# COOPERATION IN PLASMA AND MATERIAL SCIENCES

## FACULTY OF SCIENCE, MASARYK UNIVERSITY
## 3RD – 5TH FEBRUARY, 2015

**bld. 1 – conference room**

# FINAL PROGRAMME:

## FIRST DAY: FEBRUARY 3RD

**14:00 Opening and welcome lecture given by Prof. Mirko Černák – the director of CEPLANT: Welcome notes, Presentation of the Department of Physical Electronics and CEPLANT**

**14:50** coffee break (10 min)

**15:00 Dr. Dušan Kováčik** (CEPLANT): *High-speed, Low-cost Industrial Ambient Air Plasma Sources for In-line Large Area Surface Treatments*

**15:30 Laboratory visit 1:** optical methods for surface analysis laboratory and plasma-chemistry laboratory

**16:30** networking

**18:00** dinner in Czech restaurant

## SECOND DAY: FEBRUARY 4TH

**09:00 Laboratory visit 2:** Magnetron laboratory and tribology laboratory

**09:45** coffee break (15 min)

**10:00 Mr. Kenneth Epstein:** *Introduction to Cross-border Strategic Partnerships, Funding, and Licensing (focus on comparisons between Europe and China, Japan, and US)*

**10:55 Dr. Marcin Hołub:** *Electrical modelling and efficient supply systems for atmospheric pressure plasma sources*

**11:25 Dr. Jürgen M. Lackner:** *Advanced surface functionalization by vacuum coatings for tribological protection of fiber-reinforced polymers and for controlled biological interaction of implants*

**11:55** lunch

**14:00 Dr. Tirumalai Sudarshan:** *Strengths and Capabilities in Materials Science of MMI*

**14:30 Dr. Johanna Lahti:** *Nanoscale surface modification and barrier coatings for packaging materials*

**15:00** coffee break (15 min)

**15:15 Mr. Olivier Beier:** *Innovent e.V. - a non-profit, industrial research association from Thuringia / Germany*

**15:35 Dr. Kerstin Horn:** *Novel possibilities for creating functional layers using atmospheric pressure plasma CVD*

**16:05** networking

## THIRD DAY: FEBRUARY 5TH

**09:00 Laboratory visit 3:** XPS laboratory and MALDI laboratory

**09:50** coffee break (10 min)

**10:00 Dr. Radovan Tiňo:** *The use of atmospheric low-temperature plasma for the treatment of wooden surfaces*

**10:30 Dr. Joanna Pawlat:** *Application of atmospheric pressure plasma for surface decontamination*

**10:50 Dr. Camelia Miron:** *Surface modifications of polymers treated by pulsed electrical discharges in liquids*

**11:20** end of the workshop

# ABSTRACTS:

## *Introduction to Cross-border Strategic Partnerships, Funding, and Licensing (focus on comparisons between Europe and China, Japan, and US)*

### Mr. Kenneth Epstein, Principal, NewCap Partners Inc.

**focused on US/Global Cleantech/water, Energy, Advanced Materials, and Life Sciences/Healthcare M&A and Strategic Partnering Projects**

To help companies maximize their financial and business position, Ken brings an extensive experience in assessing global companies and technologies in numerous markets including advanced materials, life sciences/healthcare, aerospace/defense, Cleantech/water, and energy to determine investment opportunities and in selecting and negotiating acquisitions, divestitures, joint ventures, and strategic alliances. Areas of expertise include:

| | |
|---|---|
| Mergers & Acquisitions/Divestitures | Strategic Alliances/Strategic Planning |
| Corporate Equity Financing | Financial Management/Planning/Funding |
| Program/Project Management | Business Development |
| Market and Value Chain Analysis | Innovative Problem Solving |

**<u>PROFESSIONAL EXPERIENCE</u>**

**<u>NewCap Partners Inc. (Private Investment Banking Firm)-Principal</u>**

Ken is a registered principal at NewCap Partners with focus on mid-cap/micro-cap ($3 million-$100 million) M&A, Financings, and Strategic Partnering transactions. He has more than 25 years of international investment banking and corporate venture management experience, including selling and buying companies, negotiating global marketing and production alliances and joint ventures, as well as providing advisory services for strategic planning, acquisition and valuation. . Diverse client base has included small, midcap and private high-tech and life science companies, as well as global multibillion dollar corporations (e.g. Dow and Teijin), private equity, and venture capital funds.

