Released Abstracts

as at January 16th, 2018

Ivica Kolaric

Group manager
Fraunhofer Institute for Manufacturing Engineering and Automation IPA,
Stuttgart, Germany

Head of the department of functional materials in Fraunhofer IPA. He is a pioneer in nanocarbons and aims to transfer the amazing intrinsic properties of new materials, such as nanotubes, graphene and nanohorns, into real life applications by open innovation principles.

Within his role as Co-Director of the Fraunhofer Project Centre for Electro Active Polymers at AIST Kansai, Japan, he worked on artificial muscles, printed sensors, electrodes for energy storage and smart surfaces. In addition, he gained fundamental understanding about Asian material industries and consults international stakeholders.

The role of materials in an increasingly dematerialised economy

*I. Kolaric[1]**

1 *Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Department of Functional Materials, Stuttgart, Germany, *corresponding author: Ivica.Kolaric@ipa.fraunhofer.de*

In this contribution I will give an insight into carbon nanomaterials, especially carbon nanotubes and graphene. The focus will be on synthesis, microstructuring and selected applications in gas storage, energy storage as well as electromechanical sensing. Adsorption is a fundamental phenomenon and forms a basis for various fields like catalysis, energy storage, sensors and gas separation. Its variable morphology has given the element carbon a central position as probably the most flexible material offering a high degree of chemical and structural functionality important in all of these fields. 3D vertically aligned CNT arrays and graphene are solely carbon based model structures and are ideal candidates to unravel a variety of gas / carbon interactions. They possess a combination of micro, meso and macro pores and multiple well-defined adsorption sites all of which can be controlled with a high chemical homogeneity and reproducibility. Moreover, 3D CNT architectures are minimal footprint areal structures, nevertheless offering high specific surface area (ca. 500 - 800 m^2 / g). Our studies will also include carbon nanohorns, CNHs, a carbon modification which is composed of dahlia or bud like arrangements of cone like all carbon nanostructures. They show potential towards gas as well as energy storage.

Mechanical sensing of small forces is an area where miniaturised and highly flexible direct sensors are an ultimate goal. Direct sensing should allow to probe small forces by mechanical deflection of individual sensor elements. Herein some fundamental studies on the properties of such nanostructures with respect to detection of mechanical forces in the mN range will be presented. Due to their good electrical conductivity and proven biocompatibility CNTs qualify themselves as potential growth substrates and electrodes for the cultivation of bioactive material.

In this realm we have studied the growth of neurons and glia cells as well as the electrical characteristics of structured CNT electrodes compared to conventional microstructured electrode materials.

Acknowledgment:
Our work was supported by the DFG throughout the SPP 1570, porous media with defined pore structure. We are grateful to Dr N. Molitor of TIE company, Griesheim, for making a gift of carbon nanohorns (CNHs) possible.

MOON S. LEE

CEO
GyoRin Inc., Seoul, South Korea

Nanomaterial commercialisation specialist

Devoting her career for more than a decade to carbon nanotube industry as sales & marketing professional, insightful understanding about commercialisation scheme of nanomaterial has become the key motivation to found GyoRin Inc.

Her vision is to provide bridging solutions to technology to find optimal application for commercialisation with success.

Commercialisation scheme for nanomaterial technology

*M. Lee[1]**
*1 GyoRin Inc., Seoul, South Korea, *corresponding author: novamsl@daum.net*

It is very likely that new material and / or material technology needs min. more than a couple of decades to be finally accepted by the mainstream industry as common practice.
But how often do we hear this kind of success story about soft-landing of new material / technology? Very rare. Nanocarbon material has never been an exception as far as we have observed.

Why is it so, has been my long agony while working in nanotechnology industry more than a decade myself in a path to find a killer application to see its successful commercialisation, specifically carbon nanotubes.

Details shall be given during presentation, while we have been able to come across a successful commercialisation scheme for nanomaterials which should work for many other reliable material technologies, as well.

The very first success story we have experienced is LED lighting with CNT plastic heatsink applied.
Successful commercialisation of CNT heatsink has been conceived by asking questions if we are taking general information for granted without giving them additional thought, given the target to use CNT plastic heatsink for LED lamp. With this goal in mind, relentless questions have been made from product design of heatsink part, materials' analysis, heat distribution of lighting and thermal conduction of CNT heatsink, as core questions. The requirement for working heatsink with performance may not stay in material only and should be extended to other respect of product itself including its working environment. Right questions could narrow down right answers is what we have experienced on the journey to materialise ever long-lasting almost-maintenance-free plastic heatsink applied LED lighting regardless of installation environment.

The lesson to learn from the very first experience using CNT plastic heatsink is that there is a commercialisation scheme to make success. There can be numerous schemes, as a matter of course, and ours is one of those which we have experienced ourselves and would like to share with you all.

Keywords: Nanocarbon based plastic heatsink, dispersion technology, material engineering, structure design of the parts

GÜNTHER EBERHARD

Managing director
DistriConsult GmbH

Günther Eberhard is managing director at DistriConsult GmbH, a consultancy and advisory boutique that provides robust insights and hands-on support on channel management and strategy development issues to chemicals & polymers producers and distributors.

A chemical engineer by training, Günther has more than 30 years of experience in chemical distribution and an in-depth knowledge of the industry, from the perspective of suppliers, distributors and formulators / customers.

Previous stations in his career were chemical multinational Dow Chemical, Swiss materials and technology group Von Roll, global advisory firm KPMG and Swiss specialty chemicals distributor prochem AG (now part of Nordmann, Rassmann), were he held a number of technical development, strategic planning, marketing & sales and general management positions.

Günther is based in Zurich, Switzerland and works with a global client base on strategy development & implementation and mergers & acquisition (M&A) projects.

The role of chemical distributors in new business development for specialty additives

G. Eberhard[1], J. Mohrhauer[1]*

1 DistriConsult GmbH, Wädenswil (ZH), Switzerland, *corresponding author: geberhard@districonsult.com

When marketing and selling chemicals it is important to use the right channels in order to reach target markets and customers in the most economical way. Along the petrochemical value chain, chemicals can be sold directly through the producer's own salesforce or via an indirect channel.

