Institute. His research follows nanomaterials from their production through to their processing and ultimately to applications in composites and electrochemical power storage. This vertically integrated approach means that the appropriate materials can be processed into the optimum architecture for a given application, enabling new materials to realise their potential. He has published over 140 papers and his work on nanotube CVD production was licensed by Thomas Swan Ltd. He is a Fellow of the Royal Society of Chemistry and the Institute of Materials Minerals and Mining. He received the IOM3 Rosenhain Medal.



First Graphene ltd: from graphene production to emerging applications

Craig McGuckin,
craig.mcguckin@firstgraphene.com.au
First Graphene Ltd, Perth, Australia

Abstract

First Graphene Ltd (ASX: FGR) has developed a commercial graphene production facility for the bulk scale manufacture of graphene at competitive prices. The Company continues to develop graphene related intellectual property from which it intends to generate licence and royalty payments through several long-term university relationships including the University of Adelaide, Flinders University and Swinburne.

The Company is at the cutting edge of graphene and 2D related material developments. Most recently First Graphene has become a Tier 1 participant in the Graphene Engineering and Innovation Centre (GEIC) of the University of Manchester. First Graphene is working with numerous industry partners for the commercialisation of graphene and is building a sales book with these industry partners.

PureGRAPH™ Range of Products

The PureGRAPH™ range of products were released by FGR in September 2018, in conjunction with a detailed Product Information Sheet.

PureGRAPH™ graphene powders are available with lateral platelet sizes of 20µm, 10µm and 5µm. The products are characterised by their low defect level and high aspect ratio.

Biography of Presenter

Mr McGuckin is an experienced industry professional with exposure in the mining and petroleum industries. He has 40 years' of experience and held several public company directorships. As the founding Managing Director of First Graphene he has worked closely with the University of Adelaide to develop the initial graphene process and take this early knowledge to full scale production. Craig is based in Perth where the company's commercial graphene facility is located.

A greener and scalable approach towards the fabrication of graphene and graphene oxide

Dr Kasturi Vimalanathan

Vimalanathan, K and Raston, C.L.

E-mail: kasturi.vimalanathan@flinders.edu.au

Institute for NanoScale Science & Technology, College of Science and Engineering, Flinders University, Adelaide SA, 5001, Australia

Abstract

Our research employs the use of process intensification as an alternative strategy towards the fabrication, manipulation and functionalization of novel forms of carbon material with scalability addressed at the inception of the science. This involves the use of an energy efficient processing platform, the most recently developed microfluidic platform, the vortex fluidic device (VFD). We are currently focussed on the commercial production of graphene oxide using a green chemistry metrics, a new way of fabricating graphene oxide. The production of graphene oxide beyond the current Hummer's method will allow for the development of an energy storage alternative to lithium ion batteries

The VFD has other novel and facile capabilities including but not limited to controlling self assembly processes, and the fabrication and growth of carbon nanomaterials with distinct control over the morphology, shape and size of the nanostructures. Examples include the exfoliation of single layer graphene and other transitional metal dichalcogenides (TMDs), the fabrication of graphene oxide using a green chemistry metrics, slicing carbon nanotubes down to nanoscale dimensions, fabricating toroidal arrays of single walled carbon nanotubes, the formation of self assembled arrays of fullerene C_{60} in the form of nanotubules which are superior sensing material for detecting small molecules, and the direct exfoliation of graphene into graphene scrolls.

Biography of Presenter

Dr Kasturi Vimalanathan completed a PhD at Flinders University with her research focussed on developing novel methods to fabricate and manipulate carbon nanomaterials and other related 2D material using a green chemistry metrics under continuous flow. She employs the use of process intensification to fabricate and self assemble material within nanoscale dimensions with economical and environmental sustainability incorporated into the process. Dr Vimalanathan is currently a Postdoctoral Research Associate at Flinders University working on the development of thin film microfluidics in carbon technology and its potential in a diverse range of applications.

Functional and protective coatings using bulk GRM

Julio Gomez

Julio Gomez[1], *J Perez*[1], *and E Villaro*[2]

Email: julio@avanzare.es

1 Avanzare Innovacion Tecnologica S.L. Navarrete, Spain

2 Instituto de Tecnologías Químicas Emergentes de La Rioja, Navarrete, Spain

Abstract

Graphene and related materials (GRMs) have been demonstrated as an alternative to traditional chemical additives as functional and protective coatings over different substrates. The estimated global cost of corrosion is $2.5 trillion annually, based on repairs needed and over-dimensioning of metals structures. Polymers and their composites do not have the corrosion problems observed in metals. Graphene-based composites are an alternative to metals. However, to be a viable alternative, several challenges must be resolved. One key problem is the low fire resistance of polymers. The traditional way of flame-retarding polymers are to use coatings are based on halogenated, phosphorous based additives. However, these additives have serious environmental and health concerns. Here, the results of the production of multifunctional fire resistant/protective coatings and composites based on graphene materials will be presented. Different graphene materials have been employed in the production of composites and coating. These composites and coatings were capable of self-extinguishing the flame and completely suppressing the typical melt-dripping phenomenon during flammability tests. Furthermore, these GRM-based coatings and composites are electrically and/or thermally conductive. By incorporating different graphene materials, the electrical, thermal conductivity and fire retardant properties of composites were investigated and optimised to allow industrial processing. Using different industrial approaches depending on the matrix makes it possible to develop new multifunctional fire-safe materials based on graphene materials. Graphene materials can be also an alternative to wear and corrosion resistance of metals. This work also shows the possibility of a low friction coefficient, low wear and high corrosion resistance coating based on the incorporation of GRMs.

Figure 1. Self-extinguish coating and automotive composite component incorporating GRM

Biography of Presenter

Dr Julio Gomez leads the Fire retardant materials for automotive and construction task in the Graphene Flagship. Dr Gomez is the founder of AVANZARE, which produces graphene, other 2D materials and graphene-based composites and dispersions. In the graphene sector, AVANZARE is presently the European company with largest EBITDA (2M€) and turnover. Dr Gomez has received several national and international awards: National Entrepreneur Award by the Spanish Ministry of Industry and finalist of the National Excellence Awards, Best Product award NANOAWARDS, and the Best Practices in Innovation award in Europe by Frost & Sullivan. He has a B.S. degree in Chemistry from Universidad Complutense de Madrid and achieved the “Best B.S. degree in Chemistry award” in 1995. He received his Ph.D. in Chemistry from University of La Rioja (2000), and received the “Best PhD degree in Science and Technology award” from the University of La Rioja. He was a postdoc at the University of Nantes-CNRS.He is a member of the Social Council of La Rioja University elected by the Regional Parliament, President of the Education and Employ Committee of the Chamber of Commerce, member of the Executive board of the Chamber of Commerce from La Rioja from 2010, and member of the Regional R&D Committee and President of the Spanish Graphene Alliance.