For the last ten years, he has focused efforts on M&A activities in the advanced materials (composites, nanotechnology biomaterials, ceramics, chemicals, metals, plastics, and additive manufacturing), healthcare/life science, Cleantech/water, and energy areas with an increasing emphasis on North America/China and US/China/Japan. He has been doing global strategic partnering in Europe, China, Japan, and Southeast Asia since the late 1980's, first at Dow Chemical (based in Singapore and in the USA), and then for NewCap clients. He continues to be the lead NewCap principal to work with multinational corporate venture groups and corporate venture associations.

**<u>Dow Chemical Company-U.S. Brazil, Argentina, Singapore, Malaysia</u>**

Ken started his global, multi-functional career with the Dow Chemical Company. After several years in R&D and Sales, he spent the majority of his Dow career as a corporate venture manager involved with global companies and technologies in the advanced materials/composites, energy (fuel cells, solar, lignite), aerospace/defense, Cleantech (water, biomaterials, solar, wind, fuel cells) and construction areas.

**<u>Education</u>**

Ken holds a MBA in International Finance from the University of Michigan and a BS in Chemical Engineering from the University of Rhode Island.

## *Electrical modelling and efficient supply systems for atmospheric pressure plasma sources*

### *Dr. Marcin Hołub*

Vice dean for Organisation and Development

WEST POMERANIAN UNIVERSITY OF TECHNOLOGY, Electrical Engineering Faculty, ul. Sikorskiego 37, 70-313 Szczecin

- types and waveforms of atmospheric pressure plasma systems supply
- DBD reactor electrical modelling and power consumption estimation
- power electronic supply sources for sinusoidal DBDs
- pulsed power electronic supplies.

## *Advanced surface functionalization by vacuum coatings for tribological protection of fiber-reinforced polymers and for controlled biological interaction of implants*

***Dr. Jürgen M. Lackner***

JOANNEUM RESEARCH Forschungsges.m.b.H., Institute of Surface Technologies and Photonics, Functional Surfaces, Leobner Strasse 94, A-8712 Niklasdorf, Austria

At JOANNEUM RESEARCH, a new coating technology based on high vacuum deposition was established in the last years, which requires a maximum substrate temperature resistance of 100°C and is easily available on industrial scale for job lot coating. The basis for the application of such low deposition temperatures is a combination of adjusted ion plasma pretreatment of the substrate surface and functional multilayered, nanocomposite coatings. Application of these thin films in the tribological protection of carbon fiber composites (CFC) and for functionalizing medical material surfaces will be addressed in this talk:

CFC is an optimal structural light-weight design material due to their high specific strength, low thermal expansion and high vibration damping capability. However, their resistance to wear is low, which limits functional tribological applications of CFCs, like for guideways, bearings and cogwheels. Even a coating of CFC with long-term tribological protection is difficult due to the low thermal resistance (generally <180°C), because standard industrially-applied processes require at least 250°C heat durability of the substrate. However, the biomimetic, nacre-based design of recently developed chromium/chromium-nitride multilayer coatings prevent early cohesive film failure and introduces plastic deformation in the nano-scaled material. Toughness optimization of nanocomposite Cr-doped diamond-like carbon top layer materials lead to a narrow range of possible nanocrystalline Cr-C to amorphous a-C:H:Cr phase ratios. Finally, coatings with dry friction coefficients <0.15 and wear rates at ~0.8 GPa Hertzian pressure on CFC were developed, which are comparable to low-alloyed steels.

Surface modification of implanted materials offers a great variety of possibilities for adjusting the biocompatibility and the interaction to the biological surrounding. Deposition of thin films with several nanometers to micrometers thickness enables physical (e.g. roughness, mechanical properties, etc.) and chemical modifications (e.g. chemical and phase composition, adsorption of functional groups, etc.) of the surface, influencing strongly bacteria, cell and tissue interaction. Examples for improving the hemocompatibility of elastomers will be shown for cardiovascular implants (“artificial heart”). Antibacterial behavior and increased osteoconductivity modification will be presented based on investigations for next generation bone implants (plasma-polished and coated screws/plates for osteosynthesis elements and artificial lumbar discs). Finally, the presented work will enlighten the basics for combining cytocompatibility and semi- and non-permeable thin films for implanted sensors.

