**2D Carbides and Nitrides (MXenes) for Energy Storage**

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**Abstract:**

2D carbides and nitrides, known as MXenes, are among the most recent, but quickly expanding material families. The field is experiencing very fast growth with the number of papers on MXenes doubling every year with about 850 journal papers in 2019 and the same number in the first 6 months of 2020. Major breakthroughs have been achieved in the past 2-3 years, including the discovery of 2D M5C4 carbides with the twinned layers and CVD synthesis of MoSi2N4, representing a new family of 2D nitrides. Synthesis of dozens of predicted MXenes, demonstration of superconductivity in MXenes with specific surface terminations, stronger interactions with electromagnetic waves compared to metals, metallic conductivity combined with hydrophilicity and redox activity, led to numerous applications. MXenes are promising candidates for energy storage and related electrochemical applications, but applications in optoelectronics, plasmonics, electromagnetic interference shielding, electrocatalysis, medicine, sensors, or water purification are equally exciting. Reversible redox activity of transition metal atoms in the outer layers of MXene flakes combined with high electronic conductivity led to applications in a variety of batteries and electrochemical capacitors.

**Biography**:

Yury Gogotsi is Distinguished University Professor and Charles T. and Ruth M. Bach Professor of Materials Science and Engineering at Drexel University. He also serves as Director of the A.J. Drexel Nanomaterials Institute. His research group works on 2D carbides, nanostructured carbons, and other nanomaterials for energy, water and biomedical applications. He is recognized as Highly Cited Researcher in Materials Science and Chemistry, and Citations Laureate by Thomson-Reuters/Clarivate Analytics. He has received numerous awards for his research including the ACS Award in the Chemistry of Materials, Gamow Prize, European Carbon Association Award, S. Somiya Award from IUMRS. He has been elected a Fellow of the American Association for Advancement of Science, Materials Research Society, American Ceramic Society, the Electrochemical Society, Royal Society of Chemistry, International Society of Electrochemistry, as well as the World Academy of Ceramics and the European Academy of Sciences. He holds honorary doctorates from the National Technical University of Ukraine, Frantsevich Institute for Problems of Materials Science, National Academy of Sciences, Ukraine, and Paul Sabatier University, Toulouse, France. He served on the MRS Board of Directors and is acting as Associate Editor of *ACS Nano*.

**Towards a more sustainable energy materials future**

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**Abstract:**

Materials sustainability is particularly important when building future energy storage and conversion technologies. Such energy technologies are crucial to ensure the transition towards a zero emissions society but are relying heavily on materials. We must therefore address the fine balance between the development of emerging energy technologies and the materials we use to build them. Today, scarce metals are the components of energy storage and conversion systems. Cobalt and graphite are in the cathodes and anodes of Li-ion batteries. With the accelerated development of Li-ion battery technologies, there is a huge demand not only for Cobalt and graphite but also for Li itself, which is geographically confined to Bolivia Chile and Argentina.  Hence, we need innovative energy storage technologies beyond Li. Iridium and Platinum are the catalysts of choice for H2 production from water and its utilization in fuel cells to generate clean electricity. The current available supply for these metals cannot sustain the expansion of such technologies at a global scale. We need alternative electrocatalysts and sources for H2 production and H2 use in fuel cells. Gallium, Tellurium, Indium are used in solar cells and photocatalytic systems for solar fuel production. These materials are scarce, and alternatives must be sought for the next generation of solar panels and photocatalytic systems.

In this talk I will present some of our innovations in the design of sustainable materials to be efficiently utilized in energy storage and conversion technologies. Examples will range from efficient and sustainable batteries beyond Li to alternative catalysts to Pt for fuel cell’s cathodes as well as alternative biowaste sources to water for the production of affordable and clean H2. A new family of photoactive nanomaterials made from biomass, i.e carbon dots, will also be discussed for potential use in solar H2 production.

Magda Titirici started her academic career by completing a PhD from the University of Dortmund in 2005 followed by a Postdoctoral Research position at the Max Planck Institute for Colloids and Interfaces. After one year in this role she became an independent group leader, receiving her Habilitation in 2013 from MPIKG-University of Potsdam. She was a Professor in Sustainable Materials Chemistry at Queen Mary University of London for four years, where she maintains an active research presence. Magda moved to Imperial College in January 2019. 

**Functional 2D Materials and Devices for High-Power Energy Storage**

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High-power electrochemical energy storage devices are important components for various industrial applications, ranging from individual electronics to grid storage. The demand for power and energy supply is equally imperative in actual use and is keen to expand in the future. Thus, it is highly desirable to design new electrochemical batteries and supercapacitors to mitigate the trade-off between power density and energy density. On the other hand, as growing requirements for intelligent electronic devices and internet-of-things, extensive attentions have been attracted to functional (particularly, smart and stimuli-responsive) energy storage devices, which are rapidly responsive to the variations of devices or the external environment, *e.g.*, configuration, voltage, deformation, light, and temperature, etc. Meanwhile, the portable, implantable, and wearable electronics are advancing toward miniaturization as well as ultralight, and safe, long-term, and high-speed operation, thus stimulating the urgent pursuit for miniaturized energy storage devices.

In this lecture, we will present our recent efforts in developing functional graphene and 2D materials for high-power energy storage devices, especially for the flexible/micro-supercapacitors with smart functions. Electrochromism, thermo-response, and photo-response can be integrated into such devices which provide the possible means to monitor the electrochemical process using external stimulus, thus opening up windows for realizing the power systems for intelligent electronic devices. Towards realizing high-power electrochemical batteries, we will discuss our recent progress in the development of dual-ion energy storage devices, which involve different charge storage chemistry in contrast to the conventional “rocking-chair” mechanism.

 Xinliang Feng is a full professor and the head of the Chair of Molecular Functional Materials at Technische Universität Dresden. He has published more than 520 research articles which have attracted more than 63700 citations with H-index of 121 (Google Scholar). He has been awarded several prestigious prizes such as IUPAC Prize for Young Chemists (2009), European Research Council (ERC) Starting Grant Award (2012), *Journal of Materials Chemistry* Lectureship Award (2013), *ChemComm* Emerging Investigator Lectureship (2014), Fellow of the Royal Society of Chemistry (FRSC, 2014), Highly Cited Researcher (Thomson Reuters, 2014-2019), *Small* Young Innovator Award (2017), Hamburg Science Award (2017), EU-40 Materials Prize (2018), ERC Consolidator Grant Award (2018). He is a member of the European Academy of Sciences (2019) and member of the Academia Europaea (2019). He is an Advisory Board Member for *Advanced Materials*, *Chemical Science,* *Journal of Materials Chemistry A*, *ChemNanoMat*, *Energy Storage Materials*, *Small Methods*, *Chemistry -An Asian Journal, Trends in Chemistry, etc*. He is the Head of ESF Young Research Group "Graphene Center Dresden", Working Package Leader of WP Functional Foams & Coatings for European Commission’s pilot project “Graphene Flagship”, and spokesperson for the DFG Collaborative Research Center for the Chemistry of Synthetic 2D Materials.

**Ultrahigh-Rate Electrochemical Capacitor toward** **Alternating Current Filter**

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Electrochemical capacitor traditionally plays the role to bridge the gap between lithium batteries and conventional electrolyte capacitors. One of the emerging promising application fields for high-rate electrochemical capacitor is their huge potential to replace bulky aluminum electrolyte capacitors (AECs) and serve as alternating current filter for flexible, lightweight, and miniaturized electronics. The key point for high-performance filtering capacitor from academic to industry is the rational design and synthesis of electrode materials. Here, we will introduce our recent research results about wood-based high-rate electrochemical capacitor for filtering purpose. Wood as a renewable resource was used to fabricate highly conductive, robust, porous thin carbon membranes as free-standing electrodes for ultrafast electrochemical capacitors. Transformation of wood slice to carbon membrane was realized via wet-chemical treatment of wood slices and subsequent morphology-maintaining carbonization by spark plasma sintering. The carbon membrane-based electrochemical capacitor exhibits excellent frequency response with efficient 120 Hz filtering (phase angle = −83.5o). This wood-derived porous carbon membrane holds the potential for versatile platform for other applications which require highly conductive porous substrates.



(biography to be added)