Graphene Based Multifunctional Coatings

Md Julker Nine

Email : mdjulker.nine@adelaide.edu.au

Md Julker Nine[1,2], Dusan Losic[1,2]

[1]School of Chemical Engineering, The University of Adelaide, Adelaide, SA 5005, Australia
[2]ARC Research Hub for Graphene Enabled Industry Transformation, The University of Adelaide, Adelaide, SA 5005, Australia

Abstract

Since the discovery of graphene in 2004, this atomically thin hexagonally packed carbon layer has drawn phenomenal attention as a new disruptive material of 21st century owing to its fascinating electrical, mechanical, and optical properties. To date, an enormous interest in both academia and industry has already generated critical mass of research and developments activity on graphene based technology in both energy and environmental applications. In the last decade, graphene has also been extensively used for the development of advanced multifunctional protective coatings due to its excellent chemical resistance, impermeability to gases, adsorption capacity, antibacterial properties, mechanical strength, lubricity, and thermal stability. The useful functional properties along with the structural merits of this 2D material have great potential for applications in the field of protective coatings including corrosion resistant, flame retardant, wear/scratch resistant, anti-fouling, pollutant adsorption, noise absorption, moisture insulation, and antiseptic coatings. Moreover, the recent ban on the use of many hazardous coating constituents (Cr (VI), Co, Cd, Cu, TBT, halogenated fire retardants) created tremendous scope for graphene to dominate coating industry as an efficient substitute of conventional hazardous materials. More importantly, the natural abundance of low-cost and high-quality graphite as the precursor for the top-down synthesis of graphene derivatives is an absolute advantage to reinforce the industrial transformation of graphene based composite coatings for multifunctional applications.

Biography of Presenter

Md J. Nine is an early-career research fellow working in ARC Research Hub for Graphene Enabled Industry Transformation program, University of Adelaide, Australia. He received Master of Engineering degree from Gyeongsang National University, South Korea in 2012. In 2017, and completed his PhD degree on "Graphene based multifunctional coatings" from School of Chemical Engineering, University of Adelaide, Australia. He was awarded Doctoral Research Medal as well as Postgraduate Alumni University Medal for outstanding research at PhD level in University of Adelaide. He was also awarded Carbon Journal prize-2018 for an outstanding PhD thesis in carbon materials science and technology. His PhD works generated three intellectual properties (IPs) on graphene technology and one of them was licenced to an industry. He has published 35 scientific journal papers, 3 patents, 2 book chapters, >15 conference presentation in the area of colloids and interfaces including graphene and other carbon nanomaterials. Dr. Nine's current research interests involves colloids and interfaces science for synthesis and application of multifunctional coatings based on graphene and 2D materials. The applications of coatings are not limited to self-cleaning, corrosion resistant, fire-retardant, acoustic insulation, anti-bacterial, radiation shielding and sensing.

Preparation, Performance and Application of Composites Incorporating Graphene and Related Materials

Costas Galiotis [1,2]

Email: galiotis@chemeng.upatras.gr & c.galiotis@iceht.forth.gr

[1] *Forth/ICEHT, Patras, Greece*

[2] *University of Patras, Patras, Greece*

Abstract

In this presentation, we will review and classify the various kinds of graphene composites with emphasis to those employing a polymer matrix and will show the importance of controlling the graphene lateral size, the graphene thickness and the presence of defects (such as wrinkles, folds, cracks etc) upon their mechanical performance. The multifunctionality shown by GRM composites will be also fully discussed and indicative applications in many areas will be presented. Finally, other more exotic developments that may have an impact to this area in the near future, such as nanolaminate production and properties, will be briefly covered and commented upon.

Biography of Presenter

Prof Costas Galiotis is the Composites Work Package Leader and member of the Executive Board of the Graphene Flagship. He is a Professor at the University of Patras, Greece and Collaborating Faculty Member of the Institute of Chemical Engineering Sciences of the Foundation for Research and Technology-Hellas (FORTH/ ICE-HT), of which he was the Director from 2007 to 2013. From 1986-1997 he served as a faculty member at Queen Mary University of London, UK and has taught at both Queen Mary and Imperial Colleges of the University of London. He has 40 years of research experience in the broad area of materials science and technology and has attracted for his own work research funds of over 13 MEuro. He has published over 200 journal papers, book chapters and reviews, which have attracted over ~14000 citations (Google Scholar). He has been plenary or keynote speaker to over 50 international conferences. He is the Editor-in-Chief of "Advanced Composites Letters" and "Graphene Technology" (Springer-Nature). He has served in all the major Research Panels of CEC (ERC-Engineering, INFRAIA, Teaming, Marie-Curie IF etc) and has also served as an Expert, Vice-Chair and Independent Observer in evaluation committees. He is the Head of the National (Greek) Representation in the NMBP (Nano-Materials-Bio-Production) Committee of Horizon 2020. He is a founding member of the Graphene Flagship (2013-2023) and currently a member of its Executive Board. He has organized a number of international conferences such as 'Industrial Technologies 2014', 'GrapHEL (2012)', 'NANOCONF (2007)', 'ECCM 11 (2004) and "Graphene Week 2017''.

Graphene Platelets for Polymer Composites

Ma, Jun

Email: Jun.Ma@unisa.edu.au

University of South Australia, Adelaide, SA5095, Australia

Abstract

In comparison with metals and ceramics, polymers have been increasingly more used in industries over the past five decades owing to their relatively high specific strength and low manufacturing costs. However, most polymers are inherently limited by low stiffness and lack of functionality such as electrical conductivity. In spite of extensive studies conducted to utilize carbon nanotubes and silicate layers to address the limitations, the rise of graphene [1] now provides a more promising candidate due to its exceptionally high mechanical performance and electrical and thermal conductivity. My research team since 2008 has conducted extensive research of developing new graphene platelets [2–3] and using them for processing of epoxy [2–6], elastomers [7–9] and conducting polymers [10,11]. Our graphene platelets contain only 7 atom% oxygen and have a thickness of 2–4 nm, depending on the suspension medium for measurement. They have a Raman I_d/I_g ratio of 0.07, corresponding to an electrical conductivity of 1456 S/cm measured by a four-probe method. The selection of hardeners is vital for epoxy/unmodified graphene composites.

We compared two groups of composites respectively cured by polyoxypropylene and *4,4′*-diaminodiphenylsulfone (DDS). The DDS-cured composites showed a better dispersion and exfoliation, a higher improvement 573% in fracture energy release rate and a lower percolation threshold 0.612 vol% for electrical conductivity, because DDS contains benzene groups which create *p*–*p* interactions with graphene promoting a higher degree of dispersion and exfoliation during curing [2]. In a further research, we used DDS to chemically modify graphene platelets, covalently bonded the platelets with an epoxy matrix, and investigated the morphology and functional and mechanical performance of these composites. The covalently bonded interface prevented graphene platelets stacking in the matrix. In comparison with unmodified composites, the interface-modified composite at 0.489 vol% graphene demonstrated an eight-order reduction in the resistivity, a 47.7% further improvement in modulus and 84.6% in fracture energy release rate [4]. In another research, graphene platelets were reacted with a long-chain surfactant. The grafted surfactant created molecular entanglements with epoxy matrix, and the resulting composites had an electrical percolation threshold of 0.25 vol% [3].

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Biography of Presenter

Jun Ma received his PhD in 2002 at the Institute of Chemistry, Chinese Academy of Sciences. He then conducted research as a visiting scholar and postdoc fellow at the Centre for Advanced Materials Technology, University of Sydney. Jun in 2007 joined the University o South Australia as a lecturer and he is now an Associate Professor. His research focuses on the development of functional composites through processing polymers with a range of nanomaterials, aiming to engage with industry in the design, development, and manufacturing of advanced polymeric composite materials.

Reversible Hydrophobic to Hydrophilic Transition on Graphene

Sean Li

School of Materials Science and Engineering, The University of New South Wales, Sydney, Australia

Abstract

Although the reversible wettability transition between hydrophobic and hydrophilic graphene under ultraviolet (UV) irradiation has been observed, the mechanism for this phenomenon remains unclear. In this work, experimental and theoretical investigations demonstrate that the H_2O molecules are split into hydrogen and hydroxyl radicals, which are then captured by the graphene surface through chemical binding in an ambient environment under UV irradiation. The dissociative adsorption of H_2O molecules induces the wettability transition in graphene from hydrophobic to hydrophilic.