The presentation will outline the role of chemicals and polymers distributors in marketing and sales of additives (i.e. chemicals and polymers that confer a particular property to a product, such as CNTs or graphenes) to a broad range of compounders or formulator industries. Producers of such products can significantly enhance their market penetration and improve customer service by making the right channel management choices and selecting the right channel partners. The authors will provide a distributor selection model, which has been proven in practice for projects around a wide range of products, from (specialty) solvents to adhesive formulations. Selecting the right channel partner can greatly enhance the new business development capabilities of a producer.

A typology of distributors will help to understand the difference between distributors of industrial chemicals (often referred to as "commodities") and specialty chemicals and get insights into the drivers of success for their respective business model.

Conference participants will also learn about typical supplier expectations towards channel partners and the range of customer needs that needs to be addressed, in order to develop sustainable business relationships. Insights will be given into what constitutes a good supplier distributor relationship and what makes a supplier attractive to a distributor.

DR SIVA BOHM

CTO Talga Technologies Ltd, Cambridge, UK &
Royal Society Industrial Fellow – University of Cambridge, Cambridge, UK

Dr Sivasambu Bohm received his first degree in Berlin in Chemical Engineering and a M.Sc. at Hahn Meitner Institute in Berlin. After gaining his PhD at the University of Bath in the field of Chemistry, he worked at different academic institutions; University of Swansea, TU Delft, the University of Birmingham & India Institute of Technology, Bombay. Siva has 16 years of industrial experience (Tata) in various research fields; metallurgy, protective coatings, energy storage in automotive industry, functional and smart coatings and various aspects of nanotechnology, including synthesis and applications of graphene.

Since 2016, Dr Bohm works as Chief Technology Officer at Talga Technologies Ltd, Cambridge UK (previously, Talga Germany), where he is focussing Swedish ore into few layer graphene. He is responsible for developing and implementing a number of graphene, graphite & ore based products at commercial scale.
Dr Siva Bohm has 26 patents and has written over 90 scientific publications and is a member of Royal Society of Chemistry with a charted chemist status and Fellow of Technical of Surface Coatings & Oil and Colour Chemist Association. In addition, he is reviewer for several peer-reviewed journals. Siva has been awarded the Royal Society Industry Fellowship (part time) at University of Cambridge at Cambridge Graphene Centre.

Commercial development of graphene based coatings and composites

S. Bohm[1, 2]*

1 *Talga Technologies Ltd, Cambridge, UK, www.talgaresources.com, *corresponding author: Siva.bohm@talgatechnologies.com*
2 *Cambridge Graphene Centre, Cambridge, UK*

Graphene with its impermeability, high specific surface area and conductive nature can replace currently used toxic anticorrosive pigments in coating systems for automotive, aerospace and construction applications[1-4]. Using graphene & graphene oxide in commercial products is hindered by the lack of availability of cost effective high-quality graphene and difficulty of effective incorporation (functionalisation and dispersion) into coating systems. On overcoming these factors, coatings & composites may prove to be significant demand drivers for graphene in terms of volume consumption.

Graphene, produced from industrially scalable and cost effective top down routes (electrochemical, chemical and mechanical exfoliation processes), can be chemically tuned for incorporating into protective coatings and composites.

In this presentation, some recent progress of development carried out by Talga in independent laboratories and commercial product development will be discussed.

Keywords: Graphene industrial scale up production, anti-corrosion, multi metals protection

References:
[1] S. Bohm, Graphene against corrosion, *Nature Nanotechnology*, **2014**, 9, 741–742.
[2] S. Bohm et al., Functionalised graphene as a barrier against corrosion, *FlatChem*, **2017**, 1, 11-19.
[3] S. Bohm et al., Liquid phase high shear exfoliated graphene nano-platelets as counter electrode material for dye-sensitized solar cells, Journal of Colloid and Interface Science, **2017**, 499, 9–11.
[4] S. Bohm et al., Graphene-based anticorrosive coatings for copper, RSC Advances, **2018**, 8, 499-507.

Scientist
Nanocyl S.A, Sambreville, Belgium

Aida Nasiri is a scientist within the technology and innovation department at Nanocyl S.A. (Sambreville, Belgium). She got her Master degree of Chemical Engineering, dedicated to the preparation of nanofluid from carbon nanostructures for optimisation of energy in drilling fluid, in 2011 at Technical Faculty of Tehran University (Iran). She has developed safe-by-design nanocomposites for packaging application during her PhD thesis on process engineering at Montpellier University (France) and graduated in 2017.

DR AIDA NASIRI

Synergy of carbon nanotubes with silica and / or carbon black in rubber formulation, specific insight on tire application potential

A. Nasiri[1], V. Lison[1], A. Rul[1], M. Hurtgen[1], M. Claes[1]*
*1 Nanocyl S.A., Sambreville, Belgium, *corresponding author: aida.nasiri@nanocyl.com*

New specifications and requirements in mining, aeronautic and automotive industries lead to new products with higher mechanical, thermal and dynamical properties. Existing solutions (fillers and additives) are nowadays somehow limited and do not allow to reach new targeted properties in term of electrical conductivity, mechanical (high loadings of reinforcing fillers are generally requested, leading to not sufficient mechanical properties) and thermal properties (heat resistance and dissipation are essential for in-use parts).

Carbon nanotubes (CNTs) are cutting edge fillers that promote enhancement of rubber performances. Thanks to their high aspect ratio, very low loadings of CNTs are required to reach improved mechanical properties. The innovative concept brought shown in this technical presentation proposes to combine fillers with different shapes. Indeed, the reduction of reinforcing filler - working in synergy with carbon nanotubes - improves significantly the properties that are critical in harsh environment. HT/HP, rapid gas decompression, dynamic properties will be investigated for various rubber materials. In addition to electrical conductivity, CNT also impart thermal dissipation, resistance to heat resistance and chemical swelling, leading to a longer life and temperature of use of the final product.

