FLAIR Colloquium

Thursday, 5. December 2024, 16:00
Room R304, Building L6|01

Zoom-Link

Probing Defect Structures in Materials: Insights through EPR Spectroscopy for Supercapacitor Applications

Prof. Dr. Emre Erdem

Sabanci University, Materials Science and Nanoengineering, Istanