NJAMI Seminar Series

Building Blocks for Technology of the Future - MXenes and beyond

Dr. Yury Gogotsi

Distinguished University Professor and Bach Endowed Chair
Founding Director, A.J. Drexel Nanomaterials Institute
Department of Materials Science and Engineering
Drexel University
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Easton Hub Auditorium (in the Fiber Optics Building)

Abstract

New materials will shape our future by enabling technologies in healthcare, robotics, quantum electronics, and space that are impossible today.

Nanomaterials, especially 2D materials, serve as building blocks that can be assembled into micro- and macroscopic structures and devices. By combining nanosheets with various structures and compositions, one can achieve unique combinations of properties not available in current materials. With guidance from computational techniques, such as machine learning and other AI tools, we should be able to program the properties and functions of those assembled nanomaterials, ushering in the new materials age. The most diverse family of 2D materials is carbides, nitrides, and related structures known as MXenes. They complement graphene, transition metal dichalcogenides, and other 2D materials by offering high metallic conductivity, electrochemically active surfaces, and extreme strength. More importantly, the optical and electronic properties of MXenes can be tuned and modulated during use.

Since the discovery of $Ti_3C_2T_x$ in 2011, more than 50 stoichiometric MX compositions and dozens of solid solutions have been reported. The number of possible compositions is infinite when considering solid solutions, high-entropy compositions, in- and out-of-plane ordered MXenes, and combinations of surface terminations. MXenes can be synthesized directly from metal halides and carbon sources or by selectively etching layered ceramics in aqueous etchants, molten salts, or halogen-containing gases. MXenes have ushered in an era of computationally driven atomistic design of 2D materials, but we are only beginning our journey into the world of atomistically designed materials.

The properties of MXenes are tunable by design. For example, chemically tunable superconductivity, work function, electromagnetic interference (EMI) shielding effectiveness, and electrical and optical properties have been demonstrated. These properties can be modulated optically or via an ionotronic approach, enabling breakthroughs in fields ranging from optoelectronics and EMI shielding to communication, energy storage, catalysis, sensing, and healthcare. I'll discuss how structure and composition influence MXene properties. I'll also outline prospects for applications of MXenes and their assemblies with other 2D materials in electronics, healthcare, thermal management, communication, and energy generation and storage.

Biography

Yury Gogotsi is a Distinguished University Professor and Bach Endowed Chair in the Department of Materials Science and Engineering at Drexel University (Philadelphia, USA). He is the founding Director of the A.J. Drexel Nanomaterials Institute. He received his BS/MS (1984, metallurgy) and PhD (1986, physical chemistry) from Kyiv Polytechnic, and a DSc from the Ukrainian Academy of Sciences in 1995. He made principal contributions to developing materials for electrochemical capacitors, carbide-derived carbons, and the discovery of 2D carbides and nitrides (MXenes). His work has received over 335,000 citations. The 2025 Stanford List ranked Gogotsi 21st among all scientists across all disciplines and 2nd in Nanoscience and Nanotechnology worldwide. He is a Highly Cited Researcher in Engineering, Chemistry, and Materials Science; a Citations Laureate in Physics (Clarivate); and a recipient of numerous awards and honorary doctorates. He was elected a Fellow of the US National Academy of Inventors, World Academy of Ceramics, European Academy of Sciences, Academia Europaea, and other professional societies.