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Bio | Natalie Stingelin is a Full Professor at the Georgia Institute of Technology and the Chair of the School of Materials Science & Engineering. She held prior positions at Imperial College London, UK, at Queen Mary University of London, UK; the Philips Research Laboratories in Eindhoven, The Netherlands; the Cavendish Laboratories, University of Cambridge, UK; and the Swiss Federal Institute of Technology (ETH) Zürich, Switzerland. She is the Director of Georgia Tech's Center of Organic Electronics and Photonics, and was elected a 2023 Member of the European Academy of Sciences (EurASc); a 2021 Fellow of the U.S. National Academy of Inventors (NAI); a 2019 Fellow of the Materials Research Society (MRS); and a 2012 Fellow of the Royal Society of Chemistry (RSC). Her research interests encompass the broad area of functional polymer materials, polymer physics, organic electronics & photonics, and bioelectronics.

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Title 1 (UdS)| **Phase Diagrams of Complex Materials: From the Katana, Swiss Chocolates to Organic Semiconductors**

Title 2 (INRS)| **Terra incognita: Understanding next-generation polymer semiconductors**

Title 3 (UdeM)| **"Flexible Electronics" Sustainability: Challenges and Opportunities a Materials Science View**

Title 4 (Concordia)| **Cool plastics for Energy Sustainability**

Please see the abstracts below for each title.

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Abstract 1/UdS | In the past decade, significant progress has been made in the fabrication of polymer-based devices, such as organic light-emitting diodes (OLEDs), organic field-effect transistors (OFETs) and organic photovoltaics (OPVs), predominantly due to important improvements of existing materials and the creation of a wealth of novel compounds. Many challenges, however, still exist: from achieving reliable device fabrication, increasing the device stability and, more fundamentally, gaining a complete understanding how structural features over all length scales affect important optoelectronic and photophysical processes in such polymers, including charge transport, charge generation, and general photovoltaic processes. Here we demonstrate how classical polymer science tools can be used to elucidate the structure development of semiconducting polymers from the liquid phase, how such knowledge can be exploited to manipulate their phase transformations and solid-state order and, in turn, their electronic features and device performances. More specifically, we will illustrate how rules that explain the mechanical properties of the Katana and distinguishes good from lesser tasty chocolates, can be applied to organic semiconductors to manipulate their properties and, hence, and their consequent performance when used as active layers in organic optoelectronic devices, with focus on organic organic photovoltaic cells. Moreover, we discuss how the relatively new fast-calorimetry technique, that can measure with rates of up to 5,000 °C/s can be utilized for the identification of thermodynamic transitions of donor polymers and acceptor molecules commonly used in the organic solar cell area. Examples are provided how the change in glass transition temperature of a common polymer semiconductor that can be used to track polymer degradation upon light exposure. In short, we will demonstrate how thermal analysis can be exploited to obtain important structural information of organic energy harvesting materials, and how processing guidelines can, in turn, be established towards materials of specific optical or electrical characteristics, and improved materials design for organic photovoltaic blends.

Abstract 2/INRS | First-generation polymer semiconductors have been well-studied and are well-understood. They are flexible-chain materials, leading generally to highly heterogeneous microstructures comprised of molecularly disordered (“amorphous”) and ordered regions (crystallites/aggregates). More recent systems are, in contrast, comprised of a relatively rigid backbone, requiring often elaborate side-chain substitutions to render them processable. Because of the backbone rigidity, the individual chains of these polymers do not entangle, supporting a “liquid-crystalline”-like behavior and low long-range coherence. However, this difference is rarely discussed in litterature, and classical polymer physics views, developed for flexible-chain polymers, are applied to rationalize the behavior of next-generation materials. Here, we demonstrate on the example of P3HT and PBTTT, a flexible chain vs. a rigid-rod-like, semiconductor, that their structural difference has enormous impact on their electrochemical and optoelectronic response. Indeed, we find that PBTTT is of dynamic electronic disorder, but with a relatively narrow density-of-states. Two-dimensional coherent- excitation spectroscopy moreover reveals cross-correlations beyond the sharing of a common ground state. Importantly, a periodic change of the (0-1) intensity is identified that is identically to a low-wavenumber vibrational Raman mode, attributed to in-plane and out-of-plane torsional backbone motions, providing new insights how structural

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dynamics can be directly correlated with specific photophysical processes, towards a new framework that captures modern functional macromolecules.

Abstract 3/UdeM | In recent years, immense efforts in the flexible electronics field have led to unprecedented progress and to devices of ever increasing performance. Despite these advances, new opportunities are sought in order to widen the applications of flexible electronics technologies, expand their functionalities and features, with an increasing view on delivering sustainable solutions. We discuss here opportunities the use of multicomponent systems for, e.g., increasing the mechanical flexibility and stability of organic electronic products, or introducing other features such as self-encapsulation and faster mixed ion-electron transport. One specific strategy is based on blending polymeric insulators with organic semiconductors; which has led to a desired improvement of the mechanical properties of organic devices, producing in certain scenarios robust and stable architectures. Here we discuss the working principle of semiconductor:insulator blends, examining the different approaches that have recently been reported in literature. We illustrate how organic field-effect transistors (OFET)s and organic solar cells (OPV)s can be fabricated with such systems without detrimental effects on the resulting device characteristics even at high contents of the insulator. Furthermore, we review how blending can assist in the fabrication of more reliable and versatile organic electrochemical transistors (OECT)s.

Abstract 4/Concordia | With seabirds trapped in multipack drink rings, and mid-ocean islands of indestructible rubbish, the idea that plastics could play a big part in a sustainable future world might seem far-fetched. However, new smart plastics may yet rescue the reputation of this all-consuming 20th century material. Research into ‘cool plastics’ for cars and buildings could reduce the need for air conditioning and, thus, improve their energy efficiency. We will present recent efforts to design plastics of desired optical functions targeted for a greener world. We will discuss the potential of such systems that can offer the same flexibility, softness and light weight as commodity plastics but can control the flow of light and heat therefore assisting energy management in buildings and greenhouses in the form of heat mirrors, photovoltaic applications when used as anti-reflection coatings and semi-transparent mirrors, as well as building blocks for novel optical structures that can lead to quantum devices.