Biography of Presenter

Professor Sean Li is currently leading a research group, which consists of more than 40 researchers including 3 academics, 4 research fellows and 36 postgraduate students to work in the research areas of advanced multifunctional materials at UNSW. Their research activities were/are funded by ~$20m from Australian Research Council, Australian Renewable Energy Agency, ANSTO, CSIRO and Industries etc, since 2005. Professor Sen Li's laboratory is equipped with a number of world-class research facilities, which are specially designed and fully geared towards the development of advanced multifunctional and energy materials with a total value of $8m. It is one of the key research infrastructures in the University. Professor Sean Li has published 2 textbooks, 1 edited book, 8 book chapters and more than 275 scientific articles in international peer-reviewed journals. He received the Global Star Award from American Ceramic Society in 2013.

The Roadmap to Applications of Graphene and Related Materials

Andrea Ferrari

Email: acf26@hermes.cam.ac.uk

Cambridge Graphene Centre, University of Cambridge,
9 JJ Thomson Avenue, Cambridge CB3 0FA, United Kingdom

Abstract

Disruptive technologies are usually characterised by universal, versatile applications, which change many aspects of our life simultaneously, penetrating every corner of our existence. In order to become disruptive, a new technology needs to offer not incremental, but dramatic, orders of magnitude improvements. Moreover, the more universal the technology, the better chances it has for broad base success.

The Graphene Flagship has brought together universities, research centres and companies from most European Countries. I will overview the progress done thus far and the future roadmap.

Biography of Presenter

Prof Ferrari is the Chair of the Management Panel and the Science and Technology Officer of the European Graphene Flagship. He is currently the Professor of Nanotechnology at the University of Cambridge and a Fellow of Pembroke College. He founded and directs the Cambridge Graphene Centre and the Engineering and Physical Sciences Research Council Doctoral Training Centre in Graphene Technology. He is a Fellow of the American Physical Society, Fellow of the Materials Research Society, Fellow of the Institute of Physics, Fellow of the Optical Society and he has been recipient of numerous awards, such as the Royal Society Brian Mercer Award for Innovation, the Royal Society Wolfson Research Merit Award, the Marie Curie Excellence Award, the Philip Leverhulme Prize, and the EU-40 Materials Prize. He has also received 3 European Research Council Grants.

Multilayered graphene membranes for nanoionics

Dan Li

Email: dan.li1@unimelb.edu.au

Department of Chemical Engineering, Melbourne School of Engineering, The University of Melbourne, Melbourne, VIC 3010, Australia

Abstract

Nanoionics is concerned about the study and application of properties, phenomena, and mechanisms of ion transport and storage in nanoscale systems. Despite being the key to a myriad of indispensable technologies in energy, water and biomedicine, experimental understanding of confined ion transport at length scales below 10 nm, particularly below 2 nm, has so far been limited in terms of scale itself, but also of materials investigated. This talk will present the unique features of the multilayered graphene hydrogel membranes developed in my group in the past years and demonstrate how they could open up new opportunities for advancing the field of nanoionics/nanofluidics and enable new application for energy storage and conversion, water purification and biomedical applications.

Biography of Presenter

Professor Dan Li is a Professor in Materials Science and Engineering in the Department of Chemical Engineering at the University of Melbourne. His research interests include soft materials based on graphene and 2D nanomaterials, nanoionics and nanofluidics, materials intelligence and their application for energy storage and conversion, ion separation, wearable electronics and biomedicine. His research achievements have been recognised through numerous awards including a 2006 ARC Queen Elizabeth II Fellowship, a 2010 Scopus Young Researcher of the Year Award (Engineering and Technology), a 2011 ARC Future Fellowship, a 2016 Changjiang Scholar Award and Thomson Reuters' Highly Cited Researcher in Materials Science.

Moiré superlattices and minibands for Dirac electrons in graphene heterostructures

Vladimir Falko

Email: vladimir.falko@manchester.ac.uk

National Graphene Institute, the University of Manchester, M13 9PL, Manchester, UK

Abstract

When graphene lattice is aligned with the hBN lattice, a long-wavelength periodic moiré pattern forms due to a weak incommensurability of the two lattice structures, leading to a long-range superlattice affecting properties of electrons in graphene, including formation of miniband spectra for Dirac electrons [1-3] and reappearance of magnetic minibands [4,5] at the rational values of magnetic field flux through the supercell area (in units of $\phi_0=h/e$), also known as Hofstadter butterfly [6].

Here, we show that the quantum effect of the minibands formation in long-period moiré superlattices (mSL) in graphene/hBN heterostructures affect their transport measurements up to the room temperature. In relation to the low-magnetic-field regime, we find signatures of miniband formation in capacitance spectroscopy, resistivity and Hall effect, and also in magnetic focusing of electrons in ballistic structures. We also find that the overall temperature dependence of resistivity displays the opening in a new scattering process: the umklapp electron-electron scattering in which two electrons coherently transfer the mSL Bragg momentum to the crystal [7]. The formation magnetic minbands and their manifestation in magneto-oscillation of the diagonal conductivity tensor persist up to the room temperature [8], too, with full hierarchy of features that are attributed to the rational flux values $\phi=(p/q)\phi_0$, with $p=1$, 2 and up to 3 (and $7<q<1$), now, observed [9] at the intermediate range of 50K<T<200K.

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Biography of Presenter

Vladimir Falko is the Division Leader for Enabling Science and Materials of the Graphene Flagship. As a condensed matter theorist, he has been responsible for several advances in the theory of electronic and optical properties of atomically thin two-dimensional crystals and their heterostructures (graphene, transition metal dichalcogenides, post-transition metal chalcogenides), and he worked on various general aspects of quantum transport and fundamentals of nanoelectronics. His career has been marked by Humboldt Fellowship, EPSRC Advanced Fellowship, ERC Advanced Investigator Grant, Synergy Grant, and Royal Society Wolfson Foundation Research Merit Award. Falko is the initiator 'Graphene Week' conference series, founding Editor-in-Chief of the IoP Journal '2D Materials', and one of the initiators and leaders of the European Graphene Flagship Project. Currently, he serves as Director of National Graphene Institute and Professor of Condensed Matter Theory at the University of Manchester.

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Atomically Thin Materials for Future Low-Energy Electronics Technologies

***Michael S. Fuhrer*[1,2,3]**

E-mail: michael.fuhrer@monash.edu

[1]*ARC Centre of Excellence in Future Low-Energy Electronics Technologies, Monash University, Monash 3800 Victoria, Australia*

[2]*Monash Centre for Atomically Thin Materials, Monash University, Monash 3800 Victoria, Australia*

[3]*School of Physics and Astronomy, Monash University, Monash 3800 Victoria, Australia*

Abstract

The information technology (IT) revolution has maintained an astonishing 70% annual growth rate in the worldwide capacity to perform computational operations, bringing numerous societal benefits. This revolution is enabled by gains in the energy efficiency of computing through "Moore's Law" scaling. However Moore's Law is ending, and the sustainable energy future for computing is uncertain. The industry has identified a need for a new computing technology with vastly lower energy consumed per operation. The ARC Centre of Excellence in Future Low-Energy Electronics Technologies (FLEET) addresses this challenge, using new fundamental physical concepts to develop new electronic devices with the capacity for low-energy switching. FLEET is addressing this challenge in three themes. First, FLEET envisions topological devices which exploit the conventional to topological quantum phase transition for switching. Topological insulators differ from conventional insulators in that they have conducting states on their boundaries i.e. edges in two dimensions (2D), or surfaces in three dimensions (3D). The edge modes of 2D topological insulators may even conduct current without dissipation. FLEET is also researching exciton superfluid devices, in which long-lived pairs of electron and holes in semiconductors form a superfluid capable of dissipationless flow at room temperature. The sensitivity of the superfluid transition to external conditions (such as charge imbalance) can form the basis of ultralow energy devices. Lastly, FLEET is also investigating the use of time-dependent fields, such as light, to create topological states or enhance superfluidity, leading to new types of switches.