Together with the growing use of CNTs in industry, their behavior is now better understood and mastered. We will review in this talk how CNTs and NC7000 in particular is acting in synergy with silica and / or carbon black to enhance mechanical properties of elastomers and in particular when targeting tire applications.

CARSTEN GLANZ

Group manager
Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Stuttgart, Germany

Group manager for application of functional materials. He is specialised in the development of printed electrodes with functional materials for the using in sensors, harvesters and energy storage applications.

Since 2007 he leads several founded projects in the field of material-reinforced printed electrodes for automotive and space applications. He is also focused on development and research activities in respect to high reproducibility and long term stability of materials, products and processes. The aim of his development is to transfer lab-scale solutions to industrial applicable applications.

Printed functional layers for the use in connected car applications

C. Glanz[1], L.Boonen[1], I. Kolaric[1]*

1 *Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Department of Functional Materials, Stuttgart, Germany, *corresponding author: Carsten.glanz@ipa.fraunhofer.de*

Autonomous driving and connected cars will stimulate a rising demand on novel sensor, harvester and energy storage systems. Besides car-to-car communication, new systems for integration of electronic components in cars need to be developed. These technologies can be basically printed and applied by robots during the paint shop. In order to circumvent the use of rare resources such as gold or silver, synthetic carbon materials such as graphene or graphene-Nanoplatelets can be used. The influence of the variation of geometrical and electrical properties of the electrode on the sensing performance will be examined. Within this research printed multilayer systems are applied directly on automotive skins, used as an invisible proximity sensor. The working principle of these sensors is based on capacitive sensing, where the distance of the object is measured by changes in the electrical field of the carbon electrode when an object approaches.
To manufacture the sensors screen printing and spray coating is used. These are highly automated printing processes that can be employed into the paint shop process. In addition, this method is used due to its high productivity and reproducibility as well as realizing robust multilayer coatings.
Furthermore the sensor is covered by state-of-the art automotive paint. The technology is shown by a demonstrator.
During the talk the different layouts, production methods of sensors and varnish, evaluation of sensor signals and transfer to other applications will be shown.

Keywords: Stretchable electronics, printed sensors, screen printing, human machine interface, automotive paint, invisible sensors

Topics:
- Application of structured layers on car bodies
- Design of multi-layer based on properties of primer and varnish
- Evaluation of sensor signals and encapsulation
- Transfer to other applications

JOHANNES HOFMANN

Innovation R&D Engineer, Technical Project Leader
Department Advanced Electronics & Materials – Team High Performance Materials
Business Unit Transmission – Continental, Nürnberg, Germany

Johannes Hofmann received his Master of Engineering in chemical and process engineering in 2013 from Technical University Nuremberg. Since 2014 he has been working as a research & development engineer for the materials & packaging department at the Transmission Business Unit of Continental.

In May 2016, he joined the team High Performance Materials as an innovation engineer within the Advanced Electronics and Materials department. His major focus is to research and investigate promising innovative and functional materials and evaluate their possible application in automotive products.

Innovative materials vs. automotive requirements

J. Hofmann[1], S. Porscha[1], B. Schuch[1]*
1 Continental AG, Business Unit Transmission, Nürnberg, Germany, *corresponding author: Johannes.3.Hofmann@continental-corporation.com

The Powertrain Division of Continental engages more than 37.000 employees at over 55 locations worldwide. As a partner of the automotive industry, Continental develops and manufactures innovative products and systems for an advanced automotive future by harmonising individual mobility and driving pleasure with driving safety, environment responsibility and economy.

The Powertrain Division has widespread technological and product know-how as well as a broad product portfolio ranging from engine and transmission control units including sensors and actuators to components for hybrid and electric vehicle drivetrains.

The main trends and drivers in automotive industry are digitalisation, infotainment, autonomous driving, safety and electric mobility. Most of these trends have a big impact on the state of the automotive world today, with new requirements, different regulations or complete new products.
Therefore smart & innovative materials and technologies could make differences to provide feasibility and in the end quality to convince internal and external costumers.
First and foremost the common innovation drivers like new functions with higher performances, size and weight reduction as well as increased reliability represent important goals during the evaluation of innovative materials. For this reason, nanomaterials like graphene or carbon nanotubes (CNTs) with their unique material properties like high thermal and electrical conductivity, chemical robustness and mechanical durability are considered to be the next future high performance materials in automotive applications.
Nevertheless, in the end innovative materials and technologies also have to fit into automotive "environments" which are mainly driven by cost, manufacturability and quality beside unique selling points.
On the one hand, it is necessary to communicate and spread these industry requirements and expectations, but on the other hand it is important to consult the research and development community from the beginning to achieve a proper understanding, get similar expectations and a common target.

The presentation will illustrate the automotive world´s interest in innovative and functional materials (like graphene and CNTs) with some examples, in order to show up potentials and obstacles like some gaps between producers, material processing and end users.

Chair for Ageing and Reliability of Batteries
Helmholtz- Institute Münster, IEK-12, Forschungszentrum Jülich, Jülich, Germany

PROF. EGBERT FIGGEMEIER

Since 05 / 2016	Professorship at RWTH-University Aachen and group leader at Helmholtz- Institute Münster “Aging and Reliability of Batteries”
2012 - 2016	Senior application engineer for battery materials at 3M Germany, Neuss
2007 - 2012	Lab Head and Manager at Bayer Technology Services, GmbH, Leverkusen, Germany
2004 - 2007	Group leader and Treubel Foundation Fellow at the University of Basel, Switzerland
2001 - 2004	Researcher and Marie-Curie-Fellow at the University of Uppsala, Sweden
1998 - 2000	Post-Doc at Dublin City University, Dublin, Ireland and at University of Basel, Switzerland
1998	PhD in Physical Chemistry at University of Paderborn, Germany
1996	Diploma in Chemistry at University of Paderborn, Germany