## *Nanoscale surface modification and barrier coatings for packaging materials*

***Dr. Johanna Lahti***

*TAMPERE UNIVERSITY OF TECHNOLOGY, Korkeakoulunkatu 10, FI-33720 Tampere, Finland*

PlasmaNice was a four-year project funded by the EU FP7 Programme in the context of the NMP (Nanosciences, Nanotechnologies, Materials and new Production Technologies). The main objectives were to develop sustainable packaging materials and to combine and integrate state-of-the-art in atmospheric plasma technology, sol-gel chemistry and extrusion coating of bio-based materials. Atmospheric plasma techniques as processing methods have a number of advantages which include for example a possibility to tailor the surface chemistry at the nanometer level. In surface modification of materials, plasmas can be used e.g. to activation, cleaning, etching and coating. For packaging materials plasma activation can be used to e.g. enhance adhesion properties, wettability and printability of surfaces. In plasma deposition, a completely new surface is created which enables the possibility to create barrier coatings from precursor such as e.g. sol-gels chemistry.

NanoMend is a collaborative FP7 research and development project investigating micro- and nano-scale defect detection, cleaning and repair techniques for large area substrates. It is built by 14 leading European companies and research centres. NanoMend aims to develop technologies that are able to detect and repair defects within thin films, without reducing production efficiency. NanoMend will demonstrate the new technologies for two industrial applications; flexible photovoltaics and coated fibre-based packaging products.

Atomic layer deposition (ALD) is a technique producing conformal thin films of materials onto a substrate. With ALD, especially water vapour and oxygen barrier properties of materials can be improved. In this project, recently developed roll-to-roll ALD process is used to improve the barrier properties of different packaging materials.

## *Innovent e.V. - a non-profit, industrial research association from Thuringia / Germany*


### *Mr. Olivier Beier*

INNOVENT E.V., Pruessingstrasse 27B, D-07745 Jena, Germany


In this talk we will give a short introduction and overview about the institute INNOVENT e.V. Technology Development. INNOVENT is a private non-profit industrial research association based in Jena (Germany) and is working in 5 different research departments:

1. Surface Engineering
   - Flame Coatings (Combustion CVD)
   - Plasma techniques (atmospheric pressure and vacuum)
   - Electrochemical techniques
   - Gas phase fluorination
   - Sol-Gel deposition
2. Primer and Chemical Surface Treatment
   - Development of chemical based methods for surface treatment and adhesion enhancing
   - Corrosion protection
   - Formulation of primer and varnishes
3. Magnetic and Optical Systems
   - Research in the field of magnetism, optics and crystal growth
   - Computer simulations
4. Biomaterials
   - Resorbable Materials
   - Nanostructured Materials
   - Scaffolds for Cell Cultivation
   - Electrospinning
   - Biological and cytotoxic tests
5. Analytics / Material Testing

Achievements of each department will be addressed during the presentation as well as possibilities regarding future R&D projects and collaborations e.g. in the EU.

# *Novel possibilities for creating functional layers using atmospheric pressure plasma CVD*

***Dr. Kerstin Horn***

INNOVENT E.V., Pruessingstrasse 27B, D-07745 Jena, Germany

With the appearance of new plasma sources working at ambient pressure conditions the attempts to create functional surface coatings were intensified strongly during the last years.

The atmospheric pressure plasma chemical vapour deposition (APCVD) is a useful way to realize such functional coatings. We will report e.g. about our investigations on the preparation of silicon oxide thin films using a jet plasma arrangement. The properties of those films can be influenced by choosing defined deposition parameters. Typical applications can be found in the field of controlling surface wettability, the transmission improvement of float glass for PV applications or the corrosion protection of light metals.

These coating experiments on silicon oxide layers are the base for creating composite layers. In this case the silicon oxide matrix layer will be enriched by defined additional components. Thus, in a first part of the contribution we will focus on the possibility to create wear-resistant surfaces with bactericidal properties by using silver containing solutions as an additional precursor material. On the other hand it will be shown that surfaces can be coated by fluorescent thin films, e.g. for product identification processes. In this case organic as well as non-organic fluorescent dyes can be used as precursor materials.

## *Strengths and Capabilities in Material Science of MMI*

### *Dr. Tirumalai Sudarshan*

Editor Surface Engineering, Editor Materials and Manufacturing Processes
Founder of Surface Modification Technologies series
President and CEO

*MATERIALS MODIFICATION INC., 2809K Merrilee Drive, Fairfax, Virginia 22031, US*

Materials Modification Inc has been on the cusp of innovative technologies for over two decades. The multiple opportunities in the use of advanced materials and coatings techniques in the creation of products will be presented. MMI has had a strong involvement in the synthesis of nanopowders using microwave plasma and consolidation of powders into complex shapes using plasma pressure compaction. In addition our strong involvement with nanomaterials and its applications in various industries will be highlighted through the products developed and the challenges that were overcome. MMI through its diverse background and expertise is seeking to partner with universities and companies to bring technologies to the real world in several applications. The challenges faced and some of the stringent requirements will also be discussed.

