

**Department of Electrical and Computer Engineering
Materials Engineering Program
Texas Center for Superconductivity at Univ. of Houston
Center for Integrated Bio and Nano Systems
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Multifunctional materials for emerging technologies

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Abstract:

A ferro-rotational order describes a ferroically ordered state of an axial vector moment that is invariant under both spatial inversion and time reversal operations. This order was first theoretically proposed to complete the classification of ferroics with vector order parameters, and now is the last remaining class to be revealed after the discoveries of ferro-toroidal, ferromagnetic, and ferroelectric orders. More recently, this order is suggested to exist in a good number of complex oxides and is responsible for several novel quantum phenomena including the type-II multiferroic order. In this talk, I will present our studies of the ferro-rotational order in a type-II multiferroic material $\text{RbFe}(\text{MoO}_4)_2$ using high sensitivity rotational anisotropy second harmonic generation (RA-SHG). I will show that the higher order electric quadrupole contribution to SHG has been exploited to investigate this inversion-symmetry-preserved ferro-rotational order. I will then reveal several physical properties of this ferro-rotational order including its symmetry, domain distributions, temperature evolutions, and conjugate coupling field. I will further discuss the significance of understanding this ferro-rotational order in device applications and the new opportunities brought by the state-of-the-art SHG spectroscopy and microscopy. This presentation focuses on structure property/relationships in advanced materials, emphasizing multifunctional systems that exhibit multiple functionalities. Such systems are then used as building blocks for the fabrication of various emerging technologies. In particular, nanostructured materials synthesized via the bottom-up approach present an opportunity for future generation low cost manufacturing of devices [1]. We focus in particular on recent developments in solar technologies that aim to address the energy challenge, including third generation photovoltaics, solar hydrogen production, luminescent solar concentrators and other optoelectronic devices. [2-40].

References

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(2015); [24] *Small* 11, 4018 (2015); [25] *J. Mater. Chem. A* 3, 2580 (2015); [26] *Nano Energy* 34, 214 (2017); [27] *Nano Energy* 35, 92 (2017); [28] *Adv. Func. Mater.* 27, 1401468 (2017); [29] *Adv. En. Mater.* 8, 1701432 (2018); [30] *Chem* 3, 229 (2017); [31] J. Chakrabartty et al., *Nature Phot.* 12, 271 (2018); [32] *Nano Energy* 55, 377 (2019); [33] *Nanoscale Horiz.* 4, 404 (2019); [34] *Appl. Cat. B* 250, 234 (2019); *Adv. Func. Mater.* 29, 1904501 (2019); [35] *ACS Photonics* 6, 2479 (2019); [36] *Appl. Cat. B* 264, 118526 (2020); [37] *Adv. Func. Mater.* 30, 1908467 (2020); [38] *J. Mater. Chem. A* 8, 20698 (2020); [39] *Nano Energy* 79, 105416 (2021); [40] *Nano Energy* 81, 105626 (2021).



Short Bio:

Federico Rosei (MSc (1996) and PhD (2001) from the University of Rome “La Sapienza”) is Full Professor at the Centre Énergie, Matériaux et Télécommunications, Institut National de la Recherche Scientifique, Varennes (QC) Canada, where he served as Director (07/2011–03/2019). He held the Canada Research Chair (Junior) in Nanostructured Organic and Inorganic Materials (2003–2013) and since May 2016 he holds the Canada Research Chair (Senior) in Nanostructured Materials. Since January 2014 he holds the UNESCO Chair in Materials and Technologies for Energy Conversion, Saving and Storage.