Carbon nanotubes in batteries – benefits, hurdles and applications

*E. Figgemeier[1,2]**

1 *Helmholtz-Institute Münster, IEK-12, Forschungszentrum Juelich GmbH, Jülich, Germany *corresponding author: e.figgemeier@fz-juelich.de*
2 *RWTH University Aachen / Institute for Power Electronics and Electrical Drives, Aachen, Germany*

Research and development in the field of battery technology is currently one of the most important areas of activity for enabling electrified mobility and finding solutions for fluctuating electricity supply from alternating renewable resources. A multi-billion dollar market has evolved with high growth rates for the next decades. In this context, extensive studies on carbon nanotubes in battery electrodes during the last decades have beenperformed and the benefits of high conductivity combined with mechanical strength were demonstrated in the scientific literature. In Lithium ion batteries, CNTs are beneficial for the electrical conductivity in electrodes, which enhances the rate capability combined with charge / discharge cycle stability when added by a few weight percent. Mechanical superiority of CNT modified electrodes are particularly pronounced in metal alloy electrodes for next generation Silicon-based Lithium ion battery anodes, which have much higher energy capacities than current state-of-the-art battery cells, but have issues with mechanical work during charge / discharge cycling.

Nevertheless, practical applications of CNT in commercial batteries are rather the exception than the rule. This is caused by several factors including costs, difficulties in electrode slurry making and health concern. The presentation will analyse the benefits of CNT in battery applications and will put it into the context of commercial products. Furthermore, the future prospects of CNT in energy storage applications will be outlined.

DR PASCAL BOULANGER

COO and Chairman of the Board
NawaTechnologies S.A., Aix en Provence, France

Pascal Boulanger (52) is a graduate engineer (ENSEA), post-graduate diploma (Supelec), doctor of physics (Paris Sud-Orsay University) and MBA graduate (HEC business school, Jouy-en-Josas).
He has been a research engineer at the CEA since 1993. He has conducted researches in a variety of fields, including nuclear energy (1989-1998) and solar energy (1998-2003), integration of renewable energies into electrical power grids (2001-2003) and nanosciences (2005-2013). He is a senior expert in photovoltaic solar technology. He has held management posts during his career, ranging from laboratory manager of a 10-member group to deputy scientific manager with a staff of 650. He has been a European project coordinator and played an active part in the development of innovation funding and technology transfer projects sponsored by BPI-France (2003-2005). He has participated in a large number of collaborative projects (FP5, FP6, FP7, ANR, ADEME, A2I, regional projects, ASTRE, RTRA, and others).
He is founder of NAWATechnologies SA, a start-up issued from CEA, whose goal is to industrialise and engineer new materials for energy, transportation and environment ground-breaking applications. Pascal is now Chief Operating Officer and Chairman of the Board.

Open Innovation: Manufacturing and functionalisation of VACNTs as electrodes for supercaps

P. Boulanger[1]

1 *Nawatechnologies, Aix en Provence, France, *corresponding author: pascal.boulanger@nawatechnologies.com*

Vertically Aligned Carbon NanoTubes (VACNT) have demonstrated outstanding potentialities as novel material to prepare nanostructured composite or multifunctional materials. Nawatechnologies has brought VACNT into mass production throughout 2016 and 2017.
In this contribution we will describe the VACNT synthesis Roll-to-Roll (R2R) process and its latest results from the manufacturing floor.
The carpets of VACNT, synthesised on aluminum rolls are used as the current collector of Nawatechnologies' ultracapacitor (Ucap). The highly anisotropic structure of the carbon nanotubes carpets allows for extremely high-power densities which will be described.
Further to the advancement of Nawatechnologies' own industrialisation and commercialisation of its high power Ucap product, the company wishes that nano-making technology receives a broad market acceptance on one side and that VACNT based applications go beyond the making of Ucap electrodes.

In that context Nawatechnologies invites other industrial parties to join its Open Innovation Network to reduce the technology and manufacturing barriers of structural batteries ranging from flat structures for automobile / aerospace applications (where the housing of today's batteries becomes the composite electrode of a structural battery) to cylindrical structures for O&G / subsea applications under extreme conditions. The first proofs of concept of structural batteries and substrate free prototypes will be shown.

The company opens the door to its manufacturing line and R&D lab for an inter-company, collective work which can range from an entry level "come to see" up to "enlarge your portfolio". Albeit there are unmistaken commercial interests, the main scope is and will remain the proliferation of VACNT based applications and their quick fan-out to the market place. At the time of writing this abstract it is not yet known if the names of already existing partners can be revealed by the date of the conference, if so, they will.

ULF KÖPKE

Research and Innovation Manager
EXAKT Advanced Technologies GmbH, Norderstedt, Germany

Career:
University of Applied Science of Wedel
University degree in Physical Engineering
Scientific Assistant, Advanced Ceramic Group (TUHH)
  Investigation of piezoceramic and crack opening displacement
  by Scanning Force Microscopy
Application scientist for technical sale of
  Veeco Instruments GmbH
Integrated Dynamics Engineering
  Development and Design of
  Equipment Front End Module for Wafer

Synergetic effects during material development with processing machines

Ulf Köpke[1], Hauke Meeuw[2]*

1 *EXAKT Advanced Technologies GmbH, Norderstedt, Germany, *corresponding author: ulf.koepke@exakt.de*
2 *Hamburg University of Technology / Institute of Polymer and Composites, Hamburg, Germany*

Three roll milling technology is established for dispersion of carbon based nano particles. However, dispersing of these particles and the application-specific development of suspensions is a complex task. Development of complex suspensions can be facilitated by further development of processing machines.

Improvement of sensor technologies and their integration in the process for data acquisition is an important step. For an analysis of the obtained process data, a comparison with measurement data of established characterisation systems, outside the processing, is necessary. Due to the similarity of the dispersion process in three roll mills and the rheological characterisation, comparisons are possible from the online acquired data.

In this study, the possibilities are presented using two different MWCNT and different functionalisations.

Acknowledgment: to the Federal Ministry of Economic and financial support, our project partners and the TUHH for the cooperation over the last years.

DR VALÉRIE LISON

Polymer Dispersion Technology Manager
Nanocyl S.A, Sambreville, Belgium

Valérie Lison, as polymer dispersion technology manager, is involved in technical support and developments for customers. She joined Nanocyl S.A. (Sambreville, Belgium) in 2013 and is working within Technology and Innovation department with expertise in the field of carbon nanotube dispersion into polymer nanocomposites. She holds a master degree in chemistry with a specialisation in materials science from the University of Mons (Belgium), a PhD thesis in polymer chemistry dedicated to the development of new bio-based materials at the Laboratory of Polymers and Materials Sciences (LPMC - University of Mons), and followed by experience as postdoctoral in the same laboratory in the development of functional and adaptive coatings.

Optimisation of production of polypropylene / MWCNT composites

V. Lison[1], N. Kchit[1], M. Hurtgen[1], M. Claes[1]*

1 Nanocyl S.A., Sambreville, Belgium, *corresponding author: valerie.lison@nanocyl.com

In polymer nanocomposites containing carbon nanotubes (CNT), the critical challenge remains to manage the dispersion of CNT in most of thermoplastics resins, in terms of size and number of agglomerates. Indeed, it is quite obvious to achieve the percolation threshold above a critical filler volume fraction which coincides with the formation of a conduction network of filler particles in the continuous polymer phase. However, despite intensive studies on this field, the higher level of CNT's dispersion required by a growing number of applications in various industries has not yet been reached. It is typically the case, for example, in melt spinning process or some applications with very strict specifications in terms of surface aspect in automotive sector.

In this work, the research will be focused on processing parameters during melt mixing in twin-screw extruder to achieve a disentanglement and uniform dispersion of CNT. It includes feed method of CNT (through a masterbatch or by direct compounding at the targeted CNT content), feed position, screw profile, feed rate, screw speed, profile temperature, residence time, filling degree. The relationship between these tailored parameters and the achieved effective dispersion of CNT will be monitored through an optical control evaluation, combined with calculations of agglomerate area ratio (A/A0), electrical resistivity and rheology measurements. Additionally, the specific mechanical energy (SME) involved on each extrusion runs will be correlated with achieved results for the operating parameters.

The strategy is to develop the expertise on a commodity thermoplastic with a high consumption and a large variety of applications. That is why polypropylene was an ideal choice for this study. Moreover, this nonpolar partial crystalline polymer is a perfect challenging choice for a case study since it is well reported in literature that it is quite more difficult to disperse nanotubes in this material as compared to amorphous polar polymers like polycarbonate. Different grades will be evaluated to highlight the influence of resin's viscosity on wetting step through melt infiltration, and will be correlated with melt mixing parameters.

LAURA BOONEN

Project manager
Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Stuttgart, Germany

Research assistant and project manager in the area application of functional materials. She is specialised in the development of printed electrodes with functional materials for the use in energy storage and sensor applications.

Since 2015 she works at Fraunhofer IPA on several funded projects in the field of electrodes for energy storage applications.

Digitalisation in electrode manufacturing – towards more efficiency in joined research and small lot size production

L.Boonen[1], P.Kitzler[1], C.Glanz[1], I.Kolaric[1]*

1 *Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Department of Functional Materials, Stuttgart, Germany, *corresponding author: Laura.Boonen@ipa.fraunhofer.de*

Today's research projects often start from scratch when they investigate new materials or new production processes even if very similar experiments have been already conducted elsewhere.
To make research results available beyond a single research project the use and exchange of already established knowledge has to become more efficient. Therefore it is necessary to acquire research data more continuously and to manage it more standardised. An essential component for the continuous data acquisition is the automated monitoring of process parameters during experiments via so called digitalised processes. This leads to a data base that is constantly expanded and can be shared or exchanged partially with other research partners.

Within the project DigiBattPro researchers at Fraunhofer IPA are investigating the potential of such a continuous data tracking system exemplarily within the battery manufacturing process. Therefore experimental process stations are equipped with additional sensors to register process and quality data along the production chain. One of the researched processes is the electrode manufacturing on a roll-to-roll coating pilot line that is installed at the Fraunhofer IPA. The pilot line includes a slot die coating unit and a combined dryer and its construction is based on standard components. The continuous data acquisition and management throughout the coating process as well as for the upstream processes raw material and mixing is operated via an experiment management system.

Beyond research projects such a continuous data base can be used in industry as well. The IOT and the growing usage of mobile applications require various new battery sizes based on different cell chemistries including the usage of new materials for increased performance. That means the lot sizes of some types of batteries will get smaller. This development makes it more challenging to keep manufacturing quality stable and set-up time down, while sizes and materials need to be changed frequently in production. The entire production has to be more flexible and allow the processes to adapt faster or even enable self-regulation. This can only be realised when all process and quality parameters are continuously tracked during the entire cell manufacturing across separated process steps. Managing these parameters in a joined data base will back the development of process simulation models. The adoption of new materials can then be realised much faster using the already acquired data sets to predict favourable process parameters for material handling.

The holistic digitalised approach that is focused within the project DigiBattPro is supposed to support collaborative research and development with different partners on different places for example via peer to peer research. Based on this new R&D approaches for cost efficient, decentralised, connected funding projects for material and process development can be started.
Furthermore the standardised acquisition of data connected to many different materials can reduce the development costs as well as the set-up time for new materials in industrial production.