I will discuss FLEET's research program and how it is enabled by atomically thin materials. I will also briefly discuss research in my own laboratory at Monash University into atomically thin topological materials and devices.

Biography of Presenter

Professor Michael Fuhrer is an ARC Laurete Fellow in the School of Physics at Monash University. Michael directs the ARC Centre of Excellence for Future Low-Energy Electronics Technologies (FLEET) and co-directs the Monash Centre for Atromically Thin Materials. Prior to coming to Monash, Michael directed the Center for Nanophysics and Advanced Materials at the University of Maryland. Michael is a Fellow of the American Association for the Advancement of Science and the American Physical Society. Michael's research explores novel two-dimensional materials such as graphene, the two-dimensional surface state of three-dimensional topological insulators (e.g. Bi2Se3), and other two dimensional semiconductors, metals, and superconductors

Plasma engineering of graphene and 2D materials

Kostya (Ken) Ostrikov

E-Mail: kostya.ostrikov@qut.edu.au

Institute for Future Environments and School of Chemistry, Physics and Mechanical Engineering, Queensland University of Technology, Brisbane, QLD 4000, Australia and Joint CSIRO-QUT Sustainable Processes and Devices Laboratory, P.O. Box 218, Lindfield, NSW 2070, Australia

Abstract

This presentation highlights some unique phenomena that make low-temperature non-equilibrium plasma processes very effective in the production and processing of two-dimensional graphene and other functional inorganic and organic materials. Some of the examples considered in this presentation include metal dichalcogenides for optoelectronic applications and vertically oriented graphenes with precisely tuned water repellence/capture for energy storage and water purification applications. One of the aspects covers new trends and challenges in the application of low temperature plasmas to the scalable production of graphenes and related materials. We discuss how distinctive features of plasma possesses such as high densities of reactive species lead to high graphene growth rates, as well as higher, but precisely controllable ion and electron energies favourable for effective growth activation. It is acknowledged that scaling of existing graphene production techniques to the industrial level without compromising its properties is a major current challenge. Some of the aspects related to the challenges of scalability, equipment, and technological perspectives of the plasma-based techniques are discussed, in view of creating new possibilities for the synthesis of graphene and graphene-containing products. Interestingly, plasma-based processes may be amenable for scaling and could also be useful to enhance the controllability of common chemical vapour deposition and some other methods, and to ensure a good quality and potentially low cost of the produced graphene and other 2D materials.

Biography of Presenter

Kostya (Ken) Ostrikov pioneered the field of Plasma Nanoscience and have led it to recognition as a distinctive research field and a major advance in physics. He has made groundbreaking advances in plasma processing of nano and bio materials, and achieved recognition in the broad disciplines of physics, chemistry, and biology.His work developed a conceptual basis, theories, and experimental techniques for explaining the plasma effects in nanoscale synthesis and processing. This led to systematic approaches to produce functional nanomaterials with highly-desirable properties, and a significantly raised profile of plasma technologies in materials processing and device fabrication. His research on nanoscale control of energy and matter for a sustainable future contributes to the solution of the grand challenge of directing energy and matter at the nanoscale, a challenge that is critical for renewable energy and energy-efficient technologies for a sustainable future. Ostrikov's 2014 NSW Science and Engineering Award evidences recognition of his excellence across physical, chemical, and biological effects induced by plasmas and plasma-produced or modified materials.

Graphene Supply Chain Certification

Lachlan Hyde

Hyde, L[1], Allioux, FM[1], Hameed, N[1], Fox, BL[1],

Email: Lachlan.hyde@swin.edu.au

Manufacturing Futures Research Institute, Swinburne University of Technology, Hawthorn, Australia

Abstract

Manufacturing graphene nanoplatelets (GNPs) is simple and easy to scale[1]. However, the worldwide supply of GNP lacks transparency regarding graphene quality, contamination, functionalisation, defects or disorder, all of which can impact the advantageous properties of graphene incorporation[2]. Without strict quality assurance and control, graphene-containing products will struggle to transition from prototype to production. Similarly, without graphene quality assurance, graphene manufactures will struggle to be incorporated into sophisticated supply chains. The Graphene Supply Chain Certification Centre endeavours to enable graphene-based technologies by offering transparent graphene characterisation to graphene manufactures, product developers or product manufacturers. By analysing graphene at different stages of the supply chain, the certification centre is developing best practices and methodologies with new in-line diagnostics aimed at introduction into manufacturing environments.

Biography

Dr Lachlan Hyde is the project manager for the Graphene Supply Chain Certification initiative led by Swinburne University of Technology's Manufacturing Futures Research Institute. Previously an employee of the Australian National Fabrication Facility (ANFF) Lachlan was fortunate to undertake experiments for NASA at the Melbourne Centre for Nanofabrication (MCN). Lachlan's passion for research translation and industry linkage catalysed his promotion to Senior Process Engineer – Business Development. Lachlan's research interests include in-situ analysis of nanomaterials manufacturing, novel deposition methods, Atomic Layer Deposition (ALD), Microwave Plasma Chemical Vapour Deposition (CVD) of Diamond ellipsometry and nanofabrication.

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Graphene-based electrodes for high-power Li-ion batteries

Vittorio Pellegrini

Email: vittorio.pellegrini@iit.it

Istituto Italiano di Tecnologia, IIT Graphene Labs, Via Morego 30, I-16163 Genova (Italy)

BeDimensional srl Genova (Italy)

Abstract

The future of energy sustainability is linked to the development of efficient energy storage facilities [1]. For an increasingly diverse range of application, spanning from automotive to portable high-end electronics, lithium-ion battery technology plays a pivotal role today, and will continue to do so over the next few years [2,3]. However, to extend their use, these systems require further improvements either in terms of energy density and cycle life performance [4]. In this context, the choice of proper anode and cathode materials plays a pivotal role [5].

In this talk I will show that a novel laminated silicon-graphene heterostructure provides superior performance as anode nanomaterial in half and full Li-ion cells [6,7]. It is composed by dispersing carbon-coated polycrystalline silicon nanoparticles in between a few parallel oriented few-layers graphene flakes produced by liquid phase exfoliation (LPE) leading to high capacity values of around 1000 mAh/g at current values up to 3.5 A/g. On the cathode side, I will address a Lithium Iron Phosphate (LFP)-graphene nanohybrid obtained by a direct LFP crystal colloidal synthesis on few-layer graphene (FLG) flakes produced by LPE [8]. In Li-ion batteries, we achieve fast charge/discharge responses to high specific currents. We demonstrate a specific capacity exceeding 110 mAh g^{-1} at 20 C, with no electrode damaging. The methods here proposed yield a scalable production path of novel graphene-based materials for the next generation of high-power lithium batteries.

