

Nano-Carbon Enhanced Materials (NCEM) Consortium

The 1st Nano-Carbon Enhanced Materials (NCEM-1) consortium has been launched in April 2012 by the **Centre for Business Innovation Ltd** (www.cfbi.com) in order to provide the consortium members a unique insight into **nano-carbon materials such as graphene and carbon nanotubes**, facilitate the commercial uptake and bring together potential users with a shared interest to address commercialisation challenges. The consortium leader **Dr Bojan Boskovic**, from **Cambridge Nanomaterials Technology Ltd** (www.cnt-ltd.co.uk), is an expert in nano-carbon commercialisation. After five years and five successful NCEM consortium series (NCEM-1, NCEM-2, NCEM-3, NCEM-4 and NCEM-5, with total of 25 meetings in Europe and USA the NCEM consortium is now in the 6th year (NCEM-6). The **NCEM-6** consortium starts in March 2017 and it **is open for new members**.

The NCEM consortium provides an opportunity to engage with leading companies in the supply chain and also with leading world class experts in a commercialisation pathfinder programme for a small fraction of time and total costs of alternatives such as consultancy, meetings, workshops and conferences. It could be used to develop nano-carbon commercialisation strategy through an active technology watch programme with a unique insight into state-of-the art of carbon nanotechnologies and key player strategies and also to secure IP and develop nano-carbon technologies through participations in collaborative R&D programmes and direct commercialisation partnerships with the NCEM members and presenting organisations.

The use of nano-carbon materials, such as carbon nanotubes and graphene is a rapidly evolving field and this is an opportunity to influence where and how fast it goes, and to facilitate the commercialisation. The mission of the consortium is to facilitate the commercial uptake of technologies based on nano-carbon materials such as graphene and carbon nanotubes, and to bring together potential users from defense, energy, electronics, structural materials and metal industries, with a shared interest in understanding the challenges and opportunities of nano-carbon technologies.

The NCEM-1, NCEM-2, NCEM-3, NCEM-4, NCEM-5 consortium members: University of Cambridge (UK); Nokia Research Centre (UK); ST Microelectronics (Italy); International Copper Association (USA); Nexans (France); Bosch (Germany); Thales (UK), Henkel (Germany), Codelco (Chile), National Grid (UK), Trinity College Dublin (Ireland), Arup (UK), Statnett (Norway), Schneider Electric (France), RTE (France), AIRBUS Defense & Space (UK), GE (USA), Bose (USA) and LML Products Ltd (UK). New consortium members joining during the NCEM-5 are Rolls-Royce (UK), Acelor-Mittal (Spain), NISSAN (UK), Whirlpool (USA), Johnson Matthey (UK), Tecnalia (Spain) and Prysmian Group (Italy).

NCEM-1, 2, 3, 4 & 5 MEMBERS



The NCEM consortium meets together 5 times per year, usually at one of its members' sites or hosted at a leading research institution. World class experts are invited to join and participate at the specific meetings related to their field of expertise.

In the first five meetings of the NCEM-1 consortium in the first year and in the following five meetings of the NCEM-2, NCEM-3, NCEM-4 and NCEM-5 consortium, around 80 organisations from 14 countries have participated providing delegates and speakers (see some of the speaker organisation logos below).



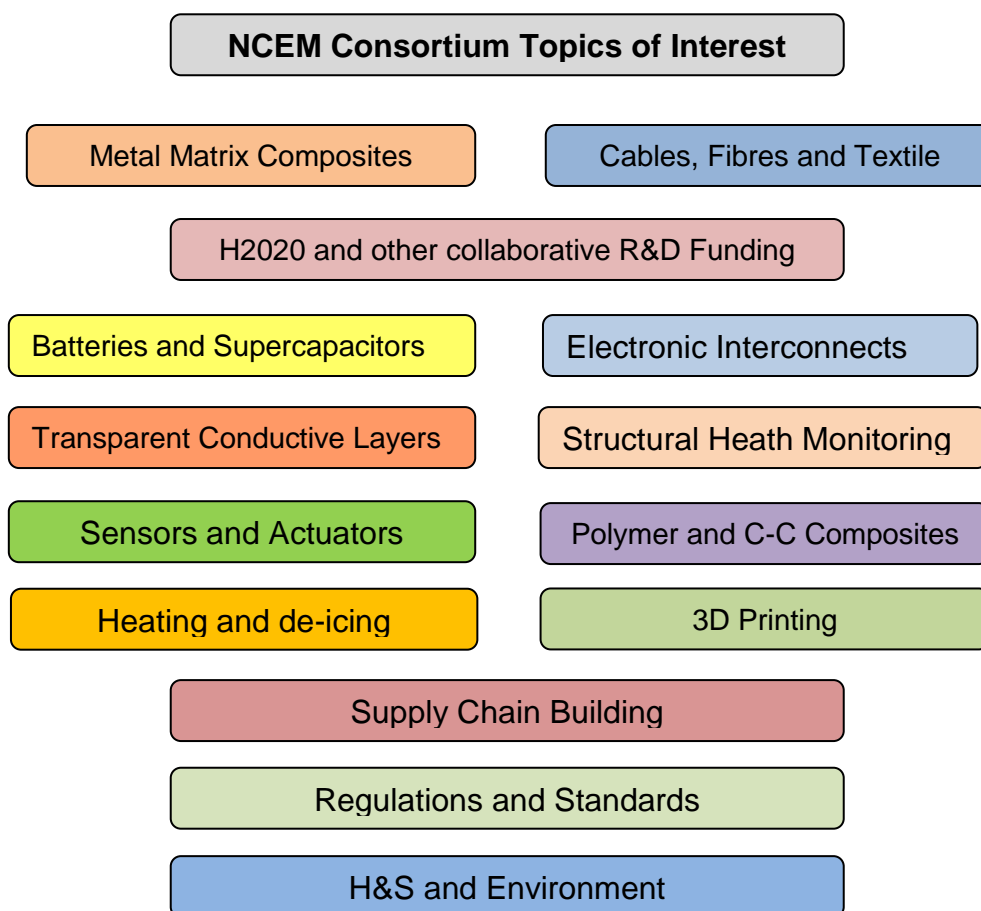


The NCEM-1 consortium meetings were in Cambridge (England), Edinburgh (Scotland), Brussels (Belgium), Stuttgart (Germany) and Dublin (Ireland). The NCEM-2 consortium meetings were in Cambridge (England), San Sebastian (Spain), London (England), Dublin (Ireland) and Boston (USA). The NCEM-3 consortium meetings were in Grenoble (France), Stevenage (UK), Brussels (Belgium), Paris (France) and Cambridge (UK). The NCEM-4 meetings were in Cambridge (UK), Houston (USA), Genoa (Italy), Cambridge (UK) and Leuven (Belgium). The NCEM-5 meetings were in Manchester (UK), Madrid (Spain), Brussels (Belgium), Cambridge (UK), and San Sebastian (Spain).

The NCEM meetings are often hosted at one of its members' sites at a leading research institution with the *tour of laboratories*: MIT, Boston (NCEM-2.5), University of Cambridge, Cambridge (NCEM-4.1), Fraunhofer IPA, Stuttgart (NCEM-1.4), CRANN Trinity College Dublin, Dublin (NCEM-1.5 & NCEM-2.4), AIRBUS Defence & Space, Stevenage (NCEM-3.2), Schneider Electric, Grenoble (NCEM-3.1), Graphenea, San Sebastian (NCEM-2.2), Cambridge Nanosystems, Cambridge (NCEM-3.5), Rice University, Houston (NCEM-4.2) and IIT, Genoa (NCEM-4.3), The Joint Institute for Innovation Policy and Nanocyl Brussels (NCEM-5.3), and Tecalia, San Sebastian (NCEM-5.5).

The NCEM consortium is controlled by its members who are suggesting the topics of interest and additional members. This is an interactive process, with members explicitly discussing the scope, focus and location of future meetings at the conclusion of each meeting.

The themes and topics of interest to the NCEM consortium are the result of discussions with the members. However, this would remain an open area for constant feedback from our members.



The NCEM consortium meetings attracted some of the leading academic, industrial and government speakers working in the field of nano-carbon materials:

- **Prof Alan Windle**, Department of Materials Science and Metallurgy, *University of Cambridge*, UK
- **Dr. Krzysztof Koziol**, Department of Materials Science and Metallurgy, *University of Cambridge*, UK
- **Dr John Hart**, Department of Mechanical Engineering, *MIT*, USA
- **Dr Brian Wardle**, Department of Aeronautics and Astronautics, *MIT*, USA
- **Christos Tokamanis**, Head of Nano Sciences and Technologies, *European Commission*, Belgium
- **Dr David R. Forrest**, *U.S. Department of Energy*, USA
- **Dr Meyya Meyyappan**, *NASA Ames Research Center*, USA
- **Dr Jean Dijon**, Research Director at *CEA - LITEN*, Grenoble, France
- **Dr Zoe Webster**, Head of Technology, *Technology Strategy Board*, UK
- **Dr Steve Hankin** and **Dr Craig Poland**, *Institute of Occupational Medicine*, Edinburgh, UK
- **Dr Anna Gergely**, Director, EHS Regulatory, *Steptoe & Johnson LLP*, Belgium
- **Dr Kyle Kissell**, Director of Technology Development, *NanoRidge*, USA
- **Dr David Arthur**, CEO, *SWeNT*, USA
- **Dr Peter Krueger**, Head of Work Group Nanotechnology, *Bayer MaterialScience*, Germany
- **Ivica Kolaric**, Head of Department of Functional Materials, *Fraunhofer IPA*, Germany
- **Jesus de la Fuente**, CEO, *Graphenea*, Spain
- **Dr Jani Kivioja** and **Dr Stefano Borini**, *Nokia Research Centre*, Cambridge, UK
- **Dr Ryan Enright**, *Alcatel Lucent Bell Labs*, Ireland
- **Dr Andy Goodwin**, *Thomas Swan & Co*, UK
- **Dr Karl Coleman**, CTO, *Applied Graphene Materials*, UK

- **Francis Massin**, CEO, **Nanocyl**, Belgium
- **Dr Georg Duesberg**, **CRANN**, Trinity College Dublin, Ireland
- **Peter Antoinette**, CEO, **Nanocomp Technologies**, USA
- **Dr Elena Polyakova**, CEO, **Graphene Laboratories**, USA
- **Dr Erick Thostenson**, **University of Delaware**, USA
- **Jose Cubillo Capuz**, Head of Advanced Materials Group, **ACCIONA** R&D, Spain
- **Chris Ward**, Head of Space R&D UK, **AIRBUS** Defense & Space, UK
- **Malcolm Burwell**, Director of Technology, **International Cooper Association**, USA
- **Francis Debladis**, Head of Nexans Research Centre, **Nexans**, Lens, France
- **Dr Paolo Bondavalli**, Head of Nanomaterial Topic Team, **Thales**, France
- **Dr Alfred A. Zinn**, **Lockheed Martin** Space Systems Company, USA
- **Dr Julio Gomez**, CEO, Avanzare, Spain
- **Dr Terry Holesinger**, Los Alamos National Laboratory, USA
- **Prof Ian Kinloch**, Professor of Material Science, University of Manchester, UK
- **Prof. Rodolfo Miranda**, Director IMDEA-Nanoscience, Spain
- **Dr Yolanda de Miguel**, Nanotechnology Cluster Director, Tecnalia, Spain
- **Roberto Suárez**, Global R&D, ArcelorMittal, Spain
- **Dr. Balu Balachandran**, Argonne National Laboratory, USA
- **Dr Siva Böhm**, Chief Technology Officer at Talga Technologies Ltd, UK
- **Neill Ricketts**, Chief Executive Officer, Versarien, UK
- **Prof. Henning Zeidler**, Chair Additive Manufacturing, Technische Universität Bergakademie Freiberg, Germany.
- **Dr. Andreas Berger**, Research Director, CIC nanoGUNE, Spain

Following successful NCEM-1.3 meeting in Brussels, the consortium submitted EC FP7 UltraWire project proposal in December 2012 that included 4 consortium members and 2 of organisations that provided speakers at the consortium meetings. The UltraWire project was granted €3.3M by the EC and it started on 1st October 2013 and finished in September 2016 (www.ultrawire.eu).

The NCEM consortium leader is **Dr Bojan Boskovic**, CEO of the Cambridge Nanomaterials Technology Ltd (www.CNT-Ltd.co.uk) a consultancy company specialising in carbon nanomaterials. He has more than 15 years of hands-on experience with carbon nanomaterials and composites from industry and academia in the UK and Europe. Previously, he was a R&D Manager at Nanocyl, one of the leading carbon nanotube manufacturing companies in Europe, a Principal Engineer-Carbon Scientist at Meggitt Aircraft Braking Systems, a Research Associate at the University of Cambridge, and a Senior Specialist at Morgan Crucible PLC. His carbon nanomaterials related work has been patented and published in leading scientific journals including Nature Materials. He was a member of the Steering and Review Group for the Mini-IGT in Nanotechnology that advised the UK Government on the first nanotechnology strategy policy document. He is also working as an advisor for the European Commission (EC) on engineering and upscaling clustering and he has experience in management of exploitation and dissemination related activities in European collaborative R&D FP7 and Horizon 2020 projects.



For further details about membership package for large corporations, SMEs and research institutions and information how to join the consortium please contact Dr Bojan Boskovic, leader of the NCEM consortium: Bojan.Boskovic@cfbi.com

Summary of NCEM-1, NCEM-2, NCEM-3, NCEM-4 and NCEM-5 meetings

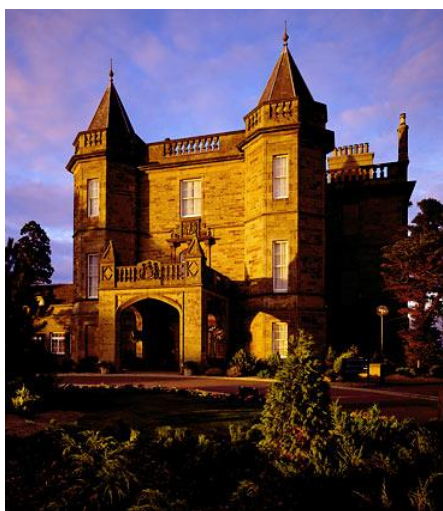
The 1st NCEM-1 (**NCEM-1.1**) Cambridge meeting was held on 18th & 19th April 2012 in Downing College and delegates were addressed by leading academics from the University of Cambridge and experts in the field of nano-carbon materials: Prof. Bill Milne from the Department of Engineering who gave a presentation about nano-carbon electronics; and Prof. Alan Windle and Dr. Krzysztof Koziol from the Department of Materials Science and Metallurgy who presented scientific advances and commercialisation challenges related to carbon nanotube fibre technology. The consortium members from Nokia Research Centre (UK) and International Copper Association also gave presentations about their vision and challenges related to the commercialisation of nano-carbon technology in mobile electronics and copper metal composite applications.



The NCEM-1.1 meeting at Downing College in Cambridge

Malcolm Burwell from International Copper Association commented after the 1st NCEM consortium meeting:

“We all felt that the value obtained from the single meeting that we just had justified the yearly fees on its own.”



Venue of the NCEM-1.2 was Dalmahoy Marriott Hotel in Edinburgh

The 2nd NCEM-1 (**NCEM-1.2**) meeting took place on 18th and 19th July 2012 in Edinburgh’s Dalmahoy Marriott Hotel and Country Club, the Scottish Baronial Manor set in 1000 acres of parkland and one of Scotland’s premier golfing venues. The morning session started with the Masterclass in NanoSafety delivered by Dr Steve Hankin and Dr Craig Poland from the Institute of Occupational Medicine from Edinburgh. This was followed by Dr Kyle Kissell, Director of Technology Development from NanoRidge, USA who presented recent developments in incorporating highly conductive carbon nanotubes into copper metal that resulted in a composite material with superior properties. His presentation was followed by a presentation from Dr Francesco Bonaccorso from the University of Cambridge on graphene applications in electronics and an update about European FP7 NMP 2013 call for collaborative R&D proposals by Dr Bojan Boskovic.

Dr Kyle Kissell, Technology Director from NanoRidge in Houston, Texas commented after the 2nd NCEM meeting:

“I believe that consortia like this are a critical step towards bridging the gap between extraordinary science and product commercialization. We feel privileged to be invited to speak to a group that is interested in DOING something as opposed to just TALKING about something. The connections we created during the two days of interactions will be crucial for the success of our products and our company.”

Dr Anna Gergely from Steptoe & Johnson LLP co-hosted the 3rd NCEM-1 (**NCEM-1.3**) meeting on 6th and 7th November 2012 in Brussels. She also presented an insight into nanomaterials- related regulations in the EU at the meeting. Guest speakers also included Dr David Arthur CEO of the SWeNT in the US, one of the leading Single Wall Nanotube (SWNT) producers and Dr Peter Krueger, Head of Working Group Nanotechnology, Bayer MaterialScience, Germany. Peter is also leading

Inno.CNT, a €90M German Government



Christos Tokamanis, from the European Commission presenting at the NCEM-1.3 meeting in Brussels

supported programme about carbon nanotube commercialisation. Christos Tokamanis, who is Head of Nano Sciences and Technologies at the European Commission (EC) in Brussels, gave a presentation about FP7 NMP Theme and an insight into nanotechnologies and nanomaterials within a new Horizon2020.

Ivica Kolaric and his team from Fraunhofer IPA in Stuttgart were co-hosting the 4th NCEM-1 (**NCEM-1.4**) meeting on 27th and 28th February 2013 and also providing us with an insight into carbon nanomaterials related research activities at Fraunhofer IPA including carbon nanotube metal composites and graphene supercapacitors. The NCEM-1.4 meeting delegates were given a tour of the Fraunhofer IPA laboratories. Dr Andre Zimmermann from Bosch in Stuttgart introduced Bosch Group and give presentation about potential

and challenges of polymers in electronics. Jesus de la Fuente, CEO of Graphenea from San Sebastian in Spain presented graphene manufacturing activities at Graphenea. Stefano Borini from Nokia Research Centre in Cambridge gave a presentation of graphene technology for future portable devices and give an update of Nokia's activities regarding graphene including Graphene Flagship programme. Dr Bojan Boskovic, NCEM Programme Director, gave an update of consortium activities including success with the EC FP7 project proposal entering the EC negotiation stage. Statnett from Norway was welcomed as new member of the consortium

Dr Chris Keely and his team and the CRANN, Trinity College **Dublin** were co-hosting the 5th NCEM-1 (**NCEM-1.5**) meeting on 15th and 16th April 2013 in Dublin and providing delegates with an insight into nano-carbon enhanced materials related research activities at the CRANN. Dr Georg Duesberg from CRANN talked about latest research in carbon based nano-structures for electronic and energy devices. Dr Ryan Enright from Alcatel Lucent Bell labs Ireland gave a talk about role of nanoscience in advanced thermal management from ICT/Telecom perspective. Dr Andy Goodwin gave an overview of carbon nanomaterial production and research activities at Thomas Swan & Co. Mark Bowers from Arup talked about carbon nanomaterial applications in construction industry and role of Arup. Malcolm Burwell from Copper Industry Association gave an update on development of ultraconductive copper-carbon nanotube composites.

The 2nd NCEM consortium (**NCEM-2**) started with the first meeting (**NCEM-2.1**) in Nokia Research Centre in **Cambridge** on 10th July 2013 and an opening dinner at the Trinity Hall College on 9th July. The NCEM-2.1 Cambridge meeting **Dr Jani Kivioja** co-organisers from Nokia gave presentation about Nokia Research Centre and nano-carbon related research activities including Graphene Flagship Programme. Dr Karl Coleman, CTO and Claudio Marinelli, Business Development Director from Durham Graphene Science (DGS) presented graphene manufacturing capacities, and discussed plans and opportunities for collaboration with DGS. Dr Krystof Koziol from Department of Materials Science and Metallurgy at the University of Cambridge gave an update on his research activities including information about the FP7 UltraWire project. Dr Haider Butt from Department of Engineering at the University of Cambridge gave a presentation about optical holograms based on carbon nanotubes. Adam Geen from the National Grid gave an overview about National Grid and opportunities for use of nano-carbon materials in electrical energy transmission applications.

Jesús de la Fuente and his team from Graphenea were co-hosting the 2nd NCEM-2 (**NCEM-2.2**) meeting on 7th and 8th October 2013 in **San Sebastian** and also providing an insight into graphene manufacturing and research activities at Graphenea. Dr. Amaia Zurutuza, Scientific Director at Graphenea, gave presentation about graphene applications and research activities at Graphenea. Jose Luis León, General Manager IDEC.aero - Advanced Composites Manufacturer for Airbus and Airbus Military (Spain) gave a presentation about carbon nanomaterials in aerospace composites. Francis Massin, CEO of Nanocyl (Belgium) gave a presentation about carbon nanotube manufacturing, product development and research at Nanocyl, one of the leading carbon nanotube manufacturers. Dr. J. Alberto Blázquez gave a presentation about experience of CEGASA and IK4-

CIDETEC (Spain) about choosing the right nano-carbon materials for battery and fuel cell applications. Dr. Teresa Álvarez Centeno from Instituto Nacional del Carbón – CSIC, Oviedo, (Spain) gave a presentation about carbon nanomaterials in supercapacitors including reflection to the work done in the FP7 ElectroGraph project regarding development of grapheme supercapacitor electrodes. Dr Virginia Ruiz from the Nanomaterials Unit, IK4-CIDETEC (Spain) gave a presentation about diversified activities on carbon nanomaterials research in their group. Schneider Electric from France was welcomed as new member of the consortium.

The 3rd NCEM-2 meeting (**NCEM-2.3**) has been co-hosted by Arup in **London** on 26th November 2013 with an opening dinner on 25th November. At the meeting speakers from Arup provided insight into: 1) products they developed and attitude towards industrial collaboration, 2) the research processes they follow and strategic areas for research and 3) opportunities for carbon nanomaterials in construction industry. Prof. Nicole Grobert from the Oxford University gave an overview of carbon nanotube and graphene synthesis and application related activities of her team. Dr Richard van Rijn, CTO from Applied Nanolayers from Netherland gave a talk about opportunities and challenges for graphene wafer scale production. Stuart Morris CEO of the GasPlas presented interesting technology for improving gas decomposition efficiency of the CVD nano-carbon production process. Dr Chris Keely, Business Development Director at CRANN, Trinity College Dublin talked about launch of their new AMBER (Advanced Materials and Bio Engineering Research) centre with €58M investment over 6 years that is looking for partnership with industry and academia. Dr Zoe Webster, Head of Technology at the Technology Strategy Board gave an overview of the UK government investment in nanotechnologies. The meeting also provided an introduction to upcoming H2020 NMP call and an opportunity for partnering discussions related to the call facilitated by Dr Bojan Boskovic based on the latest H2020 NMP call draft document.



Consortium dinner at the NCEM-2.2 meeting in San Sebastian organised by Graphenea

The 4th NCEM-2 meeting (**NCEM-2.4**) meeting in **Dublin** on 27th February 2014 with an opening dinner on 26th February 2014 has been co-organised by Dr Chris Keely and Dr Colm Faulkner and their team from Trinity College Dublin CRANN/AMBER centre. Dr Georg Duesberg from CRANN talked about latest research in carbon based nano-structures for electronic and energy devices. He was followed by two other CRANN researches Dr Shane Bergin and Dr Beatriz Mendoza-Sánchez. Dr Ryan Enright from Alcatel Lucent Bell Labs Ireland gave a talk about role of nanoscience in advanced thermal management from ICT/Telecom perspective. Dr Nathalie Caillault from Schneider Electric gave an overview of perspective on application of carbon-nanomaterials. Prof. Pagona Papakonstantinou from Nanotechnology and Integrated Bioengineering Centre at University of Ulster, Ireland talked about energy storage and production with graphene enabled materials. The meeting also provided an opportunity for partnering discussions related to the H2020 NMP calls facilitated by Dr Bojan Boskovic.

The last NCEM-2 meeting (**NCEM-2.5**) was in **Boston** - Cambridge, MA, USA on 14th May 2014 with an open-day meeting on 15th May 2014. Dr John Hart from the Department of Mechanical Engineering at the MIT presented nano-carbon related research activities of his team and gave the consortium member a tour of his laboratory at the MIT. Dr Brian Wardle from the Department of Aeronautics and Astronautics at the MIT gave presentation about his nano-carbon related composite aerospace structures research. Peter Antoinette, CEO of Nanocomp Technologies presented their carbon nanotube fiber products and talk about the carbon nanotube product company journey through the valley of death. David Arthur, CEO of the SWeNT in the US, one of the leading Single Wall Nanotube (SWNT) producers gave an update on their production and application development activities. Dr Elsa Olivetti from Department of Materials Science and Engineering at the MIT discussed issues in her presentation related to potential for displacement of traditional materials, especially metals by major novel nano-carbon material technologies. Dr Elena Polyakova, CEO of the Graphene Laboratories, Inc and 3D Graphene Labs, spoke about the graphene market and other 2D materials.

Dr Erick Thostenson from University of Delaware gave presentation about nano-carbon composites including structural health monitoring. Dr Alfred A. Zinn from Lockheed Martin Space Systems Company gave presentation about nanoenabled electronics. Dr David R. Forrest from the U.S. Department of Energy gave presentation regarding the U.S. Government initiative on development of the network of Manufacturing Innovation Institutes.



Prof. Brian Wardle from MIT presenting at the NCEM-2.5 Boston meeting at the British Consulate, Cambridge, MA, USA

The 1st NCEM-3 meeting (**NCEM-3.1**) was in **Grenoble**, France on 24th June 2014 with an opening dinner on 23rd June 2014 is co-organised by Dr Nathalie Caillault and others from Schneider Electric. After welcome and introduction from Nicolas Leterrier, Vice-President of Innovation from Schneider Electric, Jan Janssen, Director RD&I Aurubis Belgium, gave an overview of copper production and products at Aurubis. This was followed by presentation from Dr Claude Estournès, CNRS Research Director about CNT-copper nanocomposites by SPS. Dr Jean-François Silvain, CNRS Research Director and Adjunct Professor - Department of Electrical Engineering - University of Nebraska – Lincoln gave presentation about Copper-Carbon and Aluminum-Carbon Composites Fabricated by powder metallurgy processes. This was

followed by laboratory visit to the Schneider Electric Data Centre. Jose Cubillo Capuz, Head of Advanced Materials Group, ACCIONA R&D gave presentation about R&D nanotechnology strategies on civil infrastructures. Dr Jinbo Bai, CNRS Director of Research CNRS, Head of Group “Nanotubes and nano/microcomposites” talked about carbon nanotube–graphene nanoplatelet hybrids as high-performance multifunctional reinforcements in polymer matrix composites. Jerome Joaug, Business Development Director from Cambridge Nanosystems Ltd talked about graphene production scale-up challenges.

The 2nd NCEM-3 meeting (**NCEM-3.2**) meeting was in **Stevenage**, UK on 27th October 2014 with closing dinner on the same evening. After welcome and introduction from Chris Ward, Head of Space R&D UK from Airbus Defence & Space, Dr Krzysztof Koziol from the University of Cambridge gave an overview of nano-carbon research in his group at the University of Cambridge, Department of Materials Science and Metallurgy including research activities relevant to use of carbon nanotube fibers for highly conductive wires. Malcolm Burwell from International Copper Association shared experience concerning worldwide fund-raising for developing CNT/copper composite wire. After the Airbus Defence and Space Laboratory visit, Prof Tiberiu Minea, Professor of the University of Paris-Sud, presented his Physics Laboratory for Gas and Plasma and their activities related to nano-carbon materials. Dr Bruno Dufour from Hutchinson gave a presentation about nano-carbon based conducting coatings. Dr Luigi Occhipinti from the University of Cambridge presented activities at the Centre for Large Area Electronics and Cambridge Integrated Knowledge Centre including research and opportunities regarding the use of carbon nanomaterials for electronic applications. Dr Bojan Boskovic presented opportunities for collaborative R&D project that might be of interest to the NCEM consortium within Horizon 2020 NMP-2015 call for proposals.

Dr Anna Gergely, Director, EHS Regulatory from Steptoe & Johnson LLP will be co-hosting the 3rd NCEM-3 meeting (**NCEM-3.3**) in **Brussels** and she would also give an update on regulatory issues related to nanomaterials. Her presentation would be followed by Jesus de la Fuente, CEO, from Graphenea in Spain who will give an overview of graphene production and application development in Graphenea. Michel Hertz, ex. Corporate Technical Management from Nexans, France would be talking about challenges of development of a new conductor technology and turning it into a wire product with a focus on activities related to development of novel copper-carbon nanotube wire. Dr Rober Rölver and Martin Köhne, researchers from the Robert Bosch GmbH will present research on nanocarbon materials at Bosch.

Francis Debladis, Head of Nexans Research Centre, Lens, France was co-hosting the 4th NCEM-3 (NCEM-3.4) meeting in **Paris** and he also gave a presentation about Nexans with a reflection of Nexans activities related to nano-carbon materials. His presentation was followed Dr Johan Bertrand from Andra, France who talked about needs of smart materials for the new generation of waste package and the geologic repository monitoring system. Dr Paolo Bondavalli, Head of Nanomaterial topic team at Thales Research and Technology gave a presentation about opportunities for use of nano-carbon materials in aerospace and defense applications in Thales. Dr Soraya Ammi and Christian Poumarede, RTE- France, R&D Department presented the main objectives, R&D context and concerns on CNTs from a perspective of the French Transmission System Operator (TSO), RTE. Dr Louis Gorintin, from GDF SUEZ gave a presentation about application of nanomaterials for power and fluids transportation, distribution and valorisation and for energy production and storage.



Visit of the Cambridge Nanosystems laboratories during NCEM-3.5 Cambridge meeting

The **NCEM-3.5 Cambridge** meeting Day 1 on 9th June 2015 was co-hosted by Cambridge Nanosystems. Dr Krzysztof Koziol and Jerome Joaug, Co-Founders of Cambridge Nanosystems welcomed delegates and Jerome gave a presentation about their recent activities and research regarding graphene production and application. After the coffee break Mike Banach, Technical Director of FlexEnable gave talk about the use of graphene for flexible electronics. Nello Li Pira, Head of Functional Surfaces & Optical Assessment Unit from the Fiat Research Centre talked about opportunities of use of carbon nanomaterials in automotive industry. The meeting continued with tour of the Cambridge Nanosystem laboratories providing a unique insight of the graphene manufacturing technology. After the lunch break Dr Gerhard

Goldbeck, Director of Goldbeck Consultancy gave presentation about activities related to the European Commission Engineering & Upscaling Cluster that he is leading together with Dr Bojan Boskovic, CEO of Cambridge Nanomaterials Technology Ltd. He also gave a presentation about area of his professional expertise with an insight into modelling tools for advanced materials development. Ivica Kolaric, Head of Department of Functional Materials at Fraunhofer IPA, presented an overview about their recent activities regarding nano-carbone materials. Malcolm Burwell, Director of Technology of International Cooper Association, gave an update of recent activities around the world related to development of ultra-conductive copper based on nano-carbon additives. Del Stark, CEO of Del Stark Technology, presented the latest additive manufacturing market data and possibilities for use of graphene for 3D printing. He also co-chaired with Dr Boskovic the last session: **3D Graphene Printing Round Table** discussion. The NCEM-3.5 Cambridge meeting Day 2 on 10th June 2015 was co-hosted at the University of Cambridge, Department of Materials Science and Metallurgy by Dr Krzysztof Koziol and his co-workers who also gave a presentation about their activities related to nano-carbon research and provide a tour of laboratories of the Electric Carbon Nanomaterials Group. Prof. Alma Hodzic, from University of Sheffield will gave an overview of research activities related to use of carbon nanomaterials in 3D printed products for aerospace applications. Dr Sameer S Rahatekar from Aerospace Engineering at the University of Bristol talked about carbon nanotube composites for multi-scale composites.

The first meeting of the 4th NCEM consortium (**NCEM-4.1**) has been in **Cambridge** hosted by the Department of Materials Science and Metallurgy, University of Cambridge. The meeting was linked with the UltraWire Open Day 2015 Workshop that attracted over 40 delegates. The Open Day 2015 Workshop was the first opportunity to learn about some of the EC FP7 UltraWire project (www.ultrawire.eu) preliminary results and meet project partners and project management. The aim of the UltraWire project was to develop a copper nanocarbon composite with significantly improved overall properties, including electrical, thermal and mechanical performances over bulk copper using production process that will be scalable to large volume manufacture. The meeting started with in-depth overview of the project and presentation of non-confidential results given by a Project Coordinator Dr Krzysztof Koziol from Department of Materials Science and Metallurgy, University of

Cambridge. This presentation was followed by some other selected project related presentations related to H&S issues given by Sofia Billett from Institute of Occupational Medicine (IOM), computer modeling work, Live Cycle Analysis (LCA) given by Dr. Margarida Gama from ThinkStep and exploitation and dissemination discussion facilitated by Dr Bojan Boskovic from Cambridge Nanomaterials Technology Ltd. In the second day Dr. Jean Dijon, Research Director at CEA - LITEN, Grenoble, France gave presentation about carbon nanotube research at the CEA – LITEN followed by presentation related about functional coatings from Dr. Bilge Saruhan, Group leader at DLR - German Aerospace Center, Germany and Dr. Gonçalo Gonçalves about thin film graphene growth technology at AIXRON.

The second NCEM-4 consortium meeting (**NCEM-4.2**) was in **Houston**, Texas, USA hosted by Rice University. The meeting started with an organised tour of NanoRidge Materials laboratories and premises on the first day and followed by a day of presentations and discussion at the Smalley-Curl NanoCarbon Center, School of Engineering, Rice University. After welcome and introduction from John Marsh from Rice University, Prof. Dr. Andrew R. Barron, Professor of Materials Science at Rice University gave presentation about tunable carbon-capture materials. This was followed by presentation from Prof. Lourdes Salamanca-Riba, Professor, University of Maryland, about incorporation of graphene-like nanostructures in bulk Ag, and Al alloys and bulk and film Cu. The next presentation was Dr. Terry Holesinger from Los Alamos National Laboratory about development of advanced energy-related materials enhanced with nanocarbon materials followed by presentation from Dr. Horst Adams, Founder and President, Adamco Inc about super strength CNT reinforced aluminum, low CTE nano structured aluminum and nano-carbon enhanced ultra-conductive copper. The first presentation after lunch was given by Dr. Greg Kusinski, Strategic Corporate Partnership Director and DeepStar® Director at Chevron, Houston, TX, USA. Greg gave presentation about lessons learned from forming and operating the Deepstar Joint Industry Project followed by presentation from Dr. Meyya Meyyappan, Senior Scientist, Ames Research Center about nanocarbon and Related Work at NASA Ames.

The third NCEM-4 meeting **NCEM-4.3** was in **Genoa** following an invitation from the Graphene 2017 conference organiser Istituto Italiano di Tecnologia (IIT) to organise NCEM meeting day before the Graphene conference in order to have focused industrial discussion forum about the commercialisation of graphene materials where leading speakers from the conference could be invited. The meetings started with a welcome and introduction from Dr Vittorio Pellegrini, Director Graphene Labs, IIT followed by a presentation about graphene research activities at IIT from Dr Francesco Bonaccorso. The next presentation was from Dr Julio Gomez, CEO of a graphene producer Avanzare from Spain followed Dr Elena Polyakova, CEO, Graphene Laboratories, Inc, USA with her presentation “Graphene and Additive manufacturing: the Next Industrial Revolution”. After lunch session started with a presentation from Dr Paolo Bondavalli, Head of Nanomaterial Group in Thales, France followed by presentation from Dr. Akimitsu Narita, Project Leader, Max Planck Institute for Polymer Research in Germany on research activities on the bottom-up synthesis of graphene nanoribbons. The next presentation was given by Prof. Marcos A. Pimenta from the Department of Physics at Universidade Federal de Minas Gerais, Brazil who presented work done at the Center of Technology in Nanotubes and Graphene (CTNanotubos). The following presentation was on graphene for electronic applications, and research activities on graphene technology in Korea given by Prof. Jong-Hyun Ahn, Professor from School of Electrical & Electronic Engineering, College of Engineering, Yonsei University, Korea. Last two presentations were given by Dr Kibum Kang from Cornell University, USA and by Dr SungWoo Nam from Mechanical Science and Engineering, University of Illinois at Urbana-Champaign, USA.

The fourth meeting of the NCEM-4 (**NCEM-4.4**) was in **Cambridge**, UK was linked with the Centre for Business Innovation (CfBI) Summer Summit & Dinner. This was an opportunity to meet with



NCEM-4.4 meeting at Girton College in Cambridge

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representatives of leading multinational companies and institutions that are part of other CfBI consortium such as: 3M, Alliance Boots, Arla, ARM; Astra Zeneca, Boeing, BUPA, DSM, Eurapco, European Commission, GHD, Google, HP, Illumina, Intel, Johnson and Johnson, Lloyds Bank, NICE, Mondelez, Ordnance Survey Patients Know Best, Reckitt Benkiser, Royal Bank of Scotland, Royal Society for Chemistry, Scottish Enterprise, Skanska, Smith and Nephew, Telefonica, Teva Pharmaceuticals, Thomson Reuters and Velux. The meeting started with presentation from Lucía González Bermúdez, GrapheneTech, Spain regarding Industrial Graphene nanoplatelets production and applications. In order to assist their presentation as company GrapheneTech also had an exhibition stand at the meeting. The next presentation about electronic application of graphene was from Dr Cecilia Mattevi from Department of Materials, Imperial College of London UK. This presentation was followed by a presentation from Dr Matthew Cole from Department of Electrical Engineering, University of Cambridge on graphene and carbon nanotube-based field emission devices and presentation from Dr Han Zhang form Headstart Capability Group, Bose Corp, USA. The next presentation was Dr Chris Howard, University College London, UK followed by presentation from Prof Alan Windle from University of Cambridge.

The fifth NCEM-4 consortium meeting **NCEM-4.5** in **Leuven**, Belgium was linked with the UltraWire Open day 2016 Workshop that attracted over 50 delegates. The Open Day 2016 Workshop was the final opportunity to learn about some of the EC FP7 UltraWire project (www.ultrawire.eu) final results as project was finishing on 30th September 2016. The meeting started with in-depth overview of the



BBC News Click programme from 9th April 2016 about the EC UltraWire project with Dr Marek Burda from Cambridge University and Spenser Kelly from BBC

project given by a Project Coordinator Dr Krzysztof Koziol from Department of Materials Science and Metallurgy, University of Cambridge. This presentation was followed by some other selected project related presentations related to H&S issues given by Dr Steve Hankin from Institute of Occupational Medicine (IOM), computer modeling work given by Dr Katarina Molowska from University of Cambridge, Live Cycle Analysis (LCA) presentation given by Constantin Herrmann from ThinkStep, Germany. Two key science and technology development presentations were given by Pyry Hannula from Aalto University in Finland, Grzegorz Kiesiewicz from AGH University of Science & Technology in Poland, Stuart Turner from Aurubis Belgium and Nicolas Masquelier form Nexans, France. Discussion about exploitation and dissemination and a presentation of the

BBC News Click programme that was on TV first time on 09/04/2016 about the UltraWire project was facilitated by Dr Bojan Boskovic from Cambridge Nanomaterials Technology Ltd. On the second day Dr Marek Burda, an UltraWire researcher from University of Cambridge and also a Director of CAMETICS Cambridge Advanced Metals Limited gave presentation on development of new type of carbon-metal adhesives in the company. Dr Alexis Lambourne from Rolls-Royce Strategic Research, UK gave presentation about the hybrid propulsion in Rolls-Royce and the role of new materials technologies. This was followed by presentation from Prof. Jin Won (Maria) Seo from Department of Materials Engineering (MTM), KU Leuven, Belgium about fabrication of nano-carbon engineered fibres and their challenges. The next presentation was Jose Cubillo Capuz, Head of Advanced Materials Group, ACCIONA R&D, Spain about the R&D nanotechnology strategies on civil infrastructures followed by presentation from Prof. Jose-Luis Valverde from Universidad de Castilla La Mancha, Spain, related to nano-carbon materials and the H2020 NANOLEAP project. Dr Nikolaus Buchheim from Siemens AG, Germany gave presentation titled "Corporate Technology Electric airplane propulsion systems at Siemens CT". This was followed by presentation from Stuart Turner from Aurubis and presentation about European Pilot Production Network (EPPN) form Hans-Hartmann Pedersen, Research Programme Officer, Advanced Materials and Nanotechnologies, Key Enabling Technologies, European Commission, Belgium.

The First Meeting of the Nano-Carbon Enhanced Materials Consortium (**NCEM**) series **5**, took place in **Manchester** on the 8th December 2016. The NCEM-5.1 Meeting was hosted by the **National**

Graphene Institute at the University of Manchester. The National Graphene Institute is the national centre for graphene research in the UK, drawing in specialists from across the globe. The NCEM members were welcomed by Dr James Baker, Graphene Business Director, of the National Graphene Institute, UK, who gave an introduction to the Institute, prior to the tour of the facilities. Prof Ian Kinloch, from the Department of Material Science, at the University of Manchester followed up with a talk on Nano-Carbon Composites. Prof. Cinzia Casiraghi, from the School of Chemistry at University of Manchester, gave a talk on “2D-crystal based inks: from formulations engineering to devices”, followed by Dr. Craig P. Dawson, from 2-DTech Graphene in Manchester, who gave a talk on graphene and its applications. Dr Biqiong Chen, Senior Lecturer in Polymer Science, Department of Materials Science and Engineering, from the University of Sheffield, presented a talk on Graphene-based nanocomposites for engineering, energy and healthcare applications. In the afternoon, Chris Hodson, Strategic Marketing Manager, at Oxford Instruments, UK gave an overview of Chemical Vapour Deposition (CVD) and Plasma Enhanced CVD graphene processes. David Fishpool, who works at the National Composites Centre in Bristol, gave a presentation on Nano-carbon composites.

Dr Siva Böhm, Chief Technology Officer at Talga Technologies Ltd, UK & Talga Advanced Materials GmbH, Germany, talked about the Commercial Applications of Graphene in Coatings & Inks. The last speaker of the day was Roger Hardacre, who is General Manager at Advanced Laser Technology Ltd., he talked about Commercializing Novel Methods of Blown Powder Additive Manufacturing.

The second meeting of the series 5 (**NCEM-5.2**) took place in **Madrid, Spain** on the 20th January 2017, in conjunction with the NanoLeap Open Day 2017 Workshop (19th January), which attracted 64 people. Both events were hosted by the IMDEA Nanociencia. This was an opportunity for NCEM members to learn about the NanoLeap Project (www.nanoleap.eu), which brings together a European network of pilot production facilities focused on scaling up nanocomposite synthesis and processing methods. The programme was organised in two parts: first part was dedicated to presentations of NANOLEAP pilot plants and Open Access model; second part was focused on interactive open discussion about pilot production opportunities and challenges. The closed meeting for the NCEM Members took place the following day, where NCEM members were welcomed by Prof. Rodolfo Miranda, Director IMDEA-Nanoscience.



NCEM-5.1 & NanoLeap Open Day - IMDEA Nanociencia, Madrid, Spain

Followed by two members of the Research team: Emilio M. Pérez and Daniel Granados, who talked about novel strategies to interface molecules and carbon nanomaterials; and exploring routes to tailor the properties of 2D materials for optoelectronic applications. Before the lab tour, Raquel Llorens-Chiralt, from AIMPLAS, explained about a comparative study between properties of Carbon Nanotubes versus Multilayer Graphene in Polypropylene Nanocomposites. After the lunch break, Dr Juan José Vilatela, from IMDEA Materials, presented a talk on Macroscopic fibres of CNTs: synthesis, properties and selected applications. Followed by Dr Briac Lanfant, from EMPA, Switzerland, who discussed about “Lightweight metal matrix composites reinforced with carbonaceous nanoparticulate materials”. Mark Bowers, Senior Analyst, from Arup gave a presentation on Opportunities and challenges in Nano materials in Construction industry. Íñigo Larraza, from Gnanomat, talked about Gnanomat: industrialization of high quality graphene nanomaterials for the energy storage sector. This session finished with a round table discussion facilitated by Dr Boskovic.

The **NCEM-5.3** meeting was hosted by the **Joint Institute for Innovation Policy (JIIP)** on the 30th March. Members from the NCEM Consortium were also invited to participate in the *NanoData Workshop* hosted by JIIP and held on 29th March 2017. The NanoData project, was commissioned by DG Research and Innovation, and provides information and policies to enable researchers, European industries and others to innovate with nanotechnology in a safe and responsible manner. The meeting addressed the challenges for nanotechnology to reach the market by 2020 and possible policy options to encourage that transition. Scenarios for nanotechnology commercialisation to 2025 were also considered.