Keywords: Battery electrode manufacturing, slot die coating, process data acquisition, digitalisation, coating process

Topics: Introduction to battery manufacturing; overview of pilot coating line; current project situation and first results; outlook to future applications

DR JÜRGEN HEINDL

Manager Analytical Services
JEOL (Germany) GmbH, Freising, Germany

- Manager Analytical Services at JEOL (Germany) GmbH, Freising
- Application Specialist for Scanning Microscopy and Preparation Systems at JEOL (Germany) GmbH, Freising
- PhD in Material Science, Univ. Erlangen-Nürnberg
- Diploma in Physics, Univ. Erlangen-Nürnberg

Characterisation of carbon materials in the electron microscope

*J. Heindl[1]**
1 *JEOL (Germany) GmbH, Freising, Germany, *corresponding author: heindl@jeol.de*

Carbon-based nanostructures have unique properties and are highly interesting for fundamental research as well as for wide variety of technological applications.

As the properties of any material strongly depend on its structure and composition, a precise and accurate characterisation is indispensable. Electron microscopes are important tools which provide various characterisation methods such as high-resolution imaging or energy dispersion X-ray spectroscopy. As such, they can provide a wealth of chemical and structural information. However, the investigation of nanostructures made up of light elements can be rather difficult as they are highly susceptible to electron beam induced damage. With the development of scanning electron microscopes for low voltages as down to only 10 Volt, it is now routinely possible to investigate and characterise beam-sensitive nanomaterials such as graphene and carbon nanotubes. Transmission electron microscopes with advanced corrector system allow single atom imaging in carbon nano tubes or graphene sheets without any beam damage. The development of X-ray-spectrometer which can detect X-rays with only 50 eV at resolution below 0,5 eV allow the observation of chemical reaction e.g. between Li and C during charging and discharging of Li-Ion batteries.

High-end-methods require not only sophisticated instruments but also skilled users. We developed a novel model of flexible access to these techniques: the researcher can choose between the classic way to buy or lease the microscope and spectrometer or to rent the microscope including the highly skilled operator only for the actual project. This allows also for smaller companies or start-ups to use high-end characterisation techniques for their projects. This makes cost control more transparent and the project risks better manageable.

DR DIRK BROßELL

Scientist
Federal Institute for Occupational Safety and Health /
Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA), Berlin, Germany

Since 2009	Scientist at BAuA, Unit 4.5 „Particulate Hazardous Substances, Advanced Materials“
2011-2016	PhD Student at Delft University of Technology. Title of Dissertation: “Instrument Development for Nanomaterial Risk Assessment”. Promoter: Prof. Dr Andreas Schmidt-Ott
2002-2009	Undergraduate in Physics, Free University Berlin, Degree: Diplom-Physiker

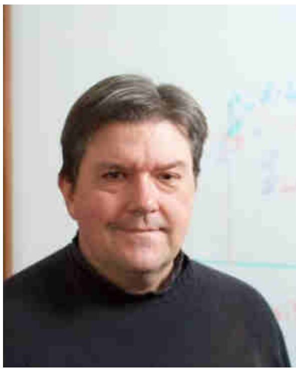
A new risk grouping concept for high aspect ratio materials - the shaker dustiness test

Dirk Broßell[1], Elisabeth Heunisch[1], Sabine Plitzko[1]*
1 Federal Institute for Occupational Safety and Health, Berlin, Germany, *corresponding author: brossell.dirk@baua.bund.de

Introduction
High aspect ratio materials (HARM) like carbon nanotubes (CNT) exhibit material properties that enable innovative applications but also raised concerns about potentially harmful effects to humans due to their asbestos-like morphology. Control banding by grouping of HARM by hazard- and exposure-related properties is a promising approach to risk assessment and risk mitigation for a large family of materials. Limit values enabling a differentiation of HARM with low, moderate or high dustiness as well as information about the dust morphology are necessary for control banding.

Methods
We have developed a dustiness test for powdery HARM, in particular for CNTs. In the Shaker method, a laminar low volume air flow passes through a vertically vibrating powder column resulting in powder fluidisation. Vibration is required to overcome adhesive forces between powder grains that would otherwise hinder fluidisation. The Shaker method combines aerosol monitoring over the dust generation process to determine the emission intensities with simultaneous dust sampling. Subsequent sample analysis by means of scanning electron microscopy (SEM) obtains information about dust morphology.

Results and Discussion
Using a standard operation procedure, we performed dustiness tests on 20 CNTs. The results lead to material rankings based on the emission intensity and the definition of limit values for low, moderate and high dustiness. The SEM-aided morphological analysis allowed us to rank the materials for the propensity to emit individual fibres and their grade of agglomeration. We also measured the diameter and length distributions to identify potential rigid fibres and those matching the WHO-criteria for hazardous fibres. These results are the basis of our proposed new grouping strategy for control banding, which classifies HARM using a risk matrix that considers both intrinsic material and process-related properties such as bio-durability, toxicity as well as dustiness, grade of agglomeration and presence of hazardous WHO-fibres.



PROF. DAVID L. CARROLL

Professor of Physics at Wake Forest University, Winston-Salem, USA
Director of the Center for Nanotechnology and Molecular Materials, Winston-Salem, USA

Prof. David Carroll earned his PhD. in Physics at Wesleyan University in Connecticut (1993) working on the excited state dynamics of charged defects induced in complex metal oxides under electron beam irradiation. His postdoctoral work at the University of Pennsylvania in Philadelphia was under the direction of Prof. D. Bonnell and focused on the application of scanning probes to transition metal oxide surfaces. From UPENN, Dr Carroll joined the group of Prof. M. Rühle at the Max-Planck-Institut für Metallforschung in Stuttgart, Germany where his work centered on the application of scanning probes to interface studies of supported nanostructures. It was at MPI that Dr Carroll obtained a life-long fascination with dimensionality in solid-state physics. Following Stuttgart, Dr Carroll became an assistant professor then associate professor at Clemson University in South Carolina where his work expanded to include organic devices and organic electronics. In 2003, Dr Carroll and his research team moved to Wake Forest University in Winston-Salem NC, to establish a center dedicated to the research and development of electroactive, matrix nancomposites. His research continues to focus on the role of dimensionality in the thermal, electrical, and optical phenomena of nanoscale structures and their mesoassemblies.

