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SCALABLE 2D-MATERIALS ARCHITECTURES

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CENIDE & WIN Seminar Series on 2D-MATURE

DFG IRTG 2803 & NSERC CREATE

Alexander Sinitskii

University of Nebraska-Lincoln

"Revealing the intrinsic properties of MXenes"

November 28th, 2024

10:00 a.m. ET / 16:00 p.m. CET

Alexander Sinitskii is a Professor of Chemistry at University of Nebraska – Lincoln. He received his B.S. and Ph.D. degrees in Materials Science from Moscow State University, and then worked as a postdoc at Rice University before joining UNL. His research program is addressing the synthesis and properties of low-dimensional materials, such as atomically precise graphene nanoribbons, transition metal chalcogenides, and MXenes, with applications in nanoelectronics, optoelectronics and chemical sensing. Sinitskii has published over 160 papers, which received over 28,000 citations (h-index > 50) and is a co-inventor on 11 patents. He received several awards for his research and teaching, including an NSF CAREER Award and a UNL College of Arts and Sciences Distinguished Teaching Award, and is currently leading an ONR MURI project on Synthetic Carbon Electronics.

MXenes are an emerging family of two-dimensional (2D) transition metal carbides, nitrides, and carbonitrides that are promising for a variety of applications ranging from energy storage and electronics to gas sensors and electromagnetic interference shielding. Advancement of these applications requires understanding of the intrinsic physical properties of MXenes, which can be determined in experiments performed on individual MXene flakes. The results of such experiments on monolayer flakes of $Ti_3C_2T_x$, $Nb_4C_3T_x$, $Ta_4C_3T_x$, TiVC, and $Cr_2TiC_2T_x$ MXenes will be discussed in this presentation. Electrical measurements of individual monolayers reveal that MXenes can be either n-type ($Ti_3C_2T_x$, $Nb_4C_3T_x$) or p-type ($Cr_2TiC_2T_x$) with very high electrical conductivities of up to 11,000 S cm^{-1} ($Ti_3C_2T_x$). Furthermore, MXenes show very high breakdown current densities of $>10^8$ A cm^{-2}, which exceed those for conventional metals. Mechanical measurements of individual MXene monolayers reveal their high Young's moduli of >300 GPa, establishing their potential for mechanically reinforced composites, protective coatings, and nanoresonators. These examples demonstrate the importance of single-flake measurements, which expand our understanding of the physical properties MXenes and broaden the already impressive range of their future applications. Several applications of MXenes in gas sensing, catalysis, and nanoelectromechanical systems (NEMS) will be discussed.