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GRAPHENE MALAYSIA 2017

REVOLUTIONISING INNOVATIONS WITH GRAPHENE

10-11 JULY 2017

DOUBLETREE BY HILTON HOTEL
KUALA LUMPUR, MALAYSIA

Organisers

NANOMALAYSIA®

PHANTOMS foundation

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ABSTRACTS BOOK

PlaTCOM Ventures

CONNECTING THE DOTS FOR SUSTAINABLE INNOVATION

We transform ideas into real commercial value for greater societal impact!

PlaTCOM Ventures Sdn Bhd is the **national technology commercialisation platform of Malaysia**. It is a wholly owned subsidiary company of Agensi Inovasi Malaysia (AIM) formed in collaboration with SME Corporation Malaysia under one of its six High Impact Programmes (HIPs) in SME Master Plan 2012-2020. We bring new meaning to the way people work and innovate in every step along the commercialisation value chain by working closely with partners around the world. PlaTCOM Ventures is a model that facilitates the commercialisation process **(end-to-end facilitation)** from idea to products and services for SMEs, public research institutes, universities, entrepreneurs and grassroots innovators.

- **High Impact Programme (HIP) 2** is a programme designed in collaboration with SME Corporation Malaysia for Malaysian SMEs to help them seamlessly move their innovations along the complex stages of the commercialisation process.
- **IBO: Online IP Trading Platform** is the national Intellectual Property (IP) trading platform that enables technology providers to promote their technologies whilst creating an ideal IP marketplace for technology hunters and investors to identify the right IP that fits with their business requirements.

IBO INNOVATION BUSINESS OPPORTUNITIES

Our Services:

IPR & Legal Services	Capacity Building	Commercialisation Support Services	Technology Scouting	PlaTCOM Angels Group
End-to-end IP & Legal Solutions	Bespoke Training and Courses	Strategic consultancy in market intelligence, company financials, business plans & technlogy needs	Sourcing the right IP for commercialisation based on industry needs	A platform to introduce technology based investment opportunities

Speak to us:

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PlaTCOM InnoSeed PlaTCOM InnoZine PlaTCOM Angels Group

In collaboration with

AIM SMECORP MALAYSIA

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FOREWORD

On behalf of the Organising Committee we take great pleasure in welcoming you to Kuala Lumpur for the second edition of the Graphene Malaysia 2017 International Conference.

Graphene Malaysia 2017 is jointly organised by NanoMalaysia Berhad and Phantoms Foundation with the endorsement from the Ministry of Science, Technology & Innovation and the Ministry of International Trade & Industry and support from Agensi Inovasi Malaysia, National Graphene Action Plan 2020, Grafoid Inc. and PlatCOM Ventures.

Graphene Malaysia 2017, a flagship event under Malaysia's National Graphene Action Plan 2020, is centered on interaction and collaborative innovation within the graphene enhanced industry.

The conference features plenary sessions and thematic workshops (Graphene production / Applications of graphene and Funding & infrastructure support) and an exhibition showcasing the latest products, services and technology in the graphene field.

We would like to thank the following companies for their participation as exhibitors: Grafoid Inc., RGS Corporation Sdn. Bhd., Haydale, Aseptec Sdn. Bhd., Abalonyx, ITS Interscience, Crest, NanoMalaysia, aNexus, Anton Paar Malaysia Sdn. Bhd., MIMOS Semiconductor (M) Sdn. Bhd., E-tecs, Adastra IP, KASS, PlaTCOM Ventures, KDJLaw, TEE Intellectual Property, Dahan Tech, Graphene 3D Lab Inc., Penchem Technologies Sdn. Bhd., GB Sekhar Sdn. Bhd. and IDC Global Sdn. Bhd.

We expect Graphene Malaysia 2017 to serve as a platform that will catalyze the collective desire to revolutionize Malaysia's local innovations with graphene.

Last but not least, a tremendous appreciation goes to the organizing team who had worked tirelessly towards this conference.

DR. REZAL KHAIRI AHMAD
Chief Executive Officer
NanoMalaysia Berhad (Malaysia)

DR. ANTONIO CORREIA
President
Phantoms Foundation (Spain)

MINISTERS´ STATEMENTS

YB DATUK SERI PANGLIMA MADIUS TANGAU
Minister of Science, Technology and Innovation
(Malaysia)

"Graphene as I see it, can re-energise Malaysia's economy to become more competitive in the sense that economic growth is sustained and the nation can now create and maintain an environment for wealth creation.
Malaysia's new economy will be accelerated by industry development; generating wealth from Science, Technology and Innovation particularly through graphene-based products such as high value tyres, better performing plastics and longer lasting batteries."

YB DATO' SRI MUSTAPA MOHAMED
Minister of International Trade and Industry
(Malaysia)

"Researchers from all around the globe have been scrambling to better understand graphene, dubbed as the supermaterial. As such, the Graphene Malaysia 2017 conference is timely in providing valuable insights and platform to further discuss the potential of graphene to be a key material in industries such as automotive, electronics and medicine. Graphene could be the resource that will drive the next era of human history, but we cannot unlock its true potential without addressing the challenges that come with it. Malaysia is keen to be part of this process."

NANOMALAYSIA'S CHAIRMAN STATEMENT

YBHG. PROF. EMERITUS DATO' IR. DR. MOHAMAD ZAWAWI BIN ISMAIL
Chairman of NanoMalaysia Berhad
(Malaysia)

"Materials throughout history have affected the development of society as we have seen with iron, brass and steel, and in the last two decades silicon materials have enabled the advancement of computers and the ubiquity of information technology. Today, the emergence of the supermaterial graphene is set to alter the future. It is hard to imagine that a single layer of graphite which is graphene could take some amazing properties, enough to have drastic implications for the future of physics, engineering, and industry. This is what inspired us in NanoMalaysia for the last five years to think of a wide range of uses for the material. At the same time encouraging government, university, and industry collaboration in order that the nation will not miss the opportunity to reap benefits from it. We are happy to co-organise Graphene Malaysia 2017, a platform for networking and collaboration and welcome all participants."

SPEAKER'S PROFILE

MURNI ALI

NanoMalaysia Berhad, Malaysia

Vice President of National Graphene Action Plan 2020 Office. Ms. Murni received her Bachelor of Science (Hons) Biomedical Degree from UPM and Master of Business Administration in International Business from University of East London, United Kingdom. With more than 10 years' experience in the field of Business Development and Marketing, she is currently heading the National Graphene Action Plan 2020 Office.

Ms. Murni brings diversified experiences in operations and managerial functions of the Business Development and Marketing fields. Well defined understanding of the business-technology interface and capacity to identify and align clients' emerging technology needs with products and services, she has been involved in various business-development disciplines underscores expertise in engaging decision makers and devising winning sales strategies and solutions exercises.

CHESTER BURTT

Grafoid Inc., Canada

Director of Communications and Government Affairs, Grafoid Inc., Canada. Mr. Burtt brings more than 30 years of sophisticated corporate and political communications-related experience to Grafoid. He is President of Chester Burtt & Associates Ltd. ("CBAL"), a corporate and public affairs advisory firm that specializes in connecting private and public companies with domestic and international opportunities. CBAL also arranges for the provision and supply of financial services in mergers, acquisitions and joint ventures.

Working through an international network and associate firms, CBAL has a 25-year history of offering a full range of services to assist companies with strategy development and decisions to best suit their investor and corporate relations. Mr. Burtt graduated with a B.A. (Honours) from Waterloo Lutheran University and an M.A. from Wilfrid Laurier University in Political Science. Mr. Burtt also sits on the Board of Directors of Focus Graphite Inc.

ANTONIO H. CASTRO NETO

National University of Singapore, Singapore

Professor A. H. Castro Neto got his Ph.D. in Physics at University of Illinois at Urbana Champaign in 1994. In 1994, he moved to the Institute for Theoretical Physics at the University of California at Santa Barbara as a postdoctoral fellow.

In 1995, he became an Assistant Professor at University of California at Riverside. In 2000, he moved to Boston University as Professor of Physics. At Boston, Prof. Castro Neto became one of the leading theorists in the study of graphene. In 2010, Prof. Castro Neto became the Director of the Graphene Research Center and Distinguished Professor at the National University of Singapore. In 2003, Prof. Castro Neto was elected a fellow of the American Physical Society. He is the colloquia Editor for Reviews of Modern Physics, and co-editor for Europhysics Letters. Prof. Castro Neto has authored more than 200 manuscripts and has published in prestigious journals including Science, Nature Materials, Nature Physics, and Physical Review Letters, and has over 12,000 citations. Prof. Castro Neto has given more than 200 seminars worldwide.

NAM SUNG CHO

Electronics & Telecommunications Research Institute - ETRI, Korea

Managing Director, Ph.D

Flexible Device Research Group / Reality Device Research Division / ICT Materials & Components Research Laboratory

Nam Sung Cho received his BS degree from Chung-Ang University, Seoul, Rep. of Korea, in 2000 and his MS and PhD degrees in chemistry from the Korea Advanced Institute of Science and Technology, Daejeon, Rep. of Korea, in 2002 and 2006, respectively. From 2006 to 2008, he was a postdoctoral associate at the University of California Santa Barbara, Santa Barbara, CA, USA. He worked in material development for OLEDs in LG Display R&D Center, Paju, Rep. of Korea, from 2008 to 2012. He joined the Electronics and Telecommunications Research Institute, Daejeon, Rep. of Korea, in 2012. His current research interests include OLED structures, OLED materials, and white OLEDs.

ANTONIO CORREIA

Phantoms Foundation, Spain

Antonio Correia is the founder and President of the Phantoms Foundation & Doctor in Physics (Université Paris 7, France). Previously he has worked in France at the CNRS and the CSIC in Spain, both national research institutes.

Currently, he is president of the Phantoms Foundation, a non-profit organization created in November 2002 in Madrid, and serves also as the Coordinator of the Eureka Cluster on Graphene and 2D materials, the nanoSpain network and the nanotechnology plan for ICEX (Spain Trade & Investment). He has been involved in more than 15 EU funded projects and author of more than 60 publications and book chapters. He serves also as a Chairman of major conferences in Graphene Worldwide.

ANDREA FERRARI

University of Cambridge, UK

Andrea C. Ferrari earned a PhD in electrical engineering from Cambridge University, after a Laurea in nuclear engineering from Politecnico di Milano, Italy. He is Professor of Nanotechnology and the Director of the Cambridge Graphene Centre and of the EPSRC Centre for Doctoral Training in Graphene Technology.

He is Fellow of Pembroke College, the American Physical Society, the Institute of Physics and the Materials Research Society. His research interests include nanomaterials growth, modelling, characterization, and devices. He was awarded the Royal Society Brian Mercer Award for Innovation, the Marie Curie Excellence Award, the Philip Leverhulme Prize, The EU-40 Materials Prize, The Royal Society Wolfson Research Merit Award. He is also the Chairman of the Executive Board of the EU Graphene Flagship.

RAY GIBBS

Haydale Ltd., UK

CEO Haydale Graphene Industries plc

Appointed CEO in 2013. Main achievements are:

• Secured £4.4m private equity funding under EIS and then successfully took the business to IPO in April 2014. Raised £6.6m on float. Valued at £17m post money.

• Developed and implemented a growth strategy by acquiring a composites consulting business in November 2014. Opened a South Korea sales and marketing operation followed by a Thai based business in September 2016 (as a low-cost operation serving the expanding Far East operation).

• Acquired a specialist, complimentary nano business in South Carolina USA for $5.2m in October 2016.

• Concluding commercial collaboration agreements for sales, securing a raw material supply chain and concluded licensing arrangements with Germany industrialization partner.

• Secured a £3.25m strategic partner investment from a Chinese based business looking to commercialise the Haydale products in China.

• Market value has grown to over £30m

VINCENT GOMES

The University of Sydney, Australia

Associate Professor Vincent Gomes is a lead researcher in the emerging areas of Polymer Science and Engineering and novel applications of polymeric nanocomposites.

AZMAN HASSAN

Universiti Teknologi Malaysia, Malaysia

Professor Dr. Azman Hassan is an expert in polymer nanocomposite and natural fibres polymer composites. His work focuses in the utilisation of local natural resources to produce value added products. Commercialisation of Epoxidised Natural Rubber (ENR) is an important area under National Key Economic Areas and his studies have shown the potential of ENR as an impact modifier for various polymers.

Through the research, he has received LRGS grant to develop kenaf reinforced biocomposites for automotive applications. His current research work focuses on developing automotive parts using graphene reinforced polymer nanocomposites. Products based on graphene is expected to contribute RM18 billion to Malaysian economy by 2020. He also has completed an international project in collaboration with Qatar University using date palm in recycled polymer composites which has impact on societal well-being. Another novel study of his research is the production of nanocellulose whiskers from empty fruit bunch which was published in Tier 1 journals. Currently, he is the Deputy President of Malaysia Polymer Society.

KUAN-TSAE HUANG

AzTrong, USA/Taiwan

He is an expert in Graphene and graphene commercialization in heat spreading, battery & supercapacitor, composites and other graphene applications. He had 20+ years working at IBM, was a Vice President, played a key role to help IBM successfully transformed into a global service company, in charge of e-commerce implementation, intellectual capital and asset Management, solution offerings, etc.

He is an experienced business transformation and implementation consultant. Dr. Huang's career included the President of National Taiwan Normal University; visiting faculty of several universities in Singapore, US and Taiwan; National Institute of Health, US, etc. He is also an experienced entrepreneur in Silicon Valley. Currently, he is the Chairman/CEO of AzTrong (Graphene & Applications), Senior Advisor to Ditthavong & Steiner patent law firm, Ditthavong & Steiner, Chairman of Taskco e-Business Corporation.

BOR Z. JANG

Angstron Materials, USA

Dr. Bor Jang Co-Founded Angstron Materials Inc. in 2007 and serves as its Chief Executive Officer. Dr. Jang has been a Member of Scientific Advisory Board at Lanka Graphite Limited since May 20, 2016. Dr. Jang is a former Dean of the College of Engineering at Wright State University and a former Fulbright Scholar and Visiting Professor with the University of Cambridge.

Dr. Jang is a leading expert in the research and development of low-cost carbon nanomaterials, battery, super capacitor, and fuel cells with nearly 100 inventions to his credit and close to 90 patents. Dr. Jang is a pioneer in the field of graphene technology, including graphene for battery and supercapacitor applications. Dr. Jang was recognized by Cambridge IP ("Patenting Flatland: Graphene," April 2012) as the world's No. 1 graphene inventor, respectively. Dr. Jang is world's first scientist to study the application of graphene materials in energy storage and conversion (e.g. supercapacitors, batteries, and fuel cells).

KIRAN KUMAR MANGA

Grafoid Inc., Canada

Experienced Consultant with a demonstrated history of working in the research industry. Skilled in Research and Development (R&D), Chemistry, Graphene, Materials Science, and Nanoparticles. Strong consulting professional with a Doctor of Philosophy (Ph.D.) focused in Materials Chemistry from National University of Singapore.

MARTIN LOHE

TU Dresden / cfaed, Germany

Martin Lohe finished his PhD in inorganic chemistry and worked as a post-doc on the application and up-scaled production of porous materials before switching his research focus towards graphene and 2D materials. He is currently working as researcher and industry project coordinator at the Chair for Molecular Functional Materials at the Center for Advancing Electronics Dresden at TU Dresden.

HASEGAWA MASATAKA

National Institute of Advanced Industrial Science and Technology (AIST), Japan

Masataka Hasegawa is the Group Leader of Carbon-Based Thin Film Materials Group in Nanomaterials Research Institute at National Institute of Advanced Industrial Science and Technology (AIST).

He received his B.S., M.E. and Doctor of Engineering (1990) at Kyoto University. He joined ElectroTechnical Laboratory (ETL) in 1990 as a researcher. His research field is carbon materials including graphene, diamond, and nanocrystalline diamond.

ABDUL RAHMAN MOHAMED

Universiti Sains Malaysia, Malaysia

Has been appointed by the Ministry of Higher Education as the Deputy Vice-Chancellor, Industry and Community Network of Universiti Sains Malaysia for a term of three years effective from 1st of May 2016.

A Top Research Scientist in Malaysia (TRSM) and an expert in Reaction Engineering and Catalysis, Air Pollution Monitoring and Control, Fuel Technology and Nanotechnology obtained his undergraduate degree in Chemical Engineering from the University of Southern California, USA and later graduated with a master of science (Chem. Eng.) and PhD in the same field from the University of New Hampshire, both in the United States. Professor Dr. Abdul Rahman Mohamed began his career at USM as a lecturer in 1993. He has served as the Director of the Industry Collaboration Centre as well as being among the main academicians heading the Research and Development Division of 'Collaborative Research in Engineering, Science and Technology'. He is well-known as a researcher and scientist with more than 80 grants awarded to him internationally, valued more than RM18 million, and having publications with high-impact citations, in addition to hundreds of research papers in various well-renowned academic journals, along with academic and professional networks from various countries including Japan and France.

NORANI MUTI MOHAMED

Universiti Teknologi PETRONAS, Malaysia

Norani Muti is a professor at the Department of Fundamental & Applied Sciences at Universiti Teknologi PETRONAS (UTP). Currently she is holding the position as a Director for UTP Centre of Innovative Nanostructures & Nanodevices (COINN).

She obtained her BSc, MSc and PhD in Physics from University of Essex, UK. She specializes in the area of Thin Film Technology, Semiconductor Technology and Nanotechnology. She established "Centre of Innovative Nanostructures and Nanodevices (COINN)" at UTP with the objective of establishing a library of nanomaterials and synthesis techniques for accelerated production of innovative and beneficial commercialized products. In 2011, COINN had been recognized as NanoMalaysia Centre of Excellence based on its continuous effort on R&D on nanotechnology, focusing on alternative and renewable energy. Research works undertaken are very much focused on cutting edge research areas ranging from novel materials with innovative nanostructures to novel nanodevices. Some of her achievements in research have been awarded medals at various local and international exhibitions. She is also actively involved in International Organization of Standardization in Nanotechnologies (ISO/TC229) as the technical expert and as the chairperson of working group 2 (measurement and characterization) in Malaysia. She is also the fellow of the Academy of Sciences Malaysia (ASM).

AHMET ORAL

NanoMagnetics Instruments & Middle East Technical Univ., Turkey

Prof. Ahmet Oral was born in 1965 and obtained his PhD in Physics from Bilkent University, Ankara, Turkey in 1994. He has built the first Scanning Tunnelling Microscopes in Turkey in 1989 during his MSc. thesis. He built the first UHV-STM in Turkey, during his PhD thesis.

Dr. Oral spent a couple of years in Bath and Oxford as post-doc, working on Scanning Hall Probe & Atomic Force Microscopes, before returning to Bilkent in 1999 as a faculty member. He is recipient of M. Parlar Young Scientist Award in 1993, Violette and Samuel Glasstone Research Fellowship in Science in 1998 and TÜBITAK Young Scientist Award in 2002. He worked at Sabanci University between February 2008 and April 2013. He was elected Associate Member of Turkish Academy of Sciences (TÜBA) in 2001 and Full Member in 2009. He resigned in 2011 from TÜBA. He is one of the founding members of The Academy of Science, Istanbul, Turkey in 2011. Dr. Oral is also the founder and CEO of NanoMagnetics Instruments Ltd. Oxford, U.K., NanoManyetik Bilimsel Cihazlar and NanoSis in Ankara, Turkey and NanoMagnetics Instruments USA, Manufacturing Scanning Hall Probe Microscopes, micro and nano-Hall sensors, Atomic Force Microscopes, Magnetic Force Microscopes & Scanning Probe Microscopes at a wide temperature range (10mK-300K). He has 56 technical publications in ISI cited journals and two book chapters.

ELENA POLYAKOVA

Graphene Laboratories Inc., USA

Elena Polyakova serves as Co-Chief Executive Officer at Graphene 3D Lab, and was instrumental in bringing the first graphene filament to market. She is also co-founder of Graphene Laboratories, Inc. where she has served as CEO and President since 2009, pioneering the commercial graphene production market.

Polyakova has grown the company's client base substantially in the past six years. Her expertise in 2D materials has gained wide publicity from news publishers such as such as BBC and Bloomberg. Polyakova has co-authored papers with Nobel and Kavli prize winners, as well as members of the National Academy of Sciences. She received a Ph.D. in Physical Chemistry from the University of Southern California and a Master's degree from the Moscow Institute of Physics and Technology.

SHINTARO SATO

Fujitsu Laboratories Ltd., Japan

Shintaro Sato received the B.S. degree in physics and the M.S. degree in science and engineering from the University of Tsukuba, Tsukuba, Japan, in 1988 and 1990, respectively, and the Ph.D. degree in mechanical engineering from the University of Minnesota, Minneapolis, in 2001.

He joined Fujitsu Ltd., Kuwana, Japan, in 2001 and moved to Fujitsu Laboratories Ltd., Atsugi, Japan, in 2002. He has been engaged in research and development of nanoelectronics devises using nanocarbon materials, including carbon nanotubes and graphene.
Dr. Sato is a member of the Japan Society of Applied Physics (JSAP).

ANTHONY SCHIAVO

Lux Research Inc., Singapore

Anthony Schiavo is an Analyst based in Lux Research's Singapore office. He leads the Advanced Materials team and supports the broader materials research at Lux. Under his leadership, the Advanced Materials team conducts research on technical and market trends in areas such as future materials platforms, advanced structural materials, and coatings.

His expertise also includes new technological innovations in digital manufacturing, materials informatics, and advanced design technologies. Anthony often is called upon to provide strategic advice and guidance for executives in the automotive, chemicals, and consumer goods industries.

MARK THOMPSON

Talga Resources Ltd, Australia

Mr Thompson has more than 20 years industry experience in mineral exploration and mining management, working extensively on major resource projects throughout Australia, Africa and South America.

He is a member of the Australian Institute of Geoscientists and the Society of Economic Geologists, and holds the position of Guest Professor in Mineral Exploration Technology at both the Chengdu University of Technology and the Southwest University of Science and Technology in China.
Mr Thompson founded and served on the Board of ASX listed Catalyst Metals Ltd and is a Non-Executive Director of Phosphate Australia Ltd.

VICKNESWARAN VELOO

Scomi Chemicals Sdn Bhd , Malaysia

Vickneswaran Veloo is the Chief Technology Officer – Scomi Chemicals Sdn Bhd (Scomi Chemicals). He has over 19 years of experience in the oil and gas industry. He was previously with Baker Hughes, specialising in drilling & completion fluid systems as well as production chemicals. He also led the Engineering Group for the entire Baker Hughes product lines ranging from drilling system tools to well completion systems in Saudi-Bahrain Geomarket as associate Technical Engineering Director.

In his current role as Chief Technology Officer for Scomi Chemicals, he is responsible for developing technologies and delivering new products at an international level. In addition, he is also in charge of overseeing the strategic direction for SESB's fluids and chemical systems in global oil & gas applications.

With an extensive global exposure in technical engineering and support, sales, marketing and strategy, Vick has held various positions with international oilfield services companies such as Scomi KMC, Baker Hughes and MI-GULF Services within the Middle East and Asia Pacific region.

Vick holds a Bachelor Degree in Chemical Engineering from the Malaysian University of Technology and is a member of the Society of Petroleum Engineers. He is also a registered practicing engineer with Board of Engineers, Malaysia.

RUNE WENDELBO

Abalonyx, Norway

CEO / General Manager at Abalonyx AS Worked as researcher at SINTEF in Oslo from 1988 - 2005. Worked with preparation and characterization of catalysts and adsorbents in SINTEF. Established Abalonyx in 2005 and Graphene Batteries in 2012.

ORGANISERS

NANOMALAYSIA BERHAD

NanoMalaysia Berhad was incorporated in 2011 as a company limited by guarantee (CLG) under the Ministry of Science, Technology and Innovation to act as a business entity entrusted with nanotechnology commercialisation activities. NanoMalaysia Berhad is mandated to spearhead the National Graphene Action Plan 2020 (NGAP 2020) which will spur Malaysia's graphene-based economy by 2020.

NGAP 2020 lays out the scope for the five most promising downstream applications in the context of Malaysia and the implications on their relevant supply chains to incorporate graphene between now and 2020.

Once robust commercial downstream industry begins to develop, Malaysia can consider broad scale production of graphene given its potential competitive advantage in having lower access costs to methane, a carbon-containing gas as a key input factor of extracting graphene.

PHANTOMS FOUNDATION

The Phantoms Foundation based in Madrid, Spain, focuses its activities on Nanoscience and Nanotechnology (N&N) and is now a key actor in structuring and fostering European Excellence and enhancing collaborations in these fields. The Phantoms Foundation, a non-profit organisation, gives high level management profile to National and European scientific projects (Involved in 11 European projects in the last 10 years either as coordinator or partner) and provides an innovative platform for dissemination, transfer and transformation of basic nanoscience knowledge, strengthening interdisciplinary research in nanoscience and nanotechnology and catalysing collaboration among international research groups.

The Foundation also works in close collaboration with Spanish and European Governmental Institutions to provide focused reports and catalogues on N&N related research areas:

- Coordinator/Editor of the Catalogue of Nanoscience & Nanotechnology Companies in Spain (published for the 6th time), which provides a general overview of the Nanoscience and Nanotechnology companies in Spain and in particular the importance of this market research, etc.
- The most recent document is the Catalogue of Graphene companies worldwide, which provides a general overview of the Graphene industry worldwide in this emerging field and in particular the importance of this market research, etc. Editions: 2014, 2015 and 2016.

Currently, one of the main core activities is to organize International conferences, meetings and workshops in particular in the "Graphene and 2D Materials" area:

- Graphene Conference Series main organizer www.grapheneconf.com
- Graphene Canada Conference Series main organizer www.graphenecanadaconf.com
- graphIn International Symposium (Graphene Industry – Challenges & Opportunities) main organizer www.graphinconf.com
- grapChina Conference Series co-organizer www.grapchina.com
- Recent Progress in Graphene and Two-dimensional Materials Research Conference (RPGR2017) co-organizer www.rpgr2017.com
- Graphene Malaysia Conference Series co-organizer www.graphenemalaysiaconf.com

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T&C applies http://grb.to/nanomy

EXHIBITORS

GRAFOID

Grafoid Inc.is a world leading graphene R&D, applications development and technology licensing company. It produces graphene and processes for transformative, industrial-scale graphene applications in partnership with leading corporations and institutions around the world. Grafoid targets four emerging graphene commercialization sectors: energy creation and storage, composites, coatings and membrane applications and technology. Grafoid is a privately held Canadian corporation founded in 2011. Headquartered in Kingston Ontario, *Grafoid's Global Technology Centre (GGTC)*, houses the company's production facilities for Grafoid's proprietary suite of Mesograf™ graphene products, it's research facilities in material science applications, and a development center for JV application development.

ⓘ For more information: www.grafoid.com

RGS Corporation Sdn. Bhd.
(Company No: 864802-V)

TechnoSpex Pte Ltd is a manufacturer and developer specializing in micro-spectroscopy for both scientific and industrial markets. We provide complete systems or compact modules that integrate seamlessly with the most upright dark field, polarization, DIC and/or fluorescence microscopes, with mapping capability option. Our uRaman and uSight series of products provide users with state-of-the-art spectroscopy measurement down to 1um spot size with research grade performance, and yet remains highly compact and affordable.

ⓘ For more information www.TechnoSpex.com

Haydale is a global technologies and materials group that facilitates the integration of nanomaterials into the next generation of commercial technologies and industrial materials. With expertise in graphene, silicon carbide and other nanomaterials, Haydale is able to deliver improvements in electrical, thermal and mechanical properties, as well as toughness. Haydale has granted patents for its technologies in Europe, USA and China and operates from four facilities in the UK, USA and the Far East.

ⓘ For more information: www.haydale.com

Aseptec Sdn Bhd is a distributor of WITec for high-resolution optical and scanning probe microscopy solutions for scientific and industrial applications. WITec's product line features scanning near-field optical microscopy using unique cantilever technology, confocal Raman Imaging and Scanning Electron Microscopy designed for the highest sensitivity and resolution, and Atomic Force Microscopy (AFM) for materials research and nanotechnology. The modular design of WITec microscopes allows the combination of these techniques. Thus not only chemical information, but also structural and topographic information can be acquired at the same time and on the same sample area using one instrument and one operating system-all from the same manufacturer. WITec's innovations in Spectroscopy, Materials Characterization and Atomic Force Microscopy continue to redefine what is possible for a wide variety of optical, structural, and chemical imaging techniques.

ⓘ For more information: www.aseptec.com.my

Abalonyx AS is a Norway based SME engaged in production and R&D related to graphene oxide and reduced graphene oxide since 2008. We produce and sell single layer graphene oxide (GO) and thermally reduced graphene oxide (rGO) in Kg-quantities and are presently developing a process for remediation of water contaminated with heavy metals and radionuclides based on a GO-based scavenger-system. We are also involved in collaborative development of scaffolds for use in regenerative medicine as well as modified GO and rGO for use in composites for construction materials, certain sports equipment and energy storage. Our sister company, Graphene Batteries AS uses a special rGO-grade in its battery developments. We actively work with our customers to tune our GO and rGO to their needs.

ⓘ For more information: www.abalonyx.no

Interscience was founded in 1978 under the auspices of the ITS Group of companies as a dedicated provider and integrator of scientific technology & solutions to meet the needs of our clients and industries. Interscience supports all major fields of scientific & medical endeavours essential to the progress of society. It provides general and specialized instruments from the top global brands, as well as scientific & medical infrastructure with the latest technologies from around the world.

One of Interscience scope of business is to cater for Material Science and Nanotechnology solutions. Material Science has become a scientific frontier that continues to develop new and improves ways for people to improve the quality of life, revitalize our industrial complex and enable conservation and making better use of our resources. From metals, ceramics, semiconductors, polymers, composites, biomaterials to advanced materials, material science covers a broad range of applications in our daily life. We are able to provide the solutions with advanced scientific instruments for material behaviour and testing. We are offering a wide range of advanced scientific instruments from sample preparations to analytical testing. Our preparative instruments range from polymer blending, sample coating and sample pre-treatment for electron microscopy, thermal analysis, surface analysis, particle size analysis, microscopy and Advance Raman spectroscopy analysis.

Interscience forges strong business foundations and long lasting relationships with both customers and principals in the scientific and medical communities. The company aims to provide the highest level of customer satisfaction through our highly trained and experienced sales & marketing, project management and engineering team.

ⓘ For more information: www.its-interscience.com

Crest was founded in 1999 whereby our foundation is built based on specialization in advanced microscopy imaging and leading-edge analytical solutions. Since its inception, Crest Group has grown to a team of more than 110 employees with a strong regional reputation of having the largest technical support group in SEA. Together with global key partners, Crest strive to provide customers market leading technological solutions in enabling important discoveries, enhancing imaging and analytical capabilities as well as achieving higher productivity. Our customers and applications include electronics, nanotechnology, material sciences, life sciences, academia, petrochemical, pharmaceutical and industrial manufacturing.

ⓘ For more information: www.crest-group.net

In the National Innovation Council meeting on the 29th of October 2009 chaired by the Right Honorable Prime Minister, Nanotechnology was identified as one of the new growth engines for the New Economic Model (NEM).

On the 14th of February 2011, the National Innovation Council convened and agreed that a nanotechnology commercialisation agency was needed and corresponding activities must be aligned with Agensi Inovasi Malaysia's (AIM) initiatives.

NanoMalaysia Berhad was incorporated in 2011 as a company limited by guarantee (CLG) under the Ministry of Science, Technology and Innovation (MOSTI) to act as a business entity entrusted with nanotechnology commercialisation activities. Some of its roles include:

- Commercialisation of Nanotechnology Research and Development
- Industrialisation of Nanotechnology
- Facilitation of Investments in Nanotechnology
- Human Capital Development in Nanotechnology

ⓘ For more information: www.nanomalaysia.com.my anexus

Make It Happen

aNexus group of companies are the only established distributor, service provider and application center for functional material and technologies, including inkjet, coating, printing, photonic curing, nano imprint, CVD, graphene roll to roll and other advance technologies from research to production in Asia. Besides providing turnkey solutions, our line of products includes the leaders in respective field for printer, coater, flash lamp sintering system, inks, etc, i.e. Fujifilm Dimatix, Coatema, Aixtron, Xenon, and many more. We can provide equipment, material, process and turnkey start up solutions in the area of inkjet graphene, coated graphene, CVD graphene and 2D materials.

ⓘ For more information: www.anexuscorp.com

Anton Paar

Anton Paar develops, produces and distributes highly accurate laboratory instruments and process measuring systems, and provides custom-tailored automation and robotic solutions. It is the world leader in the measurement of density, concentration and CO_2 and in the field of rheometry. Anton Paar GmbH is owned by the charitable Santner Foundation.

Over 2500 employees at the headquarters in Graz and the 26 sales subsidiaries worldwide ensure that Anton Paar products live up to their excellent reputation. The core competence of Anton Paar – high-precision production – and close contact to the scientific community form the basis for the quality of Anton Paar's instruments.

ⓘ For more information: www.anton-paar.com

MIMOS Semiconductor (M) Sdn. Bhd. is Malaysia's forefront technology and R&D service provider in the Electrical and Electronics Industries in Malaysia and globally, with key focus in supporting the E&E ecosystem, Nano-Semiconductor Technology, Internet of Things (IoT) and 4th Industrial Revolution. As a strategic agency under the Ministry of Science, Technology and Innovation (MOSTI), MIMOS contributes in raising Malaysia's competitiveness by pioneering market creation for Malaysian technopreneurs through patentable technology platforms, products and solutions. Serving a central role in Malaysia's transformation journey in the Electrical and Electronics Vision, MIMOS Semiconductor (M) Sdn. Bhd. endeavors to create a culture of innovation by nurturing relationships with internal and external stakeholders, in the spirit of smart partnerships and inclusive growth models and strategies

ⓘ For more information: www.mimos.my

Since 2003 E-tecs has been serving OEM/ODM needs for companies around the world.We are dedicated to providing Design and Manufacturing solutions for 2.4ghz Technology such as , Bluetooth, WiFi etc.

Year 2016 we establish our Graphene R&D centre for outdoor products and Kitchen items, Our Sub-contract Graphene manufacture was located in Mainland China and is able to produce relative Graphene raw materials from 1 layer to the above.

We also provide design house services for our clients who wish to distinguish themselves from the rest.Design services include Outlook, PCB Structure, Material Selection, Components Selection, Plastics, Developing, Testing and Certifications.

An experienced and well mannered Sales team is committed to bringing you 100% customer satisfaction and an excellent after sales service. They are fluent in English and Chinese to ensure effective communication and quick processing of your orders.
For more information please email to sales@e-tecs.com

ⓘ For more information: www.e-tecs.com

ADASTRA IP offers a ONE-Stop Centre in delivering quality, affordable, fast and reliable services to cater to the business's IP needs.

Our Chairman, Mr. Adzli Shamsuddin is a certified IP Valuer by the Intellectual Property Corporation of Malaysia (MyIPO) while our Managing Director, Mr. Mohan K was awarded the 'Best Patent Agent in 2012' by the Intellectual Property Corporation of Malaysia (MyIPO).

Together with our Directors, our team with various technical and legal background will be able to render professional support in addition to educating innovators and business owners, by providing invaluable advice on how to enforce or duly exploit your IP rights in Malaysia as well as overseas.

Our services are:

- IP Filing and Registration (Patent, Trademarks, Industrial Designs, Plant Variety)
- IP Analytics (Technology Landscaping, Prior Art & FTO Searches)
- IP Commercialisation and Technology Transfer
- IP Valuation (Certified IP Valuer)
- IP Asset Management
- Legal Services (IP Enforcement & Agreements)

ⓘ For more information: http://adastraip.com

KASS International is an Intellectual Property (IP) boutique practice which offers an end-to-end solution for your IP needs in Malaysia, the South East Asian region, and worldwide. Established at the forefront of IP since 1999, KASS is committed to the highest level of quality, professionalism and prompt service. With offices in Malaysia, Singapore, Indonesia and Myanmar, KASS handles a wide range of IP rights protection in the areas of Patents, Trademarks, Industrial Designs, Copyrights, Trade-Secrets/Confidential Information, Technology Licensing, Infringement Advice, Due Diligence, Commercialisation of IP rights, litigation support, and professional opinions and advice.

ⓘ For more information: www.kass.com.my

PlaTCOM Ventures Sdn Bhd is the national technology commercialisation platform of Malaysia. It is a wholly-owned subsidiary company of Agensi Inovasi Malaysia (AIM) formed in collaboration with SME Corporation Malaysia under one of its six High Impact Programmes (HIPs) in SME Master Plan 2012-2020.

PlaTCOM Ventures has a mission: to turn the creative ideas of our inventors and entrepreneurs into successful products and services that change the world.

PlaTCOM Ventures is designed to discover and support innovations wherever they may be, assess ideas very critically, explore them systematically, and turn the best ones into successful products and services. Rather than following traditional technology transfer models, PlaTCOM Ventures has designed a model that facilitates any segment of the entire commercialisation process (end-to-end facilitation) from idea to products and services. The whole approach will be market driven in supporting industrial innovation and competitiveness. The model is more suited to the innovation environment in the South East Asia region in providing commercialisation support for the fledgling businesses, innovators and entrepreneurs including those from academia and public research institutes.

ⓘ For more information: www.platcomventures.commy

KDJLaw is a three-way merger between the combined expertise of Messrs. Arianti Dipendra Jeremiah, a strong Intellectual Property and Technology practice led by Suaran Singh Sidhu and Brian Law, and an experienced corporate team of Rodney Koh and Tay Kian Har. KDJLaw will allow us to bring a greater depth of experience, and diversity in expertise to the work that we do.

Our Expertise: KDJLaw is a multi-disciplinary legal practice, which offers specialised services, especially in these specific areas of law:

- Intellectual Property and Technology
- Dispute Resolution and Arbitration
- Corporate Commercial
- Banking and Finance
- Employment

The partners at KDJLaw are passionate in their field of work and bring to the table decades of experience. Our clients include multinationals, public listed companies, financial institutions, private sectors, and state-owned enterprises across a range of industry sectors.

"NO IDEAS LEFT UNPROTECTED"

With over half a decade of professionalism and excellence in the burgeoning field of Intellectual Property, TEE IP aims to ensure the affordable protection of your best and brightest ideas domestically and in foreign lands. TEE IP's vast overseas network, unique IP packages and competent insider staff (quality assured personnel, agents) combine speed, convenience and quality to give you the peace of mind you need for the safe registration of your inventions and innovations be they big or small.

Undefeated Record: TEE IP prides itself on a 4 year (2010-2014) winning streak in the arena of verbal ex-parte arguments and hearings of our client's cases before the Intellectual Property of Malaysia (MyIPO).

Flexible IP Packages: Regardless of ideas requiring protection in ASEAN, the Far East or any other region of interest, TEE IP delivers affordable and dynamic packages for all your Intellectual Property needs.

Trusted Panel Agents: TEE IP remains a trusted and preferred panel consultant for the protection of the various intellectual properties that are churned from our local institutions of higher learning.

IP Office Experience: A former member within MyIPO, Mr. Tee, possesses a familiarity with the thought processes of the Registrar's office which contribute to the company's efficiency in dealing with IP woes.

ⓘ For more information: www.teeip.com

DAHAN TECH, is a leading consultant company focusing in an Printed & Organic Electronics Technology, scientific research and laboratory equipment set-up for R&D sector in Malaysia. It is registered with Malaysia Minister of Finance (MOF) and hold the 'Bumiputra' status since 2005.

ⓘ For more information: www.dahantech.com

Graphene 3D Lab offers a full spectrum of cutting edge graphene products. We manufacture graphene- enhanced functional thermoplastic materials for 3D printing and advanced thermoset adhesives. Furthermore, we also offer graphene nanoplatelets in powder form and premixed with polymer as high load master batches. Custom formulations of graphene materials in both thermoset and thermoplastic matrices can be produced to match customer needs.

3D printing materials: Our product line includes a wide variety of filaments such as Conductive Graphene Filament, a highly conductive material designed for 3D printing circuitry and sensor applications; Graphene HIPS, a hi-tech engineered FDM material enhanced with graphene for high precision 3D printing to name a few. Our 3D Printing materials are sold under Black Magic 3D trademark and can be purchased directly at www.blackmagic3d.com and through distribution network.

Adhesives (Epoxies): Graphene 3D Lab offers G6-EpoxyTM product line of high-performance epoxies for bonding, sealing and coating purposes.

R&D Products: Graphene Supermarket (www.graphene-supermarket.com), an e-commerce platform owned by Graphene 3D Lab offers the world's largest selection of graphene and other 2D based R&D materials. All materials can be customized and bulk quantities can be manufactured on demand.

For more information: www.graphene3dlab.com

IDC Group of Companies is a leader in providing the world's only all-in-one, eco-friendly, concrete strengthened, waterproofing, weatherproofing solution with Hexa Matrix Technology and also value-added construction services to our customers by creating a successful partnership with them throughout the construction process. IDC's pledge is to establish lasting relationships with the customers by exceeding their expectations and gaining the trust through exceptional performance by IDC proprietary solutions and every members of the construction team. IDC will strive to implement a long term relationship with the clients, based on safety, quality, timely service and an anticipation of their needs. To help fulfill this mission, IDC will treat all employees fairly and involve them in the quality improvement process to ensure responsiveness and cost effective work execution.

PENCHEM
BONDING TECHNOLOGIES TOGETHER

Company overview: Founded in 1999, Penchem Technologies Sdn. Bhd. is a wholly own Malaysian company
involved in designs, develops & manufactures innovative advance polymer solutions (high performance adhesive) to solve applications for automotive, semiconductors, electronics, electrical, photo-optics and green energy saving applications.

ⓘ For more information: www.penchem.com

CONTRIBUTIONS - INDEX

KEYNOTE AND INVITED SPEAKERS

ORAL PRESENTATIONS

POSTER PRESENTATIONS

Chester Burtt
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The Road to Commercialization and Lessons Learned

At the turn of the twentieth century, there were well over 200 automobile producers in the U.S. After 1901, the number of firms fell sharply and within 10 years most of the leading automobile brands were produced by Detroit-area companies, with the industry evolving to be an oligopoly dominated by three famous firms.

Could a similar phenomenon happen in the graphene sector?

The natural flake graphite market has changed dramatically in the last 5 years from a dig-and-sell commodity business to a value-added product business and, driven by national and international factors, the industry is being shaped by two colliding forces: climate change and the graphene revolution.

Globally, national governments are committing to stringent emission targets and implementing policies to foster and propel new material advancements. Traditional mining industries, weakened by the global commodity downturn, are searching for ways to revive their businesses, while new material enterprises, such as value-added graphite and graphene start-ups, are looking to leverage these game-changing opportunities.

Today, over 100 graphene producers now dot the global map, all striving to produce affordable graphene and stronger, lighter, smaller and faster applications derived from this miracle material. Time will tell if the development of the graphene sector mirrors the historical development of other industrial sectors and key questions are being asked among potential investors, partners and customers.

Who will the winners be among these companies and what factors will drive their success?

Whatever the outcome, the impact has been significant and the long-term implications will dramatically change the critical material sectors. As more and more countries ratify the Paris Accord and mandate domestic policy, the faster industry will adopt change.

Grafoid is poised to take advantage of this change. As a graphene research, development and licensing company, it has positioned itself for commercial alliances in graphene application development. Based on an investment in a patented one-step process to produce an affordable suite of graphene products, the company develops applications with joint venture partners at Grafoid's Global Technology Centre (GGTC), in Kingston, Canada.

As an early entrant in the graphene space, Grafoid's lessons learned over the past 7 years point to two keys for success: 'credibility' and 'collaboration'. It holds, the "2Cs" will determine not only the scale of overall development and the adoption and pace of graphene's acceptance, but the firms that mature into industry leaders.

No one company can do it alone and collective credibility will shape perceptions. Commercialization of graphene will only successfully happen when we work together in collaboration, fitting all the necessary pieces together – the science, material and innovation – and matching it with financial resources and industry's products and ideas. This requires cooperation, education and outreach on our part.

Antonio H. Castro Neto

Centre for Advanced 2D Materials
National University of Singapore, Singapore

Graphene in Asia

This talk will review the latest developments in the area of graphene and other 2D materials with focus on large scale industrial applications. This is a fast moving area with enormous potential for new industries.

Nam Sung Cho[1*]
Jun-Han Han[1], Jin-Wook Shin[1], Hyunsu Cho[1], Byoung-Hwa Kwon[1], Jaehyun Moon[1], Jeong-Ik Lee[1], Seungmin Cho[2]
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Gen 2 (370 mmx470 mm) sized Graphene anode OLED

By combining advanced CVD graphene growth/transfer processes and display process technologies, we have realized fully functional Gen 2 (370 mm x 470 mm) sized graphene anode OLEDs. Our result signifies the techinical feasibility of graphene as a commerically serviceable component in display and, in general, optoelectric devices. In this talk, we will address process issues, which have hurdled the realization of graphene OLED realization. In particular, we emphasize the importance of patterning graphene into dimensionally correct pixels without deteriorating their quality. Also, we present our integration scheme.
Our result is a departure of graphene from laboratory scale researches and preludes the occurrence of system level commercial products in which graphene are used.
This work was supported by Ministry of Trade, Industry and Energy/Korea Evaluation Institute of Industrial Technology (MOTIE/KEIT), research program "Development of basic and applied technologies for OLEDs with Graphene.

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Figures

Figure 1: Gen 2 (370 mm470 mm) sized Graphene anode OLED

Antonio Correia
Phantoms Foundation, Calle Alfonso Gomez 17, 28037 Madrid (Spain)

Graphene and 2D Materials" EUREKA Cluster: Fostering European Competitiveness

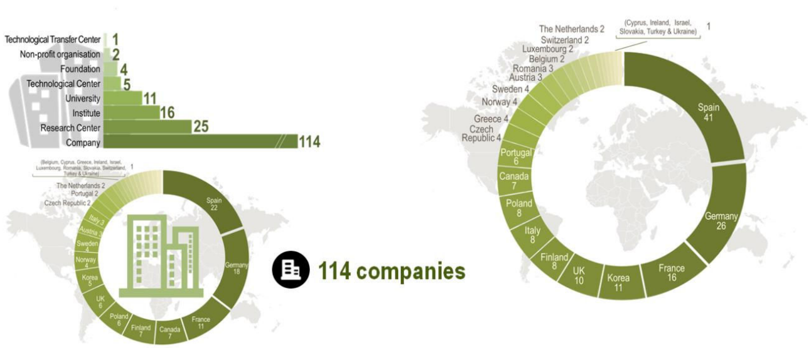
The "Graphene & 2D Materials" EUREKA cluster is defined as a complementary enabling and accelerator instrument in the European scene, fully piloted by industries to further take graphene from the mature research developed at academic laboratories into the European society in the space of 5 years, boosting economic growth, jobs creation and international leadership and investment attractiveness. This cluster will help Europe having a more dominant position in graphene patenting, will deploy the proper winning industrial strategies to gain worldwide competitiveness, and will ensure that for all promising industrial sectors of technology innovation, a fully integrated EU-value chain is established, integrating into consortia the relevant actors from low to high Technology Readiness Levels (TRL).

The cluster will clarify the differentiating potential in all sectors where EU-industries is strong and could further gain in competitiveness, and will develop proper incentives towards the achievement of EU-leadership in the fields of graphene commercialization and graphene-driven technology improvement. The cluster will elaborate and foster industrially-driven innovation strategies, that will take advantage of the existing excellent science and transnational platforms in Europe (national networks, Graphene-Flagship, etc.), and will focus on solving current challenges which are limiting the time to market and business growth of graphene-related EU companies.

Graphene has a huge potential to impact established industrial sectors, building new emerging industries and niche segments and creating economic value. The "Graphene and 2D Materials" Strategic Research Agenda currently targets 7 interlinked priority R&D areas for Europe. These areas are (1) Standardization, (2) Production and Scalability, (3) Composites, (4) Energy, (5) Biosensors and Health, (6) Optoelectronics and Electronic Devices; (7) Functional coatings.

Currently, 117 Institutions from 26 countries (among them 114 companies) expressed interest in joining the Cluster..

Figures



Andrea C. Ferrari

Cambridge Graphene Centre, University of Cambridge, Cambridge CB3 OFA, UK

The Roadmap to Applications of Graphene and Related Materials

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.

Presenting Author Ray Gibbs
Haydale Limited, Clos Fferws, Capel Hendre, Ammanford, SA18 3BL, UK

Ray.gibbs@haydale.com

Near term commercial applications for Graphene, Composites and Conductive Pastes

Abstract

The potential for graphene and other nano particles to significantly enhance material properties has been well documented. However, as carbon is inert and does not mix well with other materials it needs to be homogeneously dispersed and bonded into the host material in order to realise its potential. There are hundreds of “graphene’s” in the market today and all display different characteristics. Knowing which one works best and applying a sympathetic surface treatment for a specific application is the Haydale expertise. This functionalisation treatment plus the years of processing know how sets Haydale apart in the ability to commercialise nano materials.

For industry to adopt these new materials we need to demonstrate a repeatable and cost effective functionalisation process that is scalable and can be tailored to the specific requirement. One of the challenges industry faces is that there is currently no standard definition of graphene which means that R&D and general procurement departments may not know exactly what it is they are buying nor be able to replicate test results with a subsequent batch of material. Industry requires a standardisation of materials to remove this uncertainty.

Recent work at Haydale has now confirmed significant improvements in electrical, thermal and mechanical performance of Carbon Fibre pre preg, opening up many applications NOW. These breakthroughs plus new pastes for bio medical sensors offers real commercial opportunities for Graphene, something the world has been waiting!

Further, in order to persuade industry to adopt the new materials we need to be able to incorporate the functionalised materials into existing production facilities thus avoiding the need for replacement of existing capital equipment. Ray Gibbs will examine these challenges and explain how Haydale has established a consistent supply chain of the nanomaterials and are addressing the commercial adoption challenges through the establishment of Centres of Excellence in strategic locations across the globe.

Biography
Ray is a Chartered Accountant, and former Deloitte audit and corporate finance partner for 9 years. He has over 20 years’ experience in high technology and fast moving consumer goods businesses and is a former CFO of Chemring Group Plc. Ray was part of Haydale Graphene Industries’ management team that acquired Haydale Limited in 2010, and has been immersed into the graphene and nano world for 5 years. An accomplished international speaker now seen at many Graphene conferences, Ray offers a rare insight into industry and the ability to make the bridge with the academic world.

Vincent G. Gomes

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

vincent.gomes@sydney.edu.au

Emerging Quantum Dots from 2D materials for Biomedical Applications

Biocompatible and photostable probes are crucial for visualising and tracking biological functions and interactions, crucial for regenerative medicine and tissue engineering. We report the synthesis and applications of highly biocompatible 2D material based quantum dots for simultaneous cell and scaffold imaging. The quantum dots are synthesised from natural precursors under green and controlled conditions in hydrothermal reactors.

Our investigations reveal the unique physicochemical characteristics, high quantum yield and intense fluorescence derived from the carbogenic core of the quantum dots. The bioimaging of cells in a 3D printed scaffold demonstrate that the quantum dots enable deep tissue imaging under biomimetic conditions.

Real-time videography and cell viability tests showed excellent visualisation, photostability and robustness of these organic quantum dots for long-term cell imaging using multi-photon microscopy. Drug delivery results showed that the quantum dots are able to provide a biocompatible medium with the monitoring capabilities through imaging and delivery of medication to the desired region for treatment.

Kuan-Tsae Huang

CEO, AzTrong, US/Taiwan

Kthuang8@gmail.com

Graphene for Smart Life Applications

Graphene is considered the most revolutionary, world-changing material since plastic. With the emergence of smart mobile devices (MD), electric vehicles (EV), grid and distributed energy (G&DE) the world is moving rapidly toward a more connected and more sustainable place. All these advances can benefit from the advantage of graphene, a wonderful material with property of best thermal conductivity, electrical conductivity, strength, lighter, and thinner, etc.
Graphene is not just for high-tech applications, but for the simple devices we use every day like our light bulbs, cloth, shoes, heating pad and sealed bag for durian, etc. This talk will share experience of how graphene could play a role in the more mundane technologies of our lives, like day to day living. Some related technology such as graphene coating, graphene film, graphene composites will be discussed.

Biography

Dr. Huang is the Chairman/CEO of AzTrong, a provider of graphene-based nano-composite products and solutions and an expert in Graphene and graphene commercialization in thermal management, Li-Ion battery & supercapacitor, graphene composites and other commercial / industrial applications. He began his career at IBM Watson Research, had 20+ years working at IBM, was a Vice President and played a key role to help IBM successfully transform into a global service company. While at IBM, he was in charge of e-commerce implementation, intellectual capital and asset Management, solution offerings, etc. He is an experienced business transformation and innovation advisor / entrepreneur.
He is also the Chairman of an IoT application solution company focusing on energy, fintech and healthcare industries and senior advisor to Ditthavong & Steiner, P.C., a leading US patent law firm. He is also an experienced entrepreneur in Silicon Valley, Singapore and Taiwan as well as a VC investor. Dr. Huang has won several awards including: IBM Corporate Excellence Award, Gold Medal of Giga Information Award, NASA LAUNCH Award – 2011 which awarded to Top 10 Energy Innovators by US Department of State, NASA, USAID and NIKE. He received BS from National Taiwan Normal University, MS University of Illinois at Urbana-Champaign, and Ph.D. in EECS from MIT.

Bor Z Jang
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Mass Production of Graphene: A Graphene Inventor-and-Producer's Perspectives

This presentation will provide a critical review on several popular processes for producing isolated graphene sheets/platelets. Emphasis will be placed on the processes that are more suitable for mass production of graphene. The speaker, Dr. Bor Z Jang, is uniquely qualified to present this topic for the following reasons:

Dr. Jang filed his first patent application on graphene as early as October 2002 [1]. Before Drs. Novoselov and Geim published their historically significant paper in October 2004 [5], Dr. Jang's research team had already delivered one technical paper [2] and filed for three patent applications [1,3,4] on graphene.

Further, the research team led by Dr. Jang and Dr. A. Zhamu developed several of industry's most widely used graphene production processes/methods, including the chemical oxidation and intercalation method for mass production of single-layer graphene in 2002 & 2004 [1,3], the liquid-phase exfoliation method in 2007 [6], the supercritical fluid process in 2006 [7], the electrochemical exfoliation method in 2007 [8], etc. Dr. Jang and his business partner, Dr. A. Zhamu, co-founded Angstron Materials, Inc. (AMI) in 2007. Angstron is currently world's largest producer of single-layer graphene oxide and reduced graphene oxide suspension and powder.

The Jang/Zhamu team was also the world's very first to invent/develop several graphene-enhanced products, such as graphene composites in 2002 [1], graphene for fuel cells in 2004 [4], graphene-based supercapacitors in 2006 [9], graphene-enhanced lithium battery electrode materials (e.g. graphene/Si anode in 2007) [10], graphene thermal film in 2007 [11], graphene ink in 2008 [12], graphene-enhanced grease and lubricant [13], graphene-modified tires [14], etc., just to name a few.

Dr. Jang will offer some personal perspectives on the rapidly emerging graphene industry, emphasizing the opportunities and challenges in commercializing graphene materials and products. The technical and commercial challenges experienced by graphene producers will be high-lighted. For instance, a significant challenge is the notion that graphene is a unique material that requires different processes to bring out the most desirable characteristics for a particular application. In other words, different processes are required to produce different types of graphene materials for different applications in different market sectors.

There are also technical, economical, and regulatory issues that must be addressed in order for the large-scale production of affordable graphene materials to be fully realized. This will be followed by a discussion of some of the potential and realized applications of graphene materials, including supercapacitors, batteries, and functional composites.

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Unlocking industrial applications via Graphene composites

Graphene as a next generation wonder material possess unique physical and chemical properties, such as a two dimensional, atomic-thick chemical structure, superior electric and thermal conductivities, flexible, light-weight yet strongest material known to date, feasibility to tuning the surface from hydrophilic-to-hydrophobic, etc. [1] Exploiting such properties to develop industrial applications is the key challenge in front of the scientific and industrial community. Processing graphene materials alone is not industrially viable, due to their poor dispersion and film formation abilities.[2] Graphene can be mixed with a variety of materials like polymers, additives and nanomaterials to form hybrid materials which could enhance the efficiency of existing technologies.[3] Understanding the effect of chemical composition, degree of oxidation, lateral size and interface morphology of graphene or its oxide forms in such hybrid composites is crucial to developing important industrial applications like water filtration membranes, separator in Li-ion batteries, sensors, gas separation and high temperature plastics, etc.

In addition, developing simple, aqueous-based, low-temperature product fabrication methods is preferable for commercialization processes. In this work, we present aqueous-processable, room temperature casting/coating methods to achieve a series of graphene composite products for key applications like desalination, waste-water treatment, ion-selective membranes for battery separators, wearable sensors etc. In the process, we have studied the effects of graphene composition, oxidation degree on the performance of its filtration and sensor devices.

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Figures

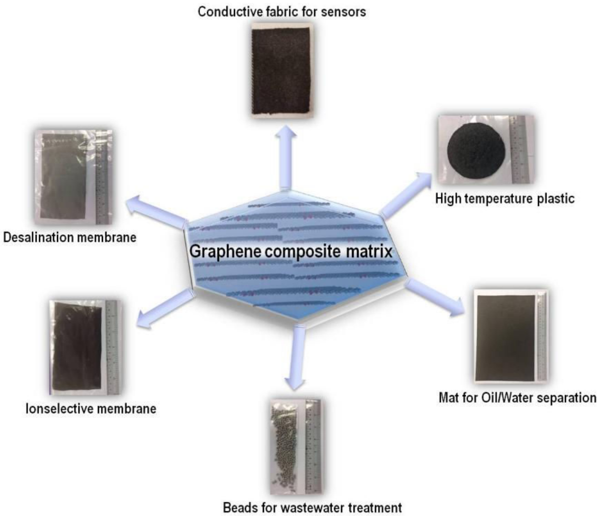

Figure 1: Schematic depicting of the graphene composite matrix and the yielded products for different industrial applications.

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Scalable production of processable graphene via electrochemical exfoliation

The worldwide hunger for efficient and clean energy storage and conversion technologies has become a great challenge due to increasing high-energy demands, environmental issues and depletion of fossil resources. The rapid rising of 2D materials over the past decade evidences not only a basic scientific interest but also their potential technological impact, as they might play a ground-breaking role in future electronics and the storage and utilization of clean electric power obtained from renewable resources.
Next to high-tech applications, commercialization is envisioned in composites, as already small amounts of additives in the range of 0.01-2% have substantial influence and can lead to exponential improvements in thermal, electrical and mechanical properties of the host materials.
For graphene, there has been a gap between laboratory-scale research and commercial applications for a long time due to the lack of reproducible bulk production methods at low cost level. Today many of these challenges seem solved, with production capacities reaching ton scale for both graphene and graphene oxide materials and the first products established on the market. However, there are still challenges. Liquid phase exfoliation techniques for instance, can provide high quality products with low defects, but the sheets are small and need surfactants or other additives to avoid restacking, which are difficult to remove and can reduce matrix-interactions and final conductivity. In contrast, graphene oxide lacks electrical conductivity and the outstanding mechanical properties of graphene, but can be dried and re-dispersed and therefor shows significant advantages in terms of processability. Due to its high density of functional groups GO can also be easily functionalized for different purposes.
The electrochemical preparation of graphene combines the best of both worlds. Depending on the process conditions a tunable level of defects and functional groups are introduced that improve processability while maintaining a good electrical conductivity and reasonable sheet size.

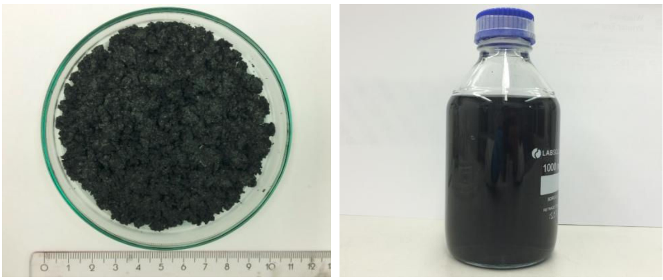

Fig. 1: Photographs of >5g of FLG produced in 15 min at lab-scale and a (surfactant free) dispersion.

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Development of graphene and related materials in AIST

It is necessary to establish high-quality and high-throughput graphene synthesis technique for the practical application of graphene transparent films. In this talk development of high-throughput plasma-enhanced CVD for high quality graphene will be discussed.
The plasma CVD is characterized by high-growth rate graphene atomic membrane compared with conventional thermal CVD (fig.1), which is suitable for the high-throughput production for the industrial use [1,2,3]. We have achieved a graphene membrane with a transmittance of 95% (two-layer) for visible light and sheet resistance of 130Ω (gold chloride doped) by developing an original plasma CVD method. The establishment of the roll-to-roll CVD is one of the key factors for realizing the commercial application of graphene. The strain in graphene synthesized by plasma CVD with high-growth rate and tension to the substrate, which is necessary for winding, is analyzed by scanning transmission electron microscopy (STEM) and Raman spectroscopy [4]. The compressive strain generated during the growth by the tension to the substrate and the difference in thermal expansion coefficient between the graphene and the copper substrate is observed, which affects electrical conductivity. It was confirmed by STEM observation that no particularly large strain was accumulated at grain boundaries and their surroundings (fig.2).
This work is mainly based on results obtained from a project supported by New Energy and Industrial Technology Development Organization (NEDO).

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Figures

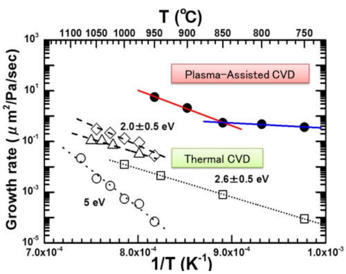

Figure 1: Temperature dependence of graphene growth rate for thermal CVD and plasma–assisted CVD which are normalized by CH4 partial pressure. [3]

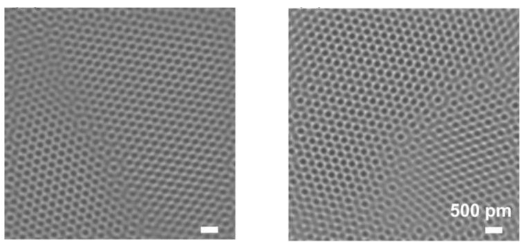

Figure 2: (Left) Domain boundary of graphene synthesized by slow growth (growth time 1200 sec) without tension to the copper foil substrate. (Right) Domain boundary of graphene synthesized by fast growth (growth time 10 sec) with tension to the substrate (2.9N/mm^2).

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Graphene production by CVD from various carbon sources & their mechanisms

Graphene is a new breed of carbon allotrope in the form of a single layer of carbon atoms arranged in an sp2-hybridized structure with a combination of properties far superior compared to other materials. Research and development in graphene synthesis have been soaring to astonishing heights the past few years especially using chemical vapor deposition (CVD) method as the race for graphene supremacy become more intense than ever. The nature and the kind of carbon source used is one of the most important key factors in the commercialization of graphene to the real world market. However, effects of the used carbon source on graphene growth mechanisms and production are rarely discussed. In the course of large-scale and low cost graphene preparation, this talk will address the recent trends regarding the utilization of diverse carbon sources used to synthesize graphene via the CVD method, the mechanisms involved and some of the works that we are working on towards a better understanding of their impact towards low cost graphene production..

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Novel 3D Graphene/Au Nanorods hybrids for selective bio-capture: Towards rapid detection of Mycobacterium tuberculosis

The primary objective of this project is to fabricate an ultra-sensitive biosensor from graphene hybrids materials in order to accurately detect the infectious bacteria, Mycobacterium tuberculosis which is the causative agent of tuberculosis, a disease characterised by the growth of tubercles in the lungs and induces high mortality in Malaysia and throughout the globe as described by the World Health Organisation because early stage detection is near impossible as extremely low amounts of the aforementioned bacteria is hard to be cultured and identified using currently available and established methodologies.

At present, many advances have been made to improve the detection of Mycobacterium tuberculosis, however, this effort still falls short of the required efficiency needed to effectively diagnose a patient. The technological gap that exists today is the inability of the immunological assays to detect the bacterial disease when the sample is low. Polymerase chain reaction (PCR) or real-time PCR on the other hand is not a very viable option albeit its high accuracy as the equipment, reagent, sample preparation required are high in cost besides requiring highly trained personnel and contamination free rooms. Similar to PCR, flow cytometry and radiometric detection also requires logistics support form specialised laboratory which makes it unsuitable for developing countries. A commonly used method called cultivation of microbes is also not reliable despite its high accuracy because the bacteria requires one to six weeks to grow on culture plates. Besides that, electrophoresis and hybridisation are commonly used for conditions requiring to differentiate mutant strains from wild strains. Furthermore, methods such as shear microscopy are highly prone to false negative results. Therefore, it is extremely vital to detect Mycobacterium tuberculosis rapidly and accurately to allow for a complete eradication of Mycobacterium tuberculosis at the onset of the infection.

In the past, cost-effective sensors have been sought after for the development of low-cost point-of-care clinical test systems. Graphene has been considered widely as a preferable choice of transducer in biosensors. It is due to its higher surface area to volume ratio (associated with elevated sensitivity). In addition, graphene possesses remarkable properties, such as extraordinary electrical conductivity, optical transparency and unusual mechanical strength which yield stability to the materials for sensor development. In this study, 3-dimensional (3D) graphene which features a microporous foam-like structure with high conductivity and defect-free is used as the biosensing element. 3D graphene grown by chemical vapour deposition (CVD) technique has unique properties where it can be easily tuned in different sizes, scaled and is free-standing as compared to its 2D counterpart which is non-visible or exists in powder form. The structure of 3D graphene will provide a high sensitivity, fast establishment of steady state, a large aspect ratio and a great signal-to-noise ratio. Using sensitive dielectric method, 3D graphene will detect electrical signal directly by the biomolecular interaction. This is through the analysis of resistance and capacitance that occurs at electrode surface layered with graphene. For the biomolecule detection on 3D graphene, sandwich strategy is commonly used because of greater specificity and minimal background signal. In this type of strategy, two probes are necessary to bind two different sites on an antigen. Here, Mycobacterium tuberculosis is sandwiched between antibody and aptamer as capturing and reporting probes, therefore, complement each other to detect Mycobacterium tuberculosis. The developed biosensor will be able to churn out results at a rapid pace so that the patient will be able to receive immediate medical attention in the event of the presence of Mycobacterium tuberculosis as prolonged infection increases the mortality risk. Another advantage of the biosensor is that it is extremely sensitive as well as selective and it can be used repeatedly. The crowning advantage of this biosensor is that it allows the

detection of minute quantities of Mycobacterium tuberculosis that would not have been able to be detected by other means and can be diagnosed easily by medical professionals.

Keywords: 3-Dimensionl graphene, Chemical Vapour Deposition, Tuberculosis, Biosensor

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Flexible Multilayer Graphene Hall Sensors on Ultra-Thin PVC Foil

Having high charge carrier mobility [1] and superior elastic properties [2], graphene is a highly suitable material for flexible electronics. Although it does not produce a graphene film as smooth as an exfoliated graphene sheet transferred onto SiO_2/Si wafer, graphene transferred onto polymeric substrates could be used for flexible electronic applications that do not require very high charge carrier mobility. In addition, controlling the number of layers in synthesizing multilayer graphene will be an ability of great importance for applications involving resistances lower and charge carrier densities higher than that of single layer graphene. We developed a method for making multilayered graphene-based conductive films on 75µm-thick PVC foil via transfer printing of graphene by iterative lamination. The graphene is synthesized via atmospheric pressure chemical vapor deposition (APCVD) on 20µm-thick copper foils. After forming the Cu/graphene/PVC stack via lamination with hot rollers, selective etching with aqueous $FeCl_3$ solution is provided by hydrophobic permanent marker ink deposited onto the parts of the copper layer to become contact pads. The multilayered conductive films can be obtained by iterative application of this scheme in which the selective etching is applied after the last lamination. The conductive film based on single layer graphene manifested sheet resistances of the order of 1 kΩ and Hall coefficients of up to 1,200 Ω/T, and withstood current density greater than 1.9×10^9 A/m^2. The resistance and Hall coefficient values were found to decrease with increase in the number of layers. Our method could be used as a platform for proof-of-concept works aiming to demonstrate graphene's potential for flexible electronics. The structural, thermal, and electronic characterization of the multilayered graphene-based conductive films on the PVC foil is to be presented.

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Graphene Thermoplastic and Thermoset Materials: An Update on Recent Progress

There is a surging demand for lighter and stronger materials in the polymer industry and extensive R&D has been done to significantly improve the properties of many polymers by the addition of graphene. Graphene nanoplatelets thoroughly dispersed in various polymer matrices represent the first commercially viable use of graphene. In this presentation, we focus on our recent developments in high performance graphene composites based on both thermoplastic and thermoset resins. One of our first graphene products is PLA-based conductive filament with volume resistivity as low as 0.6 Ω•cm. This material is compatible with most of the commercial FDM printers, and apt for creating conductive traces and sensors. In addition, we have created a line of graphene composites and master batches that can then be "let down" or diluted for further processing into parts by extrusion or injection molding.

Another significant breakthrough in functional graphene materials is the launch of several graphene-enhanced conductive adhesives distributed under trademark G6-EPOXYTM (visit www.g6-epoxy.com for full list of specifications). We have developed metal-free carbon-based epoxy with volume resistivity below 5 Ω•cm, making it one of the best metal-free conductive adhesives currently available in the market. We have also developed hybrid epoxies (highly electrically conductive adhesives) with a proprietary formulated blend of graphene, silver fillers and other additives. With the development of this proprietary formulation, we have not only ensured the electrical conductivity of these epoxies to be at par with the existing commercial products but have also successfully managed to substantially reduce the percentage of silver content in the epoxies improving the mechanical properties and ease of processing.

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Application of Graphene and Graphene Nanoribbons to Electronic Devices

Graphene has excellent electrical, thermal, and mechanical properties and is a promising candidate for materials of future electronic devices. Although graphene does not have a band gap, a graphene nanoribbon (GNR), a narrow strip of graphene, can have a band gap, and therefore be applied to devices such as diodes and transistors. We have been working on synthesis of nanocarbon materials and their application to electronics, including transistors and interconnects, for years. In this talk, we describe some of such applications.

One of the applications is a gas sensor. We recently developed a graphene-gate transistor, where the gate of a Si transistor is replaced with single-layer graphene (Fig.1) [1]. This graphene-gate transistor can be used as a gas sensor. In fact, when gas molecules adsorb on the graphene-gate surface, the Fermi level or work function of graphene can change, thus shifting the threshold of the Si transistor. This causes changes in the drain current if the gate voltage is kept constant. This graphene-gate sensor is very sensitive to NO_2 and NH_3. Normalized drain current of a graphene-gate sensor with time for NO_2 exposure is shown in Fig. 2. As can be seen in the figure, the sensor can detect NO_2 with concentrations less than 1 ppb.

Graphene can also be used for detecting high-frequency wave [2, 3]. We have recently proposed a diode consisting of a graphene nanoribbon heterojunction (Fig. 3) for high-frequency wave detection [4]. The heterojunction consists of a hydrogen-terminated armchair-edge GNR (H-AGNR) and fluorine-terminated armchair-edge GNR (F-AGNR). Since there is a difference in electron affinity between H-AGNR and F-AGNR, we can construct a staggered-type lateral heterojunction p-n diode. First principle calculations have shown that, due to band-to-band tunneling, the diode has a nonlinear reverse current of the order of kA/m. Furthermore, the junction capacitance is extremely small because of the small junction area. The voltage sensitivities of a backward diode as a function of frequency obtained numerically are shown in Fig. 4. The GNR-based backward diode can have a much better voltage sensitivity for high-frequency wave than a GaAsSb/InAlAs/InGaAs heterojunction diode [5].

We try to form graphene nanoribbons having various widths and edge-terminations using a bottom-up approach [6]. Figure 5 shows a scanning tunneling microscope image of H-AGNR we formed. In fact, we used a precursor shown in Fig. 6, aiming at synthesizing partially F-terminated AGNRs. The F atoms at GNR edges, however, were detached during the cyclodehydrogenation of partially edge-fluorinated polyanthrylenes to form GNRs. We have found by first principles calculations that a critical intermediate structure, obtained as a result of H atom migration to the terminal carbon of a fluorinated anthracene unit in polyanthrylene, plays a crucial role in significantly lowering the activation energy of carbon−fluorine bond dissociation.

This research was partly supported by JST CREST Grant Number JPMJCR15F1, Japan.