Dr Carroll is currently a Professor of Physics at Wake Forest University, Director of the Center forNanotechnology and Molecular Materials at Wake, and a Fellow of the American Physical Society.

Ultrathin, washable, and large-area graphene papers for personal thermal management

Y. Guo[1], C. Dun[2], J. Xu[2], J. Mu[1], P. Li[1], L. Gu[3], C. Hou[1], C. Hewitt[2], Q. Zhang[1], Y. Li[1], D. Carroll[2], H. Wang[1]*

1 College of Materials Science and Engineering, Donghua University, Shanghai, China, wanghz@dhu.edu.cn
2 Department of Physics, Wake Forest University, Winston-Salem, North Carolina, USA, *corresponding author: carroldl@wfu.edu
3 College of Textiles, North Carolina State University, Raleigh, North Carolina, USA

Freestanding, flexible / foldable, and wearable bifunctional ultrathin graphene paper for heating and cooling is fabricated as an active material in personal thermal management (PTM). The promising electrical conductivity grants the superior Joule heating for extra warmth of 42 ° C using a low supply voltage around 3.2 V. Besides, based on its high out-of-plane thermal conductivity, the graphene paper provides passive cooling via thermal transmission from the human body to the environment within 7 s. The cooling effect of graphene paper is superior compared with that of the normal cotton fiber, and this advantage will become more prominent with the increased thickness difference. The present bifunctional graphene paper possesses high durability against bending cycles over 500 times and wash time over 1500 min, suggesting its great potential in wearable PTM.

DR THOMAS J. S. SCHUBERT

CEO
Iolitec GmbH, Heilbronn, Germany

Year of birth: 1970
Studied chemistry at the universities of Karlsruhe und Cologne.

1997	Diplom, University of Cologne, Group of Prof. Dr A. Berkessel: „Modellstudien zur metallfreien Hydrogenase methanogener Archaea”
2001	PhD, University of Cologne, Group of Prof. Dr A. Berkessel, „Katalytische Hydrierungen mit molekularem Wasserstoff in Abwesenheit von Übergangsmetallen – Modellsysteme für die metallfreie Hydrogenase methanogener Archaea”
10/2001 - 03/2003	CTO Solvent-innovation, Cologne
Since 04/2003	CEO, founder at IoLiTec Ionic Liquids Technologies GmbH

(Co-)author of more than 80 papers and conference contributions.

GRAFAT – Graphene for functionalization of advanced textiles – Flame retardancy

Thomas. Schubert[1], S. Plebst[1]*
1 *Iolitec GmbH, Heilbronn, Germany, *corresponding author: plebst@iolitec.de*

The GRAFAT-project is a bilateral (Belgium and Germany) European-funded project with the aim of developing graphene functionalised textiles for flame retardancy and electrical conductivity. The presentation will focus on the German partners and the approach of flame retardancy.

Current state of the art flame retardants are either toxic upon decomposition or of heavy weight, sometimes even both. While common carbon allotropes might not be the most optimal solution, the carbon allotrope graphene shows a quite promising behavior. The hexagonal structure of graphene with its strong C-C-bonds has, depending on the atmosphere, a decomposition temperature of above 400°C. Its platelet structure, which is acting as an effective barrier for reactive gases, protects coated materials in an efficient way. In addition, graphene contains only the non-toxic element carbon and will decompose completely to CO_2. Furthermore, it is one of the materials with the lowest weight. Due to these special properties of graphene several research groups demonstrated a flame retardant behavior in different polymer matrices.
While the theoretical properties are more than promising, one of the major drawbacks is the high tendency to form agglomerates, finally resulting in a multi layered graphite-type species. Besides the strong tendency to form agglomerates the strong hydrophilic character causes many problems in the often water based coating processes.

Within this project IOLITEC, known as a company skilled in the production and stabilisation of dispersions, had the task to overcome the issues of agglomeration and negative interaction with most ionic / polar solvents, to obtain an optimal manufacturing process and highest possible performance.

In our contribution we will present our most prominent results, in particular that water based and even solvent-free processes can be achieved by applying our techniques. By using them it is possible to achieve coatings, which enhance flame retardant properties of fibers such as aramid, or to achieve a flame retardant character of fibers, like PES/CO (Polyester/Cotton).

Acknowledgements: BMBF / EU EraNet, Hohenstein, Centexbel, Soieries Elite, Fuchshuber TechnoTex GmbH.

DR FELICE TORRISI

Lecturer in Graphene Technology
University of Cambridge, Cambridge, UK

Felice Torrisi is a University Lecturer in Graphene Technology at the University of Cambridge and Fellow of Trinity College, Cambridge.

He obtained his PhD in Engineering from the University of Cambridge before being elected Schlumberger Research Fellow at Darwin College. His research pioneered the area of wearable electronic textiles and printed electronics with graphene and two-dimensional materials where he contributed with more than 50 publications and 4000 citations.

His current research interest moves towards nanomaterials for wearable and textile electronics for healthcare and sportswear applications.

Graphene and two-dimensional material inks enabling printed and wearable electronics

*F. Torrisi[1]**
*1 Cambridge Graphene Centre, Engineering Department, University of Cambridge, UK, *corresponding author: ft242@cam.ac.uk*

Graphene and related materials (GRMs) hold great potential for flexible (opto)electronics for their novel electrical, optical and mechanical properties. Low temperature production and deposition of GRM-based inks is extremely attractive for large-area printable, stretchable and wearable (opto)electronics. GRM inks enable a large range of device fabrication and integration options, such as digital and lithographic printing, roll-to-roll coating, as well as being ideal for embedding into polymer composites or other nanomaterials. Liquid Phase Exfoliation (LPE) of bulk precursor layered materials (such as graphite, MoS_2 crystals, etc.) is a scalable approach ideally suited to produce inks.

However, currently LPE has low yield, resulting in a low concentration of dispersed GRMs. I will give a brief overview about the development of high-yield, cost-effective and large-scale production techniques for GRM-based inks, and the portfolio of reproducible manufacturability processes enabling future GRM-based printable and flexible (opto)electronic devices and composites. I will first demonstrate cost-effective, up-scalable production of high concentration graphene inks with tailored properties (on-demand size, shape, number of layers and concentration).[1] Then I will show how careful tuning of the flakes-substrate surface interaction and GRM printing process enables stretchable electronics and smart textile devices with sensors and interconnections with up to 20 % uniaxial strain [2] as well as all printed h-BN / graphene transistors and integrated circuits on cotton and polyester textiles with mobility > 100 $cm^2\ V^{-1}\ s^{-1}$.[3] Finally, I will present my vision on manufacturability of flexible and wearable electronic and optoelectronic devices embedding the optical, electronic, mechanical and thermal functionalities of graphene, 2D crystals and their hybrid hetero-structures.

References:

[1] F. Torrisi, et al. Electrifying inks with 2D materials, *Nature Nanotechnology*, **2014**, 9, 738-739.
[2] J. Ren, et al. Environmentally-friendly conductive cotton fabric as flexible strain sensor based on hot press reduced graphene oxide, *Carbon*, **2017**, 111, 622-630.
[3] T. Carey, et al. Fully inkjet-printed two-dimensional material field-effect heterojunctions for wearable and textile electronics, *Nature Communications*, **2017**, 8, 1202-1212.

BERNHARD MÜNZING

Sales Director
The Sixth Element (Changzhou) Materials Technology Co, Ltd, Changzhou, China

Educated as Economic Engineer (Wirtschaftsingenieur) Bernhard Münzing (57) started his career at BASF selling fibre reinforced prepreg-systems mainly to the aerospace and sports industry. He then joined L. Brüggemann, a medium sized chemical company, with the responsibility for materials management (purchasing and logistics) and introduction of new products to the market. After short period as Sales Manager for a small paint company producing varnish for painters, he worked for more than 17 years for GELITA, the world leading gelatine manufacturer. Covering all potential applications areas for gelatine – food, pharma and technical – he helped customers to adopt the gelatine product during the critical phase of the BSE disease, followed by a position in business development for more than 10 years. This included the introduction of a new product line to the food market, establishing a new production technology for a special gelatine and launching gelatine based formulations into the metal processing industry (mainly aluminium). Aside that, he was responsible key account manager for one of the largest GELITA customers in Asia.

Since July 2016 he is with The Sixth Element, a leading supplier of different graphene products responsible for all markets outside China with focus on EMEA region.

Industrial usage of graphene in coatings: enhancing corrosion protection

*B. Münzing[1]**

1 The Sixth Element (Changzhou) Materials Technology Co, Ltd, Changzhou, China *corresponding author: bernhard.muenzing@thesixthelement.com.cn

Graphene, theoretically the atomic layer of graphite, can now be produced on large industrial scale. Most of these processes generate few layer graphene. This sets the focus on how graphene can be incorporated into real industrial applications. The Sixth Element has established a proprietary process to manufacture different types of graphene with specific designed properties for different applications.

Research on how to use graphene in coatings started already 2013 with the focus to reduce zinc in solvent based corrosion protection coating systems. In standard primers with high zinc content, zinc acts as cathodic sacrifice layer, as zinc is more ignoble metal, therefore protecting the underlaying metal substrate. When the zinc is more and more oxidized, the resulting zinc oxide is building up a barrier, which prevents the attack of the surrounding media (water, salt) auf the metal substrate. The idea now was to design a graphene type, being electrical conductive enough to support any cathodic function of the system and being able to act as a barrier without producing a battery cell. A further requirement was that such a graphene can be processed with standard equipment used in the coating industry.

Cooperating with an industrial partner in China, Toppen Co, the graphene type SE1132 was developed. It is a few layer graphene (maximum 15 layers) with a medium conductivity. Addition of 1 % SE1132 to an epoxy primer system and reducing the zinc content to 25 % (based on dry substance) did show significant improvements in salt spray testing and water condensation testing compared to a standard zinc rich epoxy primer. The results have been confirmed by measuring the corrosion current of such a system. The 1 % addition shows the lowest current. In China Sixth Element has received a patent for this development. Based on independent tests of Chinese authorities the system containing 1 % graphene (based on dry substance) is approved for off-shore applications. The system was first applied to protect the steel construction of an off-shore wind energy tower in 2015. Meanwhile more off-shore projects have used this system. Contrary to this, in Europe the development of such systems is in the prototyping stage.

Also in water based systems, results of prototypes show that graphene enhances corrosion protection significantly.

Short Pitches

1. W. Maser, Instituto de Carboquímica, (ICB-CSIC), Zaragoza, Spain, wmaser@icb.csic.es.

2. M. Morais, Fraunhofer Institute for Chemical Technology ICT, Pfinztal, Germany, manuel.morais@ict.fraunhofer.de.

3. K. Kunz, Leibniz Institute of Polymer Research Dresden e.V. (IPF), Dresden, Germany, kunz@ipfdd.de.

4. C. Fink, PerkinElmer, Rodgau-Jügesheim, Germany, claudia.fink@perkinelmer.com.

5. T. Schubert, Institute of Chemical Process Engineering and Plant Design, TH Köln, Köln, Germany, tim.schubert@th-koeln.de

6. T. Takatsuka, Thinky Corporation, Tokyo, Japan, s.kapahi@c3-analysentechnik.de.

7. G. v. Kerckhove, OCSiAl Europe, Leudelange, Luxembourg, gunther.van.kerckhove@ocsial.com.

8. J. Blanco Villalba, Fraunhofer Institute for Chemical Technology ICT, Pfinztal, Germany, jose.blanco@ict.fraunhofer.de

9. D. Nemec, Fraunhofer Institute for Manufacturing Engineering and Automation IPA, Germany dominik.nemec@ipa.fraunhofer.de

10. *Slot for a short pitch available - apply now!*