## *The use of atmospheric low-temperature plasma for the treatment of wooden surfaces*

***Dr. Radovan Tiňo***

*SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA, Faculty of Chemical and Food Technology, Dept. of Wood, Pulp and Paper, Radlinskeho 9, 812 37, Bratislava Slovakia*

By producing high frequency electric discharges, plasma generates ionized gas that can modify the surface properties of the material it is in contact with. Plasma treatment is a versatile and powerful technique commonly used in many industries for treatment of materials such as plastics, textiles, glass and metals. Plasma is also used for sterilization of number products in the food and pharmaceutical industries. Plasma is therefore a versatile technique with number of variable parameters (gas, flow rate, power, pressure, application time, gap, etc.) and electrode set up, that can result simultaneously in various effects for different classes of materials, especially on lignocellulosic materials containing wide range of chemicals, which particles in plasma discharge can react with. In recent years, plasma technologies operating at room temperatures and at atmospheric pressure have emerged. Depending on the treated material, plasma is expected to simultaneously provide a number of effects such as eradication of biological activity of living organisms, surface activation (pre-treatment for coating application), hydrophilization and/or strengthening through thin-film deposition, and material structure strengthening applying plasma assisted treatment. On the other hand, plasma treatment provides a cost-effective, versatile, environmentally friendly, non-thermal treatment system. Presented study summarizes various effects of two types of low temperature atmospheric plasma on wood surfaces

## *Surface modifications of polymers treated by pulsed electrical discharges in liquids*

***Dr. Camelia Miron***

RESEARCH PROGRAMME BIOELECTRICS, Leibniz Institute for Plasma Science and Technology, Felix-Hausdorff-Str. 2, Greifswald 17489, Germany

Plasma formed in water has been studied as a possible method for degradation of organic pollutants in aqueous media and for structural modifications of materials [1-3]. Pulsed electrical discharges generate a broad range of physical phenomena. Ultraviolet (UV) and visible (VIS) radiation depends on discharge parameters (applied voltage, pulse width, discharge current etc.), as well as on characteristics of the liquid. Chemically active species ($OH^{\bullet}$, $H^{\bullet}$, $O^{\bullet}$, $H_2O_2$, $H_2$, $O_2$) were seen to be formed in nearly all corona discharges systems using pulse generators able to generate pulses with durations in the range of microseconds. For a nanosecond high voltage pulse, it was found that a plasma could be formed directly in the dense liquid phase, without the need for the formation of gaseous bubble by Joule heating first which will then provide a gaseous environment to support a plasma [4]. Differences in the underlying mechanisms and plasma processes and much faster streamer velocities may further lead to a more efficient chemically active species propagation and interaction with molecules and bulk-materials, inducing surface modification and functionalization.

Nanosecond and microsecond high voltage pulses of 10 ns and 50 µs durations were used to generate pulsed discharges in distilled water for surface modifications of the aromatic and partially aromatic polyimides. Optical emission spectroscopy has shown the formation of excited species in plasma due to water dissociation and ionization. Molecular bands of hydrogen, oxygen, and nitrogen have dominated the emission spectra. The reactive species are likely to be responsible for the observed surface modifications of polymer films which were investigated by FTIR, AFM, XPS, and static contact angle measurements. The surface hydrophobicity of the polyimide films increased with treatment time. The mechanism of surface modification of polyimides treated by nanosecond pulsed discharges was different from that observed for plasmas generated with microsecond voltage pulses. Nanosecond high voltage pulses have induced an increase of the unsaturated bondings on the polyimide surface, while the segregation of polarizable groups at the film surface was responsible for the increased surface hydrophobicity when discharges were generated with microsecond high voltage pulses.

[1] M. A. Malik, A. Ghaffar, and S. A. Malik, *Plasma Sources Sci. Technol.* **10** (2001) 82.
[2] R. Joshi, R.-D. Schulze, A. Meyer-Plath, and J. F. Friedrich, *Plasma Process. Polym.* **5** (2008) 695.
[3] C. Miron, I. Sava, I. Jepu, P. Osiceanu, C. P. Lungu, L. Sacarescu, and V. Harabagiu, *Plasma Process. Polym*. **10** (2013) 798.
[4] I. Marinov, S. Starikovskaia, and A. Rousseau, *J. Phys. D: Appl. Phys.* **47** (2014) 224017.

## *Application of atmospheric pressure plasma for surface decontamination*

***Dr. Joanna Pawlat***

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Abstract not available