Dr. Rosei’s research interests focus on structure/property relationships in nanomaterials and their use as building blocks in emerging technologies. His research has been supported by multiple funding sources from the Province of Quebec, the Federal Government of Canada as well as international agencies, for a total in excess of M\$ 18. He has worked in partnership with over twenty Canadian R&D companies. He is co-inventor of three patents and has published over **425** articles in prestigious international journals (including *Science*, *Nature Photonics*, *Proc. Nat. Acad. Sci.*, *Adv. Mater.*, *Angew. Chem.*, *J. Am. Chem. Soc.*, *Adv. Func. Mater.*, *Adv. En. Mat.*, *Nanolett.*, *ACS Nano*, *Biomaterials*, *Small*, *Phys. Rev. Lett.*, *Nanoscale*, *Chem. Comm.*, *Appl. Phys. Lett.*, *Phys. Rev. B*, etc.), has been invited to speak at over **340** international conferences and has given over **250** seminars and colloquia, over **60** professional development lectures and **40** public lectures in **48** countries on all inhabited continents. His publications have been cited over **19,800** times and his H index is **75**.

He is Fellow of numerous prestigious national and international societies and academies, including: the Royal Society of Canada, the European Academy of Science, the Academia Europaea, the European Academy of Sciences and Arts, the African Academy of Sciences, the World Academy of Art and Science, the World Academy of Ceramics, the American Physical Society, AAAS, the American Ceramic Society, the Optical Society of America, SPIE, the Canadian Academy of Engineering, ASM International, the Royal Society of Chemistry (UK), the Institute of Physics, the Institution of Engineering and Technology, the Institute of Materials, Metallurgy and Mining, the Engineering Institute of Canada, the Australian Institute of Physics, Honorary Fellow of the Chinese Chemical Society, Foreign Member of the Mexican Academy of Engineering, Foreign Member of the Bangladesh Academy of Sciences, Senior Member of IEEE, Alumnus of the Global Young Academy and Member of the Sigma Xi Society.

He has received several awards and honours, including the FQRNT Strategic Professorship (2002–2007), the Tan Chin Tuan visiting Fellowship (NTU 2008), the Senior Gledden Visiting Fellowship (UWA 2009), Professor at Large at UWA (2010–2012), a Marie Curie Post-Doctoral Fellowship from the European Union (2001), a junior Canada Research Chair (2003–2013), a senior Canada Research Chair (2016–2023) a Friedrich Wilhelm Bessel Award (von Humboldt foundation 2011), the Rutherford Memorial Medal in Chemistry (Royal Society of Canada 2011), the Herzberg Medal (Canadian Association of Physics 2013), the Brian Ives lectureship award (ASM international 2013), the Award for Excellence in Materials Chemistry (Canadian Society for Chemistry 2014), the NSERC EWR Steacie Memorial Fellowship (2014), the José Vasconcelos Award for Education (World Cultural Council 2014), the IEEE NTC Distinguished Lectureship 2015–2016, the Lash Miller Award (Electrochemical Society 2015), the Chang Jiang Scholar Award (China), the Khwarizmi International Award (Iran), the Recognition for Excellence in Mentorship (American

Vacuum Society 2015), the Selby Fellowship (Australian Academy of Sciences 2016), the John C. Polanyi Award (Canadian Society for Chemistry 2016), the Outstanding Engineer Award (IEEE Canada 2017), the President's Visiting Fellowship for Distinguished Scientists (Chinese Academy of Sciences 2017), the Sigma Xi Distinguished Lectureship (2018–2020), the Sichuan 1000 talent (short term) award, the Lee Hsun Lecture Award (2018), the Changbai Mountain Friendship Award (2018), the IEEE Montreal Gold Medal (2018), the APS John Wheatley Award (2019), the Blaise Pascal Medal (European Academy of Science 2019), the IEEE Photonics Society Distinguished Lectureship (2020–2022), the Guangxi Golden Silkball Friendship Award, the TMS Brimacombe Medal (2021), the Wolfson Fellowship (Royal Society), the Prix Urgel Archambault (ACFAS 2021), the Prix du Quebec "Marie Victorin" (2021) and the Julian C. Smith Medal (Engineering Institute of Canada 2022).