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Figures

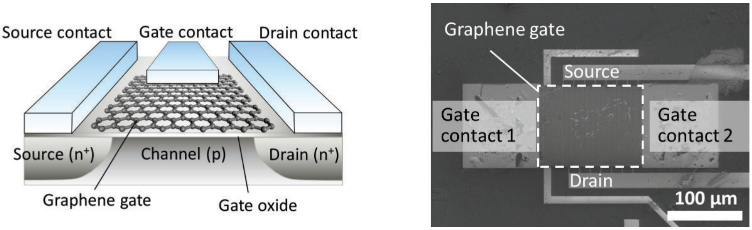

Figure 1: Schematic illustration (left) and scanning electron microscope image (right) of a graphene-gate transistor (sensor)

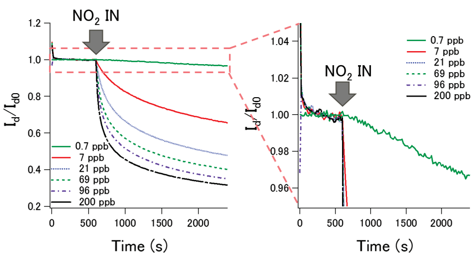

Figure 2: Dependence of the response (normalized drain current, Id/Id_0) of a graphene-gate sensor on NO_2 concentrations.

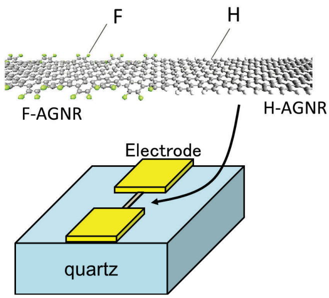

Figure 3: Illustration of a diode using a heterojunction of F-AGNR and H-AGNR.

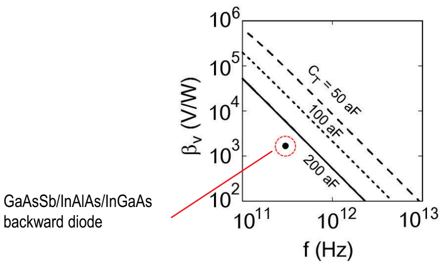

Figure 4: Calculated voltage sensitivity of a GNR diode, β_v, as a function of frequency with the total capacitance, C_T, as a parameter. The closed circle indicates β_v of a GaAsSb/InAlAs/InGaAs diode in Ref. 5.

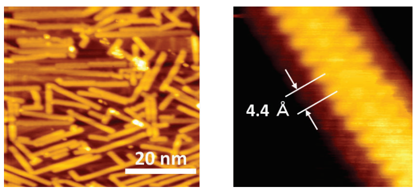

Figure 5: Scanning tunneling microscope images of H-AGNRs

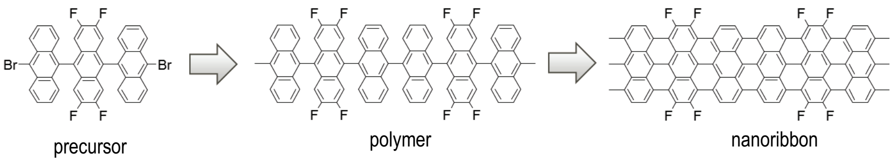

Figure 6: Scheme for synthesizing partially F-terminated AGNRs

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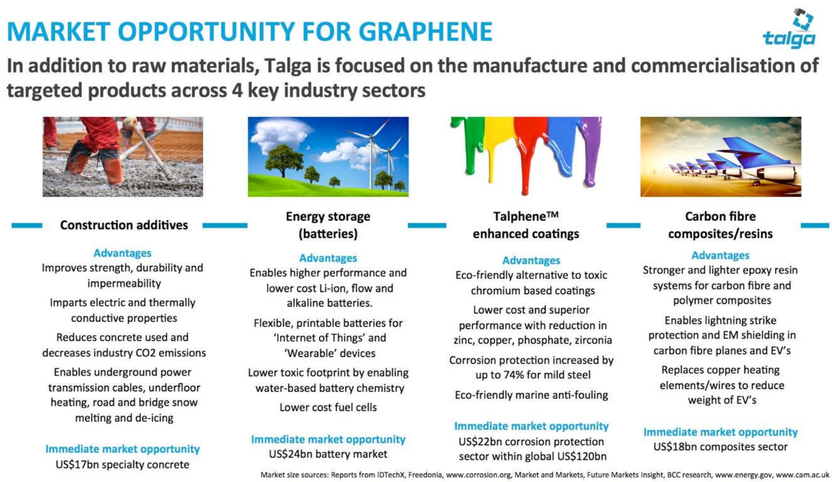
A Path to Industrial Scale Graphene Supply and Commercialisation

Many fundamental properties of graphene are well understood and applied material research has demonstrated graphene as an additive to current materials can make products stronger, lighter or more functional such as electrically or thermally conductive.
This presents a special opportunity to positively improve, and in some cases, revolutionise, the performance, applications and environmental impact of many products.
But preparing industrial scale volumes of graphene at economic cost has proven problematic. Many production techniques have limitations including (in no particular priority) cost, volume, yield, process toxicity, high energy inputs, limited particle size, oxidation and defect level among many others.
Since 2014 Talga has been developing a route of graphene production to solve this supply problem. By innovatively mining a unique natural crystalline carbon source in Sweden, and matching it to a scalable exfoliation process, large volumes of pristine and high quality graphene nanoplatelets (GNP) can be produced.
The continued success of this method is un-shackling the supply and cost constraint from graphene, enabling use in large volume additive applications across the coatings, energy, construction and composites sectors.
In contrast to raw material supply, Talga has accelerated the graphene commercialisation process by forming its own product development division in the UK and making prototype products with which to engage industry. Results of testing these prototypes is presented.

Figures



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Graphene Oxide, Applications and Markets Perspectives

Graphene oxide (GO) has a long history, first prepared by Brodey already 158 years ago[1], but by then and until recently named graphitic oxide. GO has several unique and useful properties but has so far not found any large scale industrial application. One of the fundamental problems up to now has been the risk of explosive runaway in its production, although reduced with the synthesis method of Hummers and Offeman[2]. Today, safe production has been established, opening for large scale production and industrial applications.
GO is fundamentally different from ideal graphene in that it is non-conductive and hydrophilic. However, it can easily be reduced to graphene-like “reduced graphene oxide” rGO by thermal, chemical or light induced methods. Fully reduced rGO is graphene-like in that it consists of pure carbon and is highly hydrophobic, although with a high proportion of defects. However, rGO is most often only partly reduced, to different degrees, and as such fills the gap between GO and graphene, constituting a family of materials from only slightly conductive, amphiphilic to higly conductive hydrophobic materials.
Reported applications of GO and rGO include water treatment and de-salination, polymer composites, ultracapacitors and batteries, bone replication scaffolds, sensors, rust protection and conductive coatings. Researchers at Rice University reported in 2013 the use of GO to soak up heavy radionuclides from water[3]. This is certainly one of the applications to be seen commercialized in this decade, easily requiring production of hundreds of tons of GO per year. On the other hand, applications as components in sensors, although potentially large in numbers will be small in mass due to the very limited amount used in each sensor. When it comes to energy storage, reduced graphene oxide (rGO), effectively compeets with other graphene powders.
Interesting results with use of graphene, GO and rGO for scaffolds for growth and differentiation of stem-cells have now been confirmed by multiple reports, potentially opening up for new approaches in regenerative medicine[4]. There are also reports on use of GO’s resistive properties in insulation for electrical cables.
Polymer composites represent another large potential market for GO and rGO, in part in competition with other graphene type powders. Here, the target properties as well as ease of dispersion of the composite will determine which variety of graphene type material is preferred.
Abalonyx is active in production of GO and rGO as well as in the development of GO and rGO optimized for several applications and some GO and rGO containing composite materials and Abalonyx’ sister company Graphene Batteries is engaged in application of rGO and pillared rGO for certain battery and supercapacitor applications with promising results, to be reviewed.
The final, and not least important parameter for large scale use of GO and rGO is price. Present estimates indicate that the price of GO can come down to well below 40 USD/Kg and rGO to just under 100 USD/Kg – price levels that can be tolerated by many industries if compensated by substantial improvements in performance of the GO/rGO-containing products.

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Synthesis, Characterization and Heavy Metal Adsorption of Graphene Gels for the Wastewater Treatment

Substantial metal contamination, particularly water overwhelming metal contamination, has been a typical worry for the world. It is outstanding that bioaccumulation of the substantial metal particles in the living cells brings genuine antagonistic wellbeing impacts on the human and creature organ capacities. There is proof that substantial metal particles can cause different progressive diseases (i.e. lung issues, bone injuries, etc.) [1].
Since 1800, a few urban wastewater treatment methodologies and advances have been executed to reduce the water contamination. Graphene oxide (GO) is one of the latest technologies for the wastewater treatment because it has different physio-chemical properties, which served as a selective adsorbent for adsorbing different water contaminants [2, 3]. In particular, the graphene based materials in different forms of gel will be used to remove the heavy metal ions in wastewater treatment, due to their large surface area, flexibility in number of activated functional groups, reasonable adsorption behavior in water, and excellent removal efficiency of heavy metals. Their relatively easy preparation method and biocompatibility, will demonstrate the possibility of applying the graphene based gels as an excellent candidate for preparing water treatment agents.
From our proposed batch experiments, the influences of different parameters on the maximum adsorption capacity of heavy metals and the adsorption kinetic models have been investigated. The adsorption mechanism on graphene active surfaces have being systematically elucidated. The outstanding adsorption performance of graphene gels for the removal of heavy metals is believed to be of their significant environmental applications.
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Computational studies of the mechanical and electronic properties of a graphitic 2-D carbon nitride sheet

Two dimensional (2-D) sheet of graphitic carbon monolayer exhibit the astounding physical properties, as well as very promising applications in various field [1]. Recently, another 2-D family known as graphitic porous carbon nitride (CN) sheets have gained special interest due to their unique potentials in photochemical water splitting and as membrane for separation of gases [2,3]. The two most stable CN allotropes are heptazine and s-triazine sheets. As can be seen in Figure 1, the heptazine sheet hexagonal rings are arranged in abreast manner whereas s-triazine sheet has two of its hexagonal rings separated through C-C bond. Because of the wide range of the CN sheets applications, research focus has been mainly on the investigations of the effects of embedment of nanostructures on the physical properties of the CN sheets [4]. However, the understanding of the mechanical properties and modulation of the electronic properties of these stable (heptazine and s-triazine) sheets remain unclear. In the present work [5,6], we investigate the mechanical properties and electronic properties modulations under symmetric deformations of both heptazine and s-triazine sheet based on density functional theory [7] calculations with the aid of Quantum ESPRESSO package [8]. Our results show that the in-plane stiffness and bulk modulus for s-triazine sheet are less than that of heptazine sheet. The decrease in value can be related to the nature of the covalent bonds linking the adjacent sheets and the number of atoms per unit cell. The Poisson's ratio of s-triazine sheet is in the same order of magnitude to that for heptazine sheet. The calculated values of the two critical strains (elastic and yielding points) of s-triazine sheet are in the same order of magnitude to that for heptazine which was calculated using MD simulations [9]. It is also shown that heptazine and s-triazine sheets can withstand larger tension in the plastic region. These results established a stable mechanical property for s-triazine and heptazine sheets. We also found a linear relationship of bandgap as a function of bi-axial tensile strain within the harmonic elastic region. The reduced steric repulsion of the lone pairs (p_x-, p_y-) causes the p_z-like orbital to shift to high energy, and consequently an increase in the bandgap. We find no change in electronic properties of the heptazine and s-triazine sheets under electric field up to a maximum value of 10 V/nm. These promising properties may offer opportunities in future material applications.

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Figures

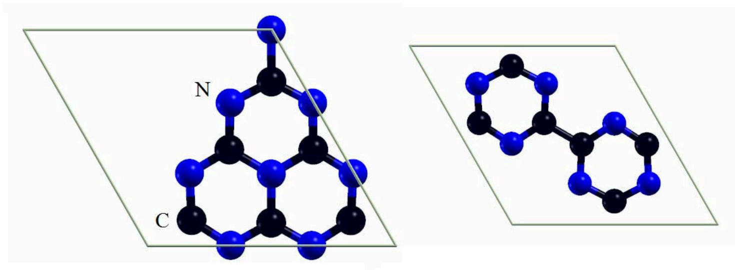

Figure 1: Optimized structure of heptazine (left panel) and s-triazine (right) sheets

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Pair states in one-dimensional Dirac systems

Analytic solutions of the quantum relativistic two-body problem are obtained for an interaction potential modelled as a one-dimensional smooth square well and the eigenvalues are obtained by solving a set of transcendental equations. Such a potential can be used to approximate the interaction potential between an electron and a hole in a broad range of one-dimensional Dirac systems such as narrow-gap nanotubes, certain types of graphene nanoribbons and armchair carbon nanotubes subjected to an external magnetic field applied along the tube's axis [1,2]. Currently the experimental focus is on attractive potentials to reveal the role of excitonic effects, but we show that within the same formalism, quasi-one-dimensional systems can also support bound states within the band gap for two repelling particles. Of special interest is the case where both the electron-electron and the electron-hole pair binding energy correspond to the middle of the band gap, as it enforces electron-hole symmetry without the recourse to a superconductor. This state is also energetically favorable as it reduces the Fermi energy of a doped system. Since our primary interest is the study of the optoelectronic applications of graphene nanoribbons and carbon nanotubes [3], we restrict ourselves to calculations concerning electron-hole pairs. The stationary excitonic energy spectrum for a quasi-one-dimensional Dirac system is shown below in figure 1. The binding energy of these pairs is found to never exceed the band gap and therefore at room temperature the electron-hole pairs should be fully ionized. Hence, undesirable effects due to dark excitons should not dominate optical processes. By analyzing the smooth square well's stationary excitonic wave functions, the appropriate boundary conditions are obtained for an abrupt square well which in turn enables the dynamic exciton energy levels to be found. We also consider delta function interaction - a highly non-trivial problem for relativistic particles - and show that different approximations for the delta function give the same result [4]. All our results, which are primarily aimed at graphene nanoribbons and narrow-gap carbon nanotubes, can also be applied to Weyl semimetals in a strong magnetic field which constrains free-particle motion to one dimension.

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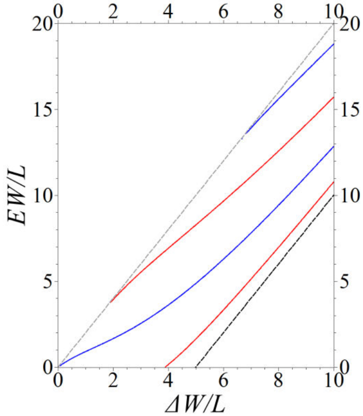

Figure 1: The energy spectrum of an electron-hole pair interacting via a one-dimensional smooth square well as a function of $\Delta W/L$ for WU_0/L=10, where W, U_0, L are the effective width and depth of the well, L is a constant and Δ half the band-gap. The gray-dashed and black-dashed lines represent $E = 2\Delta$ and $E - U_0 = 2\Delta$ respectively. The red and blue lines correspond to the even modes and odd modes respectively.