The NCEM meeting on the next day started with a welcome and introduction from Dr Jaqueline Allan, Senior Policy Advisor at The Joint Institute for Innovation Policy. Followed by Dr Yolanda de Miguel,

who is Nanotechnology Cluster Co-ordinator at Tecnalía, who gave a talk on development of multisectorial applications of graphene at TECNALIA. Other speaker was Prof. Dr Gregory Van Lier, from Vrije Universiteit Brussel, who participated in this meeting with a talk on Theoretical Analysis of Carbon Nanosystems for Composite Synthesis. Dr. Antonios Vavouliotis, Managing Director of Adamant Composites Ltd., gave a presentation titled: FXply™ technology. An upscaled and seamless integration of nanotechnology in composites applications. The last speakers of the morning were: Dr. Albert Schnieders, Chief Technology Officer and Managing Director from CNM Technologies GmbH, who talked about Carbon Nanomembranes. Dr Elias P. Koumoulos, and Dr Kate Trompeta from National Technical University of Athens, who gave a joint presentation on Advancements in carbon based materials upscaling: Carbon based and composite structures and advanced tools for performance assessment. After lunch, a programmed visit to Nanocyl SA., took place, where NCEM delegates were welcomed by Matthieu Houle, Core Technology Manager, and other of his colleagues.



NCEM-5.4 Cambridge – Dinner at St Catharine's College

The fourth meeting of the series (**NCEM-5.4**) was in **Cambridge** on the 12th July 2017, at **Wolfson College** with a dinner on the same day at St Catharine's College. The NCEM meeting started the morning 12th July, with a presentation from Neill Ricketts, Chief Executive Officer at Versarien, UK, who talked about Graphene Challenges & Opportunities of Graphene starts-ups. He was followed by Ane Irazustabarrena, Programme Director at the new NCEM member TECNALIA, who presented two of their EU funded projects: PLATFORM (<http://www.platform-project.eu/>), and IZADI Nano2Industry Project (<http://www.izadinano2industry.eu/>). After the coffee break, two NCEM members, Liudmila F. Liman, from

Nissan Research Center-Russia and Roberto Suárez, from ArcelorMittal, Spain, gave an introduction to their organisations and their activities. Before the lunch break, Dr Boskovic European Pilot Production Network (EPPN) & Innovation Hubs.

This NCEM was linked to the **UltraWire Workshop** starting on the afternoon of the 12th and 13th July 2017. It had the participation of 45 people. They came from different organisations such as Airbus, MBDA, Robert Bosch GmbH, Mitsubishi Heavy Industries Europe, Ltd. International Copper Alliance, Rolls Royce, Toyota Motor Europe NV SA University of Surrey, University of Huddersfield, Tecnalía, Prysmian Group, Bose, MKM Mansfelder Kupfer und Messing GmbH, Technische Universität Bergakademie Freiberg, Technische Universität Chemnitz, CTNano, Carbodeon, among others. Some presenters were: Prof Krzysztof Koziol, former UltraWire Project Coordinator, and current Professor of Composites Engineering, Head of Enhanced Composites and Structures Centre at the University of Cranfield (UK); Dr Balu Balachandran, from Argonne National Laboratory (USA); Prof. Andrew R Barron and Dr Alvin Orbaek White from ESRI /Swansea University (Wales); Dr Denise Willems, from Aurubis (Belgium); Dr Vlad Stolojan, from Advanced Technology Institute, University of Surrey (UK); Dr Agnieszka Lekawa-Raus, Research Fellow in the Department of Mechatronics, Warsaw University of Technology (Poland).



NCEM-5.4 Cambridge- UltraWire 2017 Exhibition Stands

There were also presentations from the two exhibitors, Dr Raquel González Teresa from GrapheneTech S.L. Spain, and Dr Siva Böhm from Talga Technologies Ltd.,UK Both companies had exhibition stands with their products, where participants had the opportunity to see some samples and learn more about these two companies.

For second year in succession, NCEM members were also invited by the Centre for Business Innovation (CfBI), to the Business Innovation Summer Summit, at Emmanuel College, on the 11th July 2017, where around 71 people participated from other CfBI Consortium and guests organisations.

One of the new NCEM members, Tecnalia hosted the last meeting of the series 5 (**NCEM-5.5**) in their offices in **San Sebastian, Spain** on the 17th October 2017, with the NCEM dinner on the 16th October. The meeting included a visit to their labs. NCEM members and guests were welcomed by Dr Iñaki Oñate, Technology Director. Followed up by Dr Yolanda de Miguel, Nanotechnology Cluster Director at Tecnalia who talked about Nanotechnology and Advanced Materials and also gave a brief introduction on couple of EU funded projects currently being ran by Tecnalia. After the coffee break, Dr Andreas Berger from at CIC nanoGUNE, gave a talk on "Nanoscience and Nanotechnology Research at CIC nanoGUNE". A visit to Tecnalia labs took place before participants went to their buffet lunch. The first presentation in the afternoon was from Javad Anzalchi, from AIRBUS Defence and Space, UK, who gave a talk on the Opportunities and Challenges for the Application of Nanotechnology to the Space Environment. This talk was followed by Peter Hansen, Engineering Manager at Haydale Composite Solutions Ltd, who gave a presentation on Graphene and 2D fillers in carbon fibre reinforced composite materials – the development of industrial applications.



NCEM-5.5 San Sebastian – Visit to TECNALIA's labs



NCEM-5.5 San Sebastian, Spain – Meeting at TECNALIA

After the afternoon coffee break, Dr Paul Williams from Johnson Matthey PLC, one of the new NCEM members, gave an introduction to Johnson Matthey PLC and their activities. During this meeting, members of the consortium had the opportunity to listen about UK Investment & Capabilities in Nanotechnology & Advance Materials & Innovation Hubs, from Dr Kalyan Sarma, who is Horizon 2020 National Contact Point for Nanotechnology and Advanced Materials at Innovate UK.

The last presentation of the day was given by Jesus de la Fuente, CEO of Graphenea, Spain, who talked about "Graphene Oxide based Polymers and Composites: market outlook and potential applications".

After an interesting and intense day of meetings, participants who were staying another night in San Sebastian, were invited by Tecnalia to an informal dinner in a local restaurant, where they were able to degust typical dishes and continue with the fructiferous conversations.