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Biography of Presenter

Dr Vittorio Pellegrini is the Director of the Graphene Labs at the Italian Institute of Technology. Presently in the Graphene Flagship, he is the leader of the Division Composite, Energy and Production and leader of the Work Package Energy Storage. His former roles include Chair of the Executive Board of the Graphene Flagship, Director of the Nanoscience School of the Italian National Research Council. He is also editor of Solid State Communications. He is the co-founder of Bedimensional srl and member of its technical staff. He obtained his PhD from the Scuola Normale Superiore, Italy, in Physics. He was consultant at Bell Labs in Murray Hill in 1996-97 and visiting professor at Columbia University in 2008. He is co-author of more than 180 publications in peer-reviewed journals and several patents. His research interests include studies of innovative electrode materials for batteries, and graphene-based composites.

Activities at the Monash node of the Graphene Enabled Industry Transformation Hub of the Australian Research Council

Mainak Majumder

E-mail: mainak.majumder@monash.edu

Affiliation, Country: Department of Mechanical & Aerospace Engineering, Monash University, Clayton, Australia

Phone: +61399056255

Abstract

The Australian Graphene Industry is slowly, but steadily becoming an active bed of research and development, entrepreneurship and commercialization activities, evident by the recent establishment of the Australian graphene Industry Association and a slew of federal funding aimed at mobilising this upcoming industry. In particular, it is to be noted that several companies have started to produce commercial quantities of graphene/graphene oxide materials for applications ranging from smart devices, supercapacitors, membranes, fire retardant coatings to name a few. This is perhaps just the beginning, many opportunities are emerging as the development of new business ventures in untapped markets or in competitive markets with products having attractive price and value points takes shape. These businesses in turn would mean that this fledgling industry will demand many new requirements such as energy- and cost-efficient methods for producing these materials, characterization and standardization, product and formulation development, scale-up and manufacturing.

At Monash University, we have been involved in many of these activities in establishing the graphene value chain and in some cases, have taken leading national role in developing academia-industry partnerships. In this talk, I will discuss our strengths particularly in the areas of separations engineering (graphene-oxide based filtration membranes) and energy storage technologies (batteries & supercapacitor). I will also discuss how our collaborations with a wide network of national and international research partners is helping us overcome many technological challenges at a faster pace and with a small financial footprint.

Biography of Presenter

Since January 2018, Mainak Majumder is a professor at the Department of Mechanical and Aerospace Engineering, and an adjunct professor of Chemical Engineering at Monash University. At Monash, he has created an 'innovation ecosystem' involving early stage corporate investment, competitive public funding, scientific discovery, patenting & licensing intellectual property, joint-venturing with end-users & commercialization, generally in the order stated. Professor Majumder applies fundamentals of materials science, notably Carbon, to emerging and multidisciplinary areas of separation engineering & energy storage and in doing so, creates scientific & business opportunities. He has developed an international reputation for inventing innovative fabrication & processing methods, grounded on strong fundamentals, with impact in a wide gamut of engineering applications. He has published > 50 articles in journals inclusive of Nature, Nature Chemistry, Nature Communications, and has received >3400 citations with an h-index of 24. He was the founding board-of-directors of Ionic Industries (>2500 share holders) which is an Australian public company engaged in commercialization of graphene-based products. He has delivered >20 invited talks in countries such as US, China, Portugal, UK, Australia & India.

Graphene on silicon carbide on silicon for integrated energy storage

***Francesca Iacopi*[1,*]**

Email: Francesca.iacopi@uts.edu.au

[1]University of Technology Sydney, Faculty of Engineering and IT and Centre for Clean Energy Technology, Sydney 2007, Australia

Abstract

Graphene is a promising but challenging material to be harnessed for wafer -level micro and nanodevices. We have pioneered a catalyst- based methodology to obtain large -scale graphene from silicon carbide on silicon substrates in a transfer -free and site -selective fashion [1, 2], with particularly promising applications in integrated energy storage systems [3].

In fact, the combination of graphene and silicon carbide on silicon is ideal, for multiple reasons.

First, the use of a silicon substrate enables easy microfabrication and compatibility with silicon technologies. Second, the silicon carbide on silicon not only allows for a templated, wafer -scale and site- selective synthesis of graphene, but also greatly improved adhesion of graphene to the substrate.

Third, the silicon carbide layer underneath the graphene benefits beyond the simple template and solid source surface, allowing to create and support a highly porous, large surface area graphene with excellent conformality for use as highly performing electrodes in planar micro-supercapacitors on silicon [4].

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Biography of Presenter

Smart use and management of energy is rapidly becoming one of the most basic requirements for a sustainable future. A fundamental solution to this is designing devices with ultralow energy consumption, minimising all the parasitic energy losses (electrical, thermal, mechanical) which make devices power-hungry and also less performant. Low energy consumption needs to be complemented with efficient energy storage. Graphene and other 2D materials can enable all of these functionalities. My group's scope is to design nanodevices with unprecedentedly low energy consumption and dissipation, complemented by solutions for integrated energy storage: Low-power consumption electronics; low-loss plasmonics; low-damping mechanical systems for highly sensitive molecular recognition; and efficient on-chip energy storage.

Printable Graphene Electronics

E. Skafidis

E. Skafidas, *J. Yong, Y. Liang, Y. Yang*

E-mail: sskaf@unimelb.edu.au

Department of Electrical and Electronic Engineering,

University of Melbourne, Melbourne, Australia

Abstract

Currently, in order to implement an ANN on advance CMOS technology node, a typical lithographic mask set for the current generation central processor units at a 14 nm CMOS technology node costs approximately $USD 18 million, with wafer production costing approximately $USD 10,000. The high cost of building electronics is recognised as a significant barrier to innovation, and new architectures and fabrication methods for low-cost electronics design and fabrication are a research priority area. In this talk we discuss new techniques, including graphene based inks, for printable electronics that will enable high performance, low cost electronic systems

Biography of Presenter

Professor Stan Skafidas, from the Department of Electrical and Electronic Engineering, leads the Melbourne School of Engineering's research in nanoelectronics and is the Director for Centre for Neural Engineering. He received a PhD from The University of Melbourne in 1997. Before joining NICTA in 2004, he was Chief Technology Officer at Bandspeed (1998-2004), a company he cofounded, based in Austin Texas, which designed and manufactured semiconductor chipsets for wireless systems and products. At Bandspeed, he co-invented Adaptive Frequency Hopping – A coexistence technology that allows Bluetooth devices to sense the and avoid radio interference. This technology transformed Bluetooth into the robust and easy to use radio communication medium that it is today. AFH has been incorporated in every Bluetooth product since ver 1.2. In 2014 alone, there were over 3 Billion devices sold incorporating this technology. The Bandspeed company was acquired by multinational semiconductor provider Broadcom Inc. Professor Skafidas has over 300 publications in the fields of nanoelectronics, neural engineering, biosensors and wireless communications. He is listed as an inventor on 28 International patents. In November 2012, Professor Skafidas was elected as a Fellow to the Australian Academy of Technological Sciences and Engineering (ATSE). Professor Skafidas is recognised for his vision, leadership and major technical accomplishments in industry, research institutions, academia and international standardisation committees. Adaptive frequency-hopping technology that he developed now forms a critical part of the Bluetooth standard and has been incorporated in several billion devices. His research in nano-electronics has advanced the disciplines of wireless communications, single chip radars and medical diagnostic systems.

Graphene and Immune Cells

Lucia Gemma Delogu

M Orecchioni[1], E Vazquez[2], K Kostarelos[3], M Prato[4], A Bianco[5], X Feng[6], and
Lucia Gemma Delogu[1,6]

Email: Lucia_Gemma.Delogu1@tu-dresden.de or luciagemmadelogu@yahoo.it

[1]University of Sassari, Sassari, Italy, [2] Univerty of Castilla La Mancha, Ciudad Real, Spain
[3] University of Manchester, Manchester, UK [4] University of Trieste, Italy
[5] CNRS, Institut de Biologie Moléculaire et Cellulaire, Laboratoire d'Immunologie et Chimie Thérapeutiques, Strasbourg, France [6]Center for Advancing Electronics Dresden, TU Dresden, Dresden, Germany

Abstract

Graphene, with its unconventional properties, can open up new fascinating perspectives in nanomedicine, especially for the development of innovative biomedical technologies. The overall objective of our research group is to provide new insights on its immune impact and identify highly biocompatible graphene-based nanomaterials with specific dimensions and functionalization suitable for medical exploitation. Our work focuses on the advantages of the intrinsic immune properties of graphene which could be translated into the everyday clinical practice [1,2]. We propose an integrative analytical pipeline encompassing genomic and cellular characterization of the impact of graphene on human immune cells present in the blood stream: peripheral blood mononuclear cells. Notably, our findings illustrate how the small dimensions are correlated to a specific activation of immune response [3]. We employed, for the first time in the context of graphene, single cell mass cytometry to investigate the different interactions of graphene oxide and amino-functionalized graphene. We identified 15 cellular main populations corresponding to 200 nodes of distinct but logically interconnected cell sub-populations. Using several analytical tools (ie. SPADE and viSNE), we found that only the functionalized $GONH_2$ was able to induce a specific dendritic cell. Monocyte activation skewed towards a Th1/M1 response, as demonstrated by the increased production of classic M1 cytokines (TNFα, IL6, and CCL4). This effect was proved also by the overexpression of pathways critical for the development of an effective anti-tumor immune response (i.e. interferon signalling, CCR5 and CXCR3 ligands) [4]. We also investigated the potential application of few layer graphene, produced by ball milling process, in cancer therapy against myelomonocytic leukemia [5]. Currently, we are exploring graphene nanoribbons as well as a wide variety of functionalized graphene to lay the foundation for the basis of materials classification not only by their chemical and physical parameters but also by their bio and immune characteristics.

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Biography of Presenter

Dr Lucia Gemma Delogu served at the University of Sassari, Italy, as Assistant Professor of Biochemistry from 2012-2017. She has also worked at the University of Southern California, Los Angeles from 2007-2009. In 2011, she was selected as one of the "200 Best Young Talents of Italy" from the Italian Ministry of Youth. She has received several awards including the Marie S. Curie Individual Fellow under Horizon 2020 by the European Commission, the "Medicine, Biology e Nanotechnology Award" in 2012. She has served the European Commission as an invited expert on review panels of FP7 FET Flagships.

Graphene Oxide Membranes Graphene Materials for Antimicrobial Applications

Yuan Chen

Email: yuan.chen@sydney.edu.au

The University of Sydney, School of Chemical and Biomolecular Engineering, NSW, 2006, Australia

Abstract

Graphene materials (GMs), such as graphene, graphene oxide (GO), reduced GO (rGO), and graphene quantum dots (GQDs), are emerging as a new class of broad-spectrum antimicrobial agents. Here we describe our research efforts in exploring graphene materials for antimicrobial applications. First, we examined the antimicrobial mechanisms of GMs, and the complex picture of underlying structure–property–activity relationships is sketched. [1-3] Next, we examined how two crucial players (*i.e.*, surrounding environment and bacteria) influenced their interactions and demonstrated a new method that dramatically enhances the antibacterial activity of GO. [4-5] Later, two applications of GMs in the design of antibacterial GM-polymer composites are introduced. Other antibacterial agents can be incorporated into graphene hydrogels for enhancing their antibacterial activities. [6-7] Finally, the key hurdles of the field are highlighted, and several directions for future investigations are proposed. [8]

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Biography of Presenter

Professor Yuan Chen received Bachelor's and Master's degrees from Tsinghua University in China, and a PhD from Yale University in the United States. He was at Nanyang Technological University in Singapore from 2005 to 2015. He joined the University of Sydney in 2015. He received the Australian Research Council Future Fellowship (Level 3) in 2016, an Excellence in Review Award from Carbon in 2015, a Young Scientist Award from the Singapore National Academy of Science in 2011, a Tan Chin Tuan Exchange Fellowship in Engineering in 2010, and JSPS exchange award in 2009. He is currently serving as an editor for Carbon (impact factor 6.337) and Nanomaterials (impact factor 3.553). He also serves as Chair for Australian Carbon Society and Asian Association of Carbon Groups.

CVD Graphene Based membrane for water purification

Dong Han Seo

Dong Han Seo[1], Adrian Murdock[1], Tim Van Der Laan[2], Ho Kyong Shon[3], Stephen Gray[4], Graeme Millar[2], Kostya Ostrikov[2]

Email: Michael.Seo@csiro.au

[1] CSIRO Manufacturing, 36 Bradfield Road, Lindfield, NSW 2070, Australia.

[2] Institute for Future Environments and Institute for Health and Biomedical Innovation, School of Chemistry, Physics, and Mechanical Engineering, Queensland University of Technology, Brisbane, QLD 4000, Australia.

[3]Centre for Technology in Water and Wastewater, School of Civil and Environmental Engineering, University of Technology Sydney (UTS), P. O. Box 123, 15 Broadway, NSW 2007, Australia

[4] Institute for Sustainability and Innovation, College of Engineering and Science, Victoria University, Werribee, VIC 3030, Australia.

Abstract

Current water purification membranes cannot handle a wide spectrum of pollutants which makes water treatment process to be multistage and chemical intensive. Here we demonstrate water purification via a membrane distillation process using a CVD graphene derived from an ambient air CVD process where graphene film is produced from a renewable oil source without any compressed gases. CVD graphene film derived from this process consists of multi-layer, mismatched, partially-overlapping, graphene grains. Graphene films derived from ambient air CVD process exhibit significantly superior retention of water vapour flux and salt rejection rates, and a superior anti-fouling & anti-wetting capability under a mixture of saline water containing contaminants such as oils and surfactants, and contaminants with harsh chemical natures compared to commercial distillation membranes. Moreover, real world applicability of our membrane is demonstrated by processing sea-water from Sydney Harbour over 72 hours with macroscale membrane size of 4 cm^2, maintaining stable flux of ~50 Lm^2h^{-1} processing ~0.5 L per day. Numerical simulations show that the channels between the mismatched grains could be an effective water permeation route as well as anti-fouling barrier layer for the contaminant rejection. Our research will pave the way for large-scale graphene-based membranes for diverse water treatment applications.

Biography of Presenter

Dr. Dong Han Seo is a Research Scientist at CSIRO Manufacturing. His research focus is in graphene synthesis from both plasma & thermal processes, biomass conversion, sensors, energy storage devices, and membranes for water purification. He completed his Bachelor of Science (Physics) with First Class Honours at University of Sydney in 2009. Then completed PhD in Science from University of Sydney and was awarded an Australian Institute of Physics Best Postgraduate Award in 2014. During His postdoctoral Fellowship at CSIRO, (2014-2017) he invented innovative graphene synthesis process- GraphAir. He is main inventor of three patents and his research was highlighted in many media including ABC, BBC News, and The Australian article: "Tackling challenges from space to Earth's surface.

Graphene Oxide Membranes

Rakesh Joshi

Email: r.joshi@unsw.edu.au

School of Materials Science and Engineering

University of New South Wales Sydney, Australia

Abstract

We have studied separation, purification, water absorption and sponge like behavior of graphene oxide (GO). Using GO membranes, we have achieved high-water flux in practical conditions with ~100% rejection (or below detection limit) of targeted toxic molecules. We have studied the water adsorption behavior of graphene oxide and our highly reproducible results suggest that GO membranes completely outperform silica gel, a commercial benchmark desiccator. On using GO as intercalation template, we noticed a highly recurring sponge like behavior to foreign molecular/ionic species. The interlayer spacing (d) of graphene oxide increases to a higher value on intercalating, depending on the size of species, followed by obtaining initial value of 'd'on desorption. This highly reproducible behavior enables multiple possible applications of graphene oxide.

B. Lian, Y. You, X, Jin of UNSW Sydney and H. Bustamante of Sydney Water have significantly contributed to this work. Majority of the results have been published or submitted for publication in various Journals.

Biography of Presenter

Dr Joshi's breakthrough work with Nobel Laureate Sir Andre Geim on Graphene Oxide Membranes (link is external) is amongst the most influential contributions in the field of graphene-based filtration. Recently, he was awarded the prestigious JSPS Invitation Fellowship from Japan and Humboldt Fellowship from Germany for his work in water purification using graphene. He has published ~70 refereed journal papers with ~55 as first or corresponding author and 2 international patents. He recently edited a virtual special Issue on Graphene Based Membranes (link is external) for the Journal of Membrane Science. Joshi is currently leading various industry funded research projects on application of graphene and is also Fellow of the Royal Society of Chemistry

Graphene Growth by Chemical Vapour Deposition and Integration Challenges

Ken Teo

k.teo@aixtron.com

AIXTRON Ltd, Anderson Road, Swavesey, Cambridge CB24 4FQ, United Kingdom

Abstract

The unique properties of graphene which include high carrier mobility, electrical conductivity, transparency, thermal conductivity and mechanical strength, make thin film graphene, grown by chemical vapour deposition (CVD), as a prominent candidate for novel electronic, opto and sensing applications.

Growth and device results are presented from small scale up to 300mm wafer scale. Graphene on wafer produced had to meet two distinct specifications, firstly compatibility with semiconductor fabrication lines, in particular, low metal contamination; and secondly, material performance with significant carrier mobility. Various growth strategies, based upon CVD were investigated, namely graphene on metal foil, graphene on Germanium wafers and graphene on insulator; these would subsequently be transferred as needed. Graphene on metal foil could yield material with satisfactory mobility but metal contamination would be an issue (therefore focus on alternative transfer methods to see if the contamination can be lowered); whereas graphene on Ge or insulator would not have metal contamination but the mobility which was much worse needed to be improved. Results with respect to contamination and mobility will be compared and discussed. For non-wafer based applications, large scale growth of graphene onto foils is required. We have developed a double-end open roll to roll reactor system for graphene growth. The open system allows true inline integration into a continuous production line. Results for growth of graphene onto various metal foils will be presented.

This work is the result of a collaboration between AIXTRON (UK), Graphenea (Spain), ITME (Poland), Technical University of Denmark (Denmark), IMEC (Belgium) and IIT (Italy).

Acknowledgement: This work is partly funded by Graphene Core 1, grant agreement 696656, under European Community's Horizon 2020 Framework Programme.

Biography of Presenter

Dr Ken Teo is Chair of the Executive Board, Graphene Flagship. He is the Managing Director at AIXTRON Ltd (UK) and Group Innovation Officer at AIXTRON Group. He holds a BE (Elec) from the University of Canterbury, MBA and PhD from the University of Cambridge. In 2005, Dr. Teo founded and ran Nanoinstruments Ltd (UK) which manufactures innovative Graphene and Carbon Nanotube growth equipment for research and industry; in 2007, Nanoinstruments was acquired by AIXTRON. His previous roles include Director of Nanoinstruments at AIXTRON, Lecturer in Electrical Engineering at University of Cambridge, Fellow/Director of Studies at Christ's College Cambridge, Royal Academy of Engineering Research Fellow, Fellow of the Institute of Nanotechnology, Project Engineer at Defence Material Organisation (Singapore) and Product Engineer at PDL Holdings (NZ). Dr Teo has extensive experience in the area of carbon nanomaterials and is the author/co-author of ~200 papers and 12 patents.

Advanced Materials Enabling the Fourth Industrial Revolution

Mohammad Choucair

Chief Executive Officer, Archer Exploration Limited

Email: m.choucair@archerx.com.au

Abstract

I am pleased to welcome you to Archer Exploration Limited (ASX:AXE). Our mission is to positively contribute to global systems enabling the Fourth Industrial Revolution. Our vision is to develop and integrate advanced materials for use in reliable energy, human health, and quantum technologies for the betterment of society. We know that this can only be achieved by applying our values of excellence, creativity, and collaboration, in everything we aim to achieve.

At Archer, we develop mineral resources.

Through a unique combination of exploration and innovation, we're creating advanced materials from Australia's natural resources to find and source the building blocks of modern technology. With projects spanning graphite, manganese, copper, cobalt and more, we're making the materials of the future possible.

Innovation to reinvent materials thinking.

By harnessing the potential of scientific innovation, we're transforming our mineral resources into the advanced materials needed to drive the new order of performance required by future industries and technologies.

Integration to accelerate global impact.

Our collaborative approach to mineral and materials development is enabling a new wave of converging technologies, each with the potential to revolutionise global industries spanning energy, medicine, and electronics.

Reliable Energy

Energy technologies are an integral part of society. The ability to control the accumulation of heat, light and electricity efficiently and reversibly has wide-reaching applications in energy storage and use. We are developing advanced materials for a future circular economy based on providing non-polluting alternatives to fossil fuels.

Human Health

Future technologies incorporating complex biosensing devices will need to quickly identify disease and infection. We are developing material probes that can be integrated as functional elements for rapid diagnostic medical imaging and in the detection of complex biological molecules connected to the human immune system.

Quantum Technology

Materials that enable quantum information processing could transform all industries dependent on computational power and are at the heart of some of the biggest challenges facing quantum computing. We are developing the fundamental components to practical quantum computers for wide-scale commercial use.

As you will see in the following document, our focus on end-to-end material centric solutions results in an interdependency across the various complex systems we operate, which potentially gives rise to solving some of the world's grand challenges. If you would like more information about Archer or are interested in working with us, please feel free to contact us.

Biography of Presenter

Dr Mohammad Choucair obtained PhD in Chemistry from the UNSW in 2010 where he was a recipient of an Australian Postgraduate Award and the Royal Australian Chemical Institute Cornforth Medal for the most outstanding Chemistry PhD thesis in Australia. During his PhD, Dr Choucair was awarded a Commercialisation Training Scheme Scholarship to complete a Graduate Certificate in Research Management and Commercialisation at the Australian Graduate School of Management. Dr Choucair was the founder of Carbon Allotropes and was appointed as Archer Exploration Limited's CEO on 1 December 2017. He has a strong technical background in nanotechnology, and has spent the last decade implementing governance, control and key compliance requirements for the creation and commercial development of innovative technologies with global impact. Dr Choucair served a 2-year mandate on the World Economic Forum Global Future Council for Advanced Materials and is a Councillor of The Royal Society of New South Wales. He has a strong record of delivering innovation and has been recognised internationally as a forward-thinker

Talga Resources ltd.

Martin Phillips

martin@talgaresources.com

Talga Resources Ltd, Perth, Australia

Abstract

Talga Resources Ltd (ASX: TLG) is an advanced materials technology company enabling stronger, lighter and more functional products for the multi-billion dollar global coatings, battery, construction and polymer composites markets via graphene and graphite products.

The company owns the highest grade graphite mineral resource in the world and has developed an innovative process to make the mass production of high quality graphene possible. This enables the conversion of Talga’s 100% owned natural raw graphite source in Sweden into high quality graphene and graphite products, using a patent pending industrially scalable and environmentally friendly electrochemical system. Talga, through its wholly owned German subsidiary, Talga Advanced Materials GmbH, has built a pilot test work facility and a technical team in Rudolstadt, Germany. Source material from trial graphite mining in Sweden is feeding scale up test work on Talga's innovative processing technique. Test work is providing the data to support expansion and also provides samples for distribution to partners for industrial validation leading to commercial agreements.

Joint development programs, managed by the company’s wholly owned UK subsidiary, Talga Technologies Limited, for graphene and graphite enhanced products are underway with a range of international corporations

Biography of Presenter

Mr Phillips is an experienced project manager, commercial manager and company director with over 25 years of global metals and mining sector experience. He is based in Europe where his responsibilities include managing Talga’s graphene and graphite project developments as well as to oversee and drive processing operations through Talga’s German subsidiary operations, Talga Advanced Materials GmbH.

Building on an early career that included engineering roles in battery recycling programs and smelting innovations at MIM’s Mt Isa and UK operations, Mr Phillips constructed and managed operations and implemented growth strategies for offshore smelting businesses. Mr Phillips holds a Bachelor of Chemical Engineering (Honours) and a Graduate Diploma in Applied Finance and Investment. He is a Member of the Australian Institute of Company

Directors and the Australasian Institute of Mining and Metallurgy and he holds a Confederation of British Industry (C.B.I.) Engineering Award.

POSTERS

Processing and Characterisation of Graphene Quantum Dots using Ultrasonication Process for Biosensing Applications
Julia Chov and Dr. Tran Tung
School of Chemical Engineering, The University of Adelaide, SA 5005, Australia

Adsorption of Radioactive Caesium using a 3D Reduced Graphene Oxide Composite Aerogel
A.G. Al-Dasooqi, D. Tran, D. Losic
School of Chemical Engineering, The University of Adelaide, SA 5005, Australia

Tribological performance of two types of diamond like carbon films on polished alumina substrates
Authors: Ay Ching Hee, Dusan Losic
School of Chemical Engineering, University of Adelaide, Adelaide, Australia

High Performance of Graphene Thin Films Manufactured by Microwave and Atmospheric Plasma Treatment
Mohamad Faris Fauzi, Dr. Tran Tung
School of Chemical Engineering, The University of Adelaide, SA 5005, Australia.

Development of shear-thinning Gelatin/Laponite/Graphene hydrogel
Authors: Hadi Rastin , Dusan Losic, Diana Tran
School of Chemical Engineering, The University of Adelaide, Adelaide, SA 5005, Australia

Simple, facile fabrication of MoS2/graphene paper based electrodes for supercapacitor
Hongxia Wang, Diana Tran, Mahmoud Moussa, Dusan Losic
School of Chemical Engineering, The University of Adelaide, Adelaide, SA 5005, Australia

Laser Scribed Graphene/V2O5 Supercapacitors
Mahmoud Moussa, Rhys Phillips, Dusan Losic
ARC Research Hub for Graphene Enabled Industry Transformation, School of Chemical Engineering, University of Adelaide, Adelaide, Australia

Potential of Ionic Liquid (IL) and Graphene Oxide (GO) as Inhibitor in Corrosion Control
Mohammad Dhamiry Mohammad Faidz, Prof.Namita Roy Choudhury, Dr.Rajkamal Balu
School of Chemical Engineering, University of Adelaide, Australia

Hydrothermally reduced graphene oxide composite aerogels for improved process water cation adsorption
Nicola Matulick, Diana Tran, Dusan Losic
School of Chemical Engineering, University of Adelaide, Adelaide, Australia

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Functionalized Graphene Hybrid with Thiol-(Cysteamine)-eneClick Chemistry for Efficient Hg (II) Ions Removal

Pei Lay Yap, Shervin Kabiri, Diana N.H. Tran and Dusan Losic
School of Chemical Engineering, University of Adelaide, Adelaide, Australia
ARC Hub for Graphene Enabled Industry Transformation, The University of Adelaide, Adelaide, SA 5005, Australia.

Fabrication and Characterization of 3D Graphene-alginate Scaffolds for Tissue Engineering Applications

School of Chemical Engineering, University of Adelaide, Adelaide, South Australia, Australia
Negar Mansouri,,Said Al-Sarawi,, Jagan Mazumdar,,Dusan Losic
School of Chemical Engineering, University of Adelaide, Adelaide, Australia
School of Electrical and Electronic Engineering, University of Adelaide, Adelaide, South Australia, Australia

Effects of Incorporating Modified Nanoclay into Polylactide-Graphene Nanocomposite Filament for 3D Printing on Mechanical Strength

Farizah Mohd Azmi, Dusan Losic and Diana Tran
School of Chemical Engineering, The University of Adelaide.

Graphene-based Fumigant Sensors

Nathan Stanley, Le Hong An Nguyen, DusanLosic
School of Chemical Engineering, University of Adelaide, Adelaide, Australia

Improvement of Thermoelectric Properties Through Manipulation of Microstructure Effect of Graphene Reinforcement

Sadeq Hooshmand Zaferani, Reza Ghomashchi, Daryoosh Vashaee, Soon-Jik Hon
School of Mechanical Engineering, University of Adelaide, SA 5005, Australia
Department of Electrical and Computer Engineering, North Carolina State University, NC 27606, United States
Division of Advanced Materials Engineering, Kongju National University 1223-24 Cheona Daero, Seobuk-gu, Cheonan-si, Chungnam 331-717 South Korea

Effect of industrially produced pristine graphene concentrations on enhancing properties of ordinary Portland cement mortars

Van Dac Ho, Cam Coghlan, Andy Goodwin, Craig Mc Guckin, Ching-Tai Ng, Togay Ozbakkaloglu, Dusan Losic
University of Adelaide, Adelaide, Australia

Graphene and 2D Materials composites for Electromagnetic Radiation Shielding Applications

Le Yu, Dr Diana Tran, Dr Alexandre Santos, Prof. Dusan Losic
School of Chemical Engineering, University of Adelaide, Adelaide, Australia
Department of Medical Physics, Royal Adelaide Hospital, Adelaide, Australia

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Graphene films: flexible electrodes and applications
Tran Tung, Dusan Losic
Graphene Hub, School of Chemical Engineering, The University of Adelaide, 5005

Graphene Fire Retardant Film for Structural Materials
A.Tadesse, MD Nine, D.Tran, D.Losic
School of Chemical Engineering, University of Adelaide, Adelaide, Australia

Preparation of Graphene-Hydroxyapatite Additives via Ball Milling for Fire Retardant Paper
Muhammad Iskandar Yusri*, Professor Dusan Losic, Md Julker Nine
School of Chemical Engineering, The University of Adelaide

Shear stress mediated scrolling of graphene oxide
Thaar M.D. Alharbi, Warren D. Lawrance, Colin L. Raston
Flinders University, South Australia