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A Study of Graphene Ink in Fine Solid Lines Printed by Micro-flexographic Printing Process for Electronic Industry

Abstract:
Graphene had a good potential as printing ink in producing micro to nano solid lines printing capability for the application of printing electronic, graphic and bio-medical [1]. This study elaborated the application of graphene as a printing ink use in combination of flexography and micro-contact printing technique which known as Micro-flexographic printing for micro fine solid lines. The Micro-flexographic printing technique will assist toward printed micro to nano scale of RFID (Radio Frequency Identification) antenna and Organic Field Effect Transistor (OFET) which will be used in many sectors for example in electronic devices, biomedical application, security and etc. The interest of RFID technology met the emerging demands in the automation process [2]. These RFID components demonstrated by this technology in relation to other existing identification systems as shown in Figure 1. Another application in printing electronic was OFET liked showing in Figure 2. It gave consistency and homogeneous ink layers in printing process. Hence, this study will put a step forward looking the roll to roll printing process which was vital prior to print any functional materials on thin film or other substrates layered. Organic transistors were stilled in development process stage and their performance cannot be competed with traditional semi-conductor transistors. The wettability and incompatibilities has to be overcome where a smooth and homogeneous interface is crucial for the OFET performance [3]. In aspect of biomedical application, cell culturing could be printed in low cost with higher throughput. This printing method could avoid the use of batteries and wires connection which decreased the overall size of the biomedical device. During printing experimental process, graphene was used a printing ink medium to print the fine solid lines image on biaxially oriented polypropylene (BOPP) thin film substrate. Graphene was a pure carbon with one atom thick and nearly transparent. Graphene material could be exposed in a lot of application but it stilled not commercially used in printing industry. Graphene had high thermal conductivity which suitable for super capacitors fabrication [4]. Several printing trial had been done by using laboratory Micro-flexographic printing machine which was combination of flexography and micro-contact printing technique [5]. The printing plate with 3 μm fine solid lines image for lines width and gap was used in this experiment work. It was made by polydimethylsiloxane (PDMS) material. The material property of PDMS liked deformation was suitable to use in Micro-flexographic printing method. This research was successfully produced graphene fine solid lines with 2.7 μm width and the line height at 1 μm liked showing in Figure 3. The graphene line image was captured by using D 3100 AFM. The results also showed the surface roughness, Ra was 20 nm. The graphene fine solid lines printed image development was a continuous process in improving the printing technique. The achievement was very important for high speed micro to nano technology printing not only in electronic industry but also for graphic and bio-medical purpose with less waste, simple, rapid, low cost method and roll to roll capability.

Figures

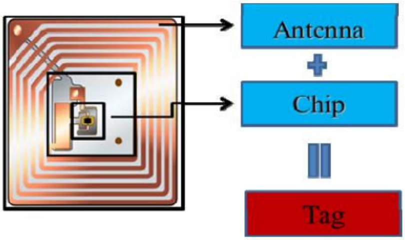

Figure 1: RFID tags component [2]

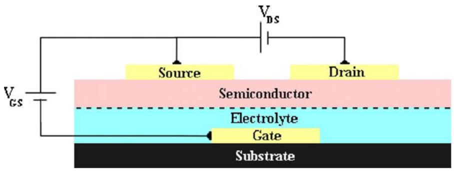

Figure 2: OFET design structure [3]

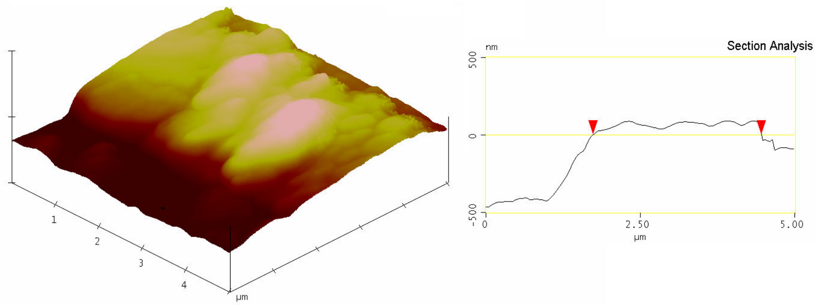

Figure 3: 3D image of graphene fine solid line and section analysis

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Fabrication of graphene via electrochemical exfoliation of graphite and its properties in polyaniline composites

Abstract
Graphene have drawn tremendous research interest owing to its exceptional mechanical, thermal, electrical and optical properties. One of the most applications of the graphene is to incorporate it into some polymers as the reinforcing fillers to introduce good thermal and electrical properties. The current research focuses on the synthesis and characterization of conducting nanocomposites where graphene was incorporated into polyaniline (PANI). In the present study, graphene was synthesized via electrochemical exfoliation of graphite, wherein functional graphene can be produced during the exfoliation process. The effect of electrochemical potential is one of the factors that controlling the quality of the synthesized graphene. It was found that high quality graphene can be produced with lower electrochemical potential (+5V). The result was confirmed by Raman spectra, wherein smaller I_D/I_G ratio was obtained indicated a lower degree of defects. Fabrication of conducting graphene/PANI nanocomposites by using synthesized graphene have been successfully fabricated using one-step in situ polymerization. However, one major bottleneck for the application of graphene is their poor dispersibility in polymer matrices resulting from the strong van der Waals interactions among the graphene. The precipitation and aggregation of the graphene affect the properties of the nanocomposites. The electrical conductivity of the nanocomposites was studied by the resistance meter measurement system. It was found that the electrical conductivity of PANI increased by five orders of magnitude with addition of 5 wt% graphene.

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Modeling and Simulation of Perforated Graphene Nano-Electro-Mechanical (NEM) Switch by 3D Finite Element Simulation

The success of semiconductor industry depends on reliable performance and scalable manufacturing processes. As the size of semiconductor devices miniaturize to a few tens of nanometers and the demand for more applications keep increasing, another strategy will be needed. Nanoelecromechanical (NEM) switch is one of the promising devices to solve the problems of high power consumption in complementary metal-oxide semiconductor (CMOS) circuits [1]. NEM switch is built into logic circuits, relays, data storage and high frequency communication because of its high ON-OFF current ratio and low leakage current. However, conventional NEM switch still underperforms compared to the conventional semiconductor switch because of low reliability and high actuation pull-in voltage [2]. There are two common ways to reduce the mentioned problems such as the introduction of new materials and proper geometrical design [3, 4]. Graphene is one of the suggested 2D materials for this NEM switch application because of its superior properties namely high electron mobility excess of ~200,000 $cm^2/V.s$, high Young's modulus of ~1 TPa, superior current density capacity of ~108 A/cm^2, the ultra-thin thickness of ~0.335 nm and low resistivity of ~1 μ.Ω-cm [5-7]. For these reasons, graphene can provide better reliability and lower actuation pull-in voltage than conventional switch. An optimized geometrical design of NEM switch can also achieve the same objectives of better reliability and low actuation pull-in voltage. In the past few years, the geometrical design of graphene switch has changed to actuated bottom and top electrode to improve its mechanical stability and actuation pull-in voltage [8, 9]. Others introduced the concept of perforation in the beam structure of RF MEMS switch to increase the beam flexibility, lower the actuation pull-in voltage and enhance the switching speed [10]. There are also previous work who achieved different shapes of perforation in graphene sheets through experimental work [11]. However, to the best of our knowledge, similar perforation concept was not introduced in the graphene beam based NEM switch application to reduce the actuation pull-in voltage. In this work, we emphasize on the actuation pull-in voltage reduction for NEM switch by using 3D FEM modeling and simulation of multilayer graphene beam with and without the perforated structure of different geometrical dimensions. These simulation works were carried out with the FEM-based CAD tool IntelliSuite (8.8.5.1, IntelliSense, Lynnfield, MA, USA) under Thermo-electromechanical model. Firstly, we used the device structure and dimensions from previous work to validate our proposed model [12]. Based on this experimental work, we used 860 GPa as the Young's modulus for graphene in all the FEM simulations which are comparable to the values of 500 GPa measured for the multilayer graphene between 2 to 8 nm of thickness [13]. Afterwards, we studied the design parameters of the NEM switches, such as, graphene beam length *L*, thickness *t*, and air gap thickness *g* because of their influence on the mechanical and electrical properties of the switch. The length and thickness of the graphene beam were varied from 0.8 μm to 1.5 μm and 3.0 nm to 9.0 nm, respectively. The air gap thickness was varied from 50 nm to 130 nm. The optimized design from this initial model was then re-analyzed with a perforated beam. In the perforated beam as shown in Figure 1, we varied the hole length *HL*, hole width *HW*, distance between two holes *DL* and number of hole column *CN*. This perforation is expected to reduce the biaxial residual stress and the graphene beam stiffness, thus contributing to the reduction of graphene beam buckling-effect to increase the switch lifetime and reduced actuation pull-in voltage. This analysis confirms that the small air gap, long and thin graphene beam contribute to the actuation pull-in voltage reduction as shown in Figure 2. The introduction of perforation in the graphene beam further reduced the actuation pull-in voltage by 9% and 32% for the 6-column and 12-column of hole, respectively. Their hysteresis value is also reduced by 25% for the 12-column of hole. These results presented here is expected to expedite improvements in the working parameter and dimension for low voltage operation of graphene NEM switch device fabrication.

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Figures

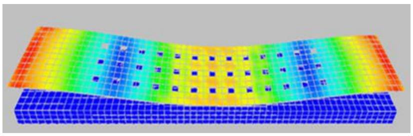

Figure 1: Graphene NEM switch with bottom actuation electrode during ‘on-state’ mode for the perforated graphene beam

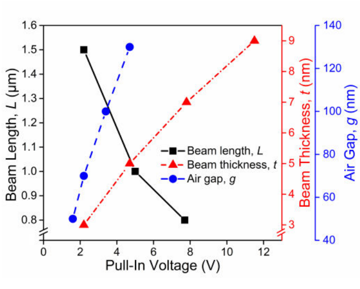

Figure 2: Trends of actuation pull-in voltage against beam length, beam thickness and air gap thickness of graphene NEM switch device.

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Preliminary studies on preparation of acrylate base graphene and graphene oxide (GO) nanofluid via physical blending as pour point depressants (PPD)

PPD emulsion product is advantageous for use in sub-ambient temperature as it improve the physical handling characteristic compared to traditional product. This superiority properties of the emulsion is largely contributed by the continuous phase of the emulsion itself. It is due to good low thermal properties of the continuous phase plus the polymer is being encapsulated within it. Nonetheless, the performance of emulsified PPD still limited since it mainly dependant on the polymer properties itself. Nanoparticles became an attention in academic and industry world as it can enhance properties of a polymer even at low loading. This provides a solution towards the lack performance of emulsified PPD by incorporating the nanoparticles particularly graphene material. Therefore, this presentation will highlight the production of PPD nanofluids through physical blending technique, mechanism involved and some progressing studies which provide a better awareness of the graphene material impact in crude oil treatment. Introduction of graphenic material reduce particles size of PPD fluids as the material adsorps onto the oil-water interfacial layer. Addition of nanoparticles showed potential in enhancing the inhibition process of paraffin wax which higher compared to normal PPD fluids. This also supported by the observation from polarized optical microscopy results, as the nano-materials displayed the more agglomeration of paraffin wax crystals which indicated a good inhibition occur as it lead to lower pour point of the paraffin wax fluids.

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Nanosecond Laser-Assisted Nitrogen Doping of Graphene Oxide Dispersions

We have studied different approaches for the synthesis of N-containing reduced graphene oxide (RGO). Thermal treatments of graphene oxide (GO), prepared by a modified Hummer´s method, in presence of ammonia gas have been proposed as a simple, efficient and reproducible method for the synthesis of N-doped RGO.[1] These samples are markedly more stable against thermal oxidation in air than their non-doped counterparts, which opens up new possibilities for tailoring the properties of graphene and related systems.[2]

Moreover, we have explored the preparation of N-doped RGO in bulk form by laser irradiation of GO, further expanding the protocols available for the synthesis of N-doped graphene-related materials. The GO sample, dispersed in an aqueous solution of ammonia, was irradiated with a pulsed Nd:YAG laser with emission wavelengths in the infrared (IR) 1064 nm, visible (Vis) 532 nm, and ultraviolet (UV) 266 nm spectral regions (Figure 1).

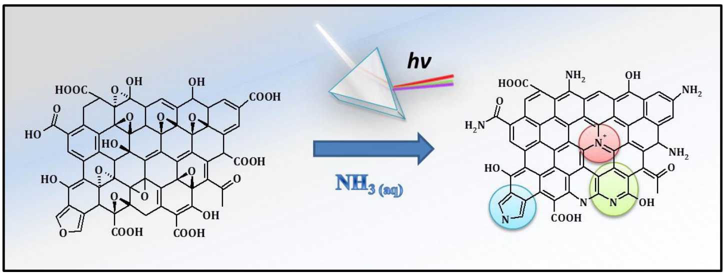

Figure 1. Schematic representation of the synthesis of bulk N-doped reduced graphene oxide samples by laser-assisted synthesis.

We have investigated the role of both the laser wavelength and fluence on the resulting material by means of TEM, XPS, Raman and UV/Vis spectroscopies. Regardless of the laser energy employed, the resulting N-doped material presents a higher fraction of pyrrolic nitrogen compared to nitrogen atoms in pyridinic and graphitic coordination, reaching relatively high N-pyrrolic contents (71.4 %). Noticeably, whereas increasing the laser fluence of UV and Vis wavelengths results in an increase in the total amount of nitrogen, up to 4.9 at. % (UV wavelength at 60 mJ cm^{-2} fluence), the opposite trend is observed when the GO is irradiated in ammonia solution through IR processing. The obtained level of doping is within the range achieved by most doping strategies. However, the proposed laser-based methodology allows the bulk synthesis of N-doped RGO in a simple, fast (nanoseconds), and cost efficient manner.[3]

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Ultra-rechargeable flexible Graphene micro Supercapacitor power banks charged by solar power

Abstract

A Supercapacitor differs from the normal capacitor in two basic ways: the plates of a Supercapacitor have a larger surface area and the distance between them is much smaller, as compared to the conventional capacitors due to which it can be used for high power density applications. A Supercapacitor is similar to ordinary capacitor, however, it can store extremely large amounts of charge. Capacitors used in electronic circuits have capacitances in the ranges of 400 to 800 micro farads and those used in RF applications are as small as 1 Pico farad [1-2]. Although, the large amount of charge represents only a small fraction of the electrical energy that can be stored into a battery, its ability to charge and discharge instantaneously as compared to other lithium-ion and lithium polymer battery offers it a competitive edge. This is because a Supercapacitor develop charge by static polarization, while a conventional battery is energized slowly through chemical reactions [3].
The proposed fabrication methods enable the on-chip integration of microelectronic devices and therefore provide an opportunity for the development of a variety of micro/nano-sized energy devices. composite materials comprising a polyaniline nanofibers conducting polymer and a filler nanomaterial (Few Layered Graphene nano sheets) and methods of making the composite materials. This study also relates to the use of the composite materials for making prototype of flexible supercapacitors device. The invention further relates to compositions formed in the method and their use in various applications including in making the composite materials and the use of said compositions and composite materials in flexible electrodes which are used in micro supercapacitors based power banks charged with solar energy.
Herein we developed flexible electrodes which are showing specific capacitance around 650F/g and this device shows excellent cyclic stability up to 1000cycles.The electrodes are fabricated using Exfoliated graphite(EG) material and which are further processed by insitu-coating of Few Layered Graphene (FLG)-polyaniline composite material to enhance the specific capacitance of the electrode. The electrodes are assembled with suitable separator and electrolyte. In this proposed project we are working on prototype of the device (Dairy type supercapacitor power banks) and integration with solar panels. (Please see the figure)

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Figures

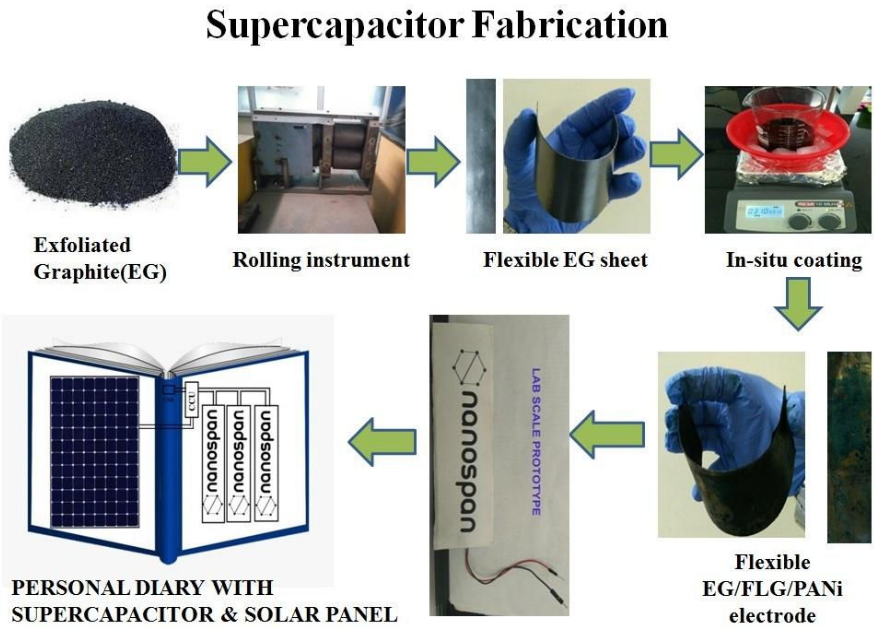

Figure 1: Process steps of making proposed Supercapacitors

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Graphene Wafer Technology for Sensors and Nanoelectronics Device Applications

There have been extensive interest on Graphene as the enabling technology for next generation nanoelectronics. At present, large corporation is looking into developing the technology to synthesise graphene on a large area and incorporating them into semiconductor device platform to enable the development of graphene nanoelectronics, sensors and devices. This is important as it will subsequently lead to the volume production of these graphene semiconductors, sensors and devices to the market. In view of that, this talk will highlight the research and development activities that have been performed in order to generate manufacturing-ready graphene-synthesis processes so that the feasibility of incorporating graphene as an active material for applications in semiconductors, sensors and devices in a production-ready environment can be demonstrated.

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Graphene PLA/THF Slurry based Passive Saturable Absorber in Erbium Doped Fiber Laser

Abstract
Immanent technological advantages offered by ultrafast fiber lasers are making them the go-to alternatives for comprehensive industrial and scientific applications. Graphene has been extensively utilized as passive saturable absorber (SA) in generating ultrafast laser either in Q-switched or mode-locked regime [1-4] since its first reported work by Zhang et al in 2009 [5]. Intrinsic properties of which graphene possesses such as ultrafast carrier relaxation and ultra-broadband resonate nonlinear optical response has made it to be favoured to a greater extent and prevalent in generating pulse in fiber lasers [6]. Some of the many synthesis processes of graphene such as liquid phase exfoliation (LPE), chemical vapour deposition (CVD), reduced graphene oxide (rGO), micro-mechanical cleavage [7] and electrochemical exfoliation technique [8] requires rather complicated and expensive implementation and some causes uncontrollable physical morphology that is important in the generation of pulsed laser. The recently introduced three-dimensional (3D) printer filament based on conductive Graphene-Polylactic acid (PLA) has open up a possible new approach in fabricating graphene based passive saturable absorber. The filament with a diameter of 1.75 mm is extruded through a 3D printer nozzle at 210 ˚C to reduce the diameter to 200 μm. Next, the extruded Graphene-PLA with the weight of 25 mg was mixed with 1 ml of Tetrahydrofuran (THF), then sonicated for 10 minutes in order to dissolve the PLA and produce a graphene-PLA/THF suspension. To integrate the graphene-PLA/THF slurry based saturable absorber, the suspension was placed by drop-casting method at the end of a fiber ferrule and finally graphene slurry was left behind after the THF evaporated. The characterization of the fabricated saturable absorber is investigated by using Field Emission Scanning Electron Microscope (FESEM) for its' morphology, and Raman spectroscopy for its' peak shifts. The FESEM image of the graphene-PLA/THF slurry is shown in Figure 1 where the structure of the graphene can be clearly seen. The distinct peak shift of the saturable absorber for D band, G band and 2D band are observed at 1348 cm^{-1}, 1582 cm^{-1} and 2699 cm^{-1}, respectively as shown in Figure 2. From Raman spectroscopy, the Intensity of G peak is at 389 and intensity of 2D peak is at 287, and the ratio of I(G)/I(2D) is about 1.35 which shows that it is a multi-layer graphene with the number of graphene layer (nGL) of around 25 layer [9]. The fiber ferrule with the graphene-PLA/THF slurry attached is mated with another clean ferrule connector and integrated in the fiber laser cavity. A stable passively Q-switched erbium-doped fiber laser (EDFL) operating at 1531.01 nm was observed with the threshold input pump power of 30.45 mW and the maximum input pump power of 179.5 mW. By increasing the input pump power from 30.45 to 179.5 mW, the pulse train of repetition rate increases from 42 kHz to 125 kHz, while the pulse width reduces from 6.74 μs to 2.58 μs. The generated pulsed produced maximum pulse energy and maximum peak power of 11.68 nJ and 4.16 mW, respectively at maximum input pump power. The recorded signal to noise ratio is about 44 dB shows that the proposed graphene slurry based saturable absorber able to produced pulse with good stability and low fluctuation.

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Figures

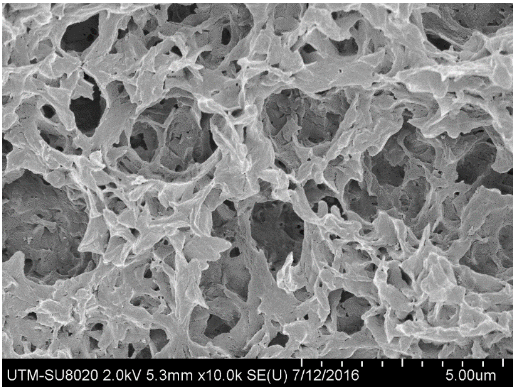

Figure 1: FESEM image of graphene-PLA/THF slurry

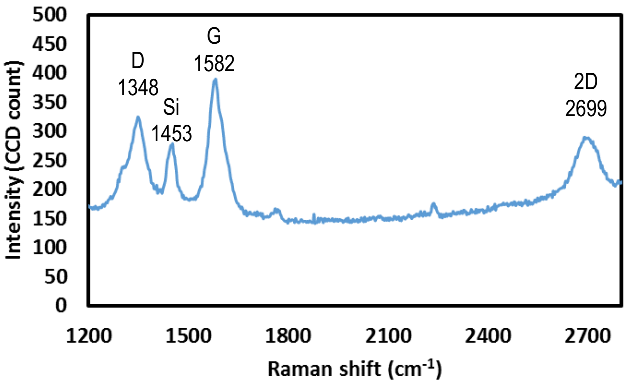

Figure 2: Raman spectroscopy of the graphene-PLA/THF slurry

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Influence of Graphene Content on Thermal Stability of Cellulose/Graphene Biocomposite Solid Electrolyte

Abstract
An environmental friendly cellulose/graphene (CG) biocomposite solid electrolyte was prepared by sol-gel method. The influence of graphene content on the conductivity and thermal stability of the CG biocomposites were investigated at different compositions of graphene (0, 20, 40 and 60 wt%). Graphene was dispersed in *α*-cellulose using ionic liquid 1-butyl-3-methyl-imidazolium chloride (BmimCl). Thermal stability of CG biocomposite was analysed using Thermogravimetric Analysis (TGA) conducted in a nitrogen atmosphere to study the decomposition of biocomposite solid electrolyte. Electrochemical impedance spectroscopy analysis was carried out to study the conductivity properties of CG biocomposites. Two degradation peaks of CG biocomposite were observed from the derivative thermogravimetric (DTG) curves, the first degradation peak (T_{p1}) occurred between ~70 to 110 ˚C due to removal of water and the second degradation peak (Tp_2) shown between 250-400 ˚C corresponding to decomposition of labile oxygen group. The major weight loss at ~270 ˚C is caused by pyrolysis of oxygen-containing group thus producing CO, CO_2 and stream [1]. The second peak initial decomposition temperature (2nd T_{onset}) of 0 wt.% graphene content is at 195 ˚C while for CG biocomposite with 60 wt.% graphene composition 2nd T_{onset} is at 205 ˚C. Tp_2 of 0 wt.% graphene content is at 275 ˚C while for CG biocomposite with 60 wt.% graphene composition is at 300 ˚C. Thermal stability of CG biocomposite with 60 wt.% graphene is higher than 0 wt.% graphene, suggesting strong bonding between cellulose and graphene which results in enhanced thermal stability [2]. The investigation showed that the greater graphene content in CG biocomposite had a higher conductivity. The highest conductivity of CG biocomposite solid electrolyte obtained is 2.85×10^{-4} Scm^{-1} with 60 wt% graphene composition while CG biocomposite without graphene showed lowest conductivity of 1.78×10^{-7} Scm^{-1} which acts as an insulator. The highest conductivity obtained by CG with 60 wt.% graphene is related with its maximum thermal stability due to less oxygen-containing group present [3]. In this study, it was found that CG biocomposites exhibited good thermal properties along with promising conductivity for a solid electrolyte. This research is believed to provide and environmental friendly method to prepare cellulose/graphene biocomposite solid electrolyte which is useful in the future applications of energy.

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Figure & Table

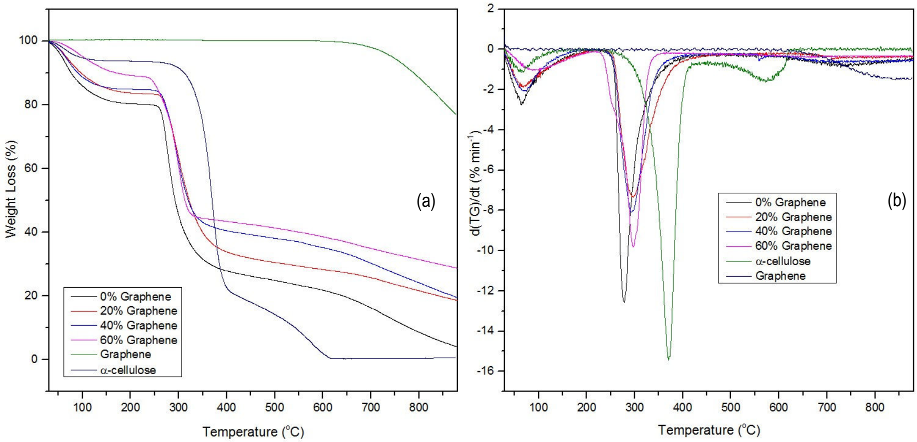

Figure 1: (a) TG and (b) DTG curve of CG biocomposites.

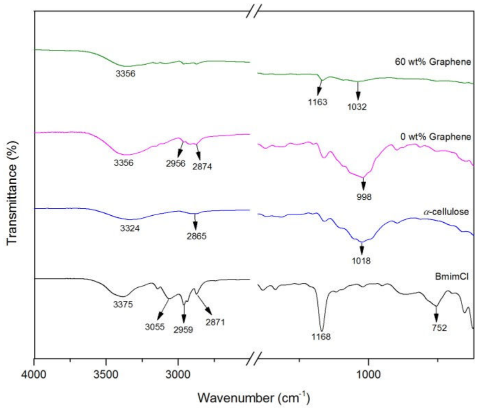

Figure 2: FTIR spectrum of CG biocomposites, BmimCl and *α*-cellulose

Table 1: Conductivity for pure cellulose and polymer composite solid electrolyte at ambient temperature.

Graphene Content (wt%)	**Conductivity ($S\ cm^{-1}$)**
0	1.78×10^{-7}
20	2.98×10^{-5}
40	1.27×10^{-5}
60	2.85×10^{-4}

Table 2: TGA/DTG parameters of 2nd degradation peak CG biocomposite solid electrolyte.

Graphene Content (wt%)	T_{p2} (˚C)	T_{onset} (˚C)	$T_{50\%}$ (˚C)	Degradation Temperature Range (˚C)
0	275	195	295	235-430
20	300	195	320	245-460
40	300	179	320	235-420
60	300	205	315	225-355

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Investigation of the nonlinear optical properties of nitrogen doped graphene using 800 nm femtosecond laser

Investigation of nonlinear optical properties of nitrogen doped graphene on indium tin oxide (ITO) substrate. Preparation of nitrogen doped graphene involves chemical deposition with high temperature subsequently followed at room temperature to form the as-synthesized N-graphene. Sample used have a thickness of ≅ 375 nm which demonstrates peaks absorptions at 330nm and at 420 nm using UV-Vis. The nonlinear optical properties of nitrogen doped graphene were observed using Z-scan technique at 800 nm femtosecond laser pulse. These nonlinear optical properties of nitrogen doped graphene shows an enhancement in (n2= -9.77x10-10) and (β=311x10-5) with the increment of input power (20-90mW).

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Figures

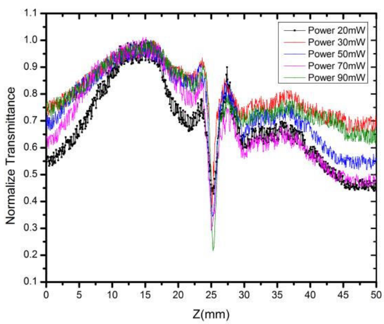

Figure 1: Close aperture of Z-scan curve for samples nitrogen doped graphene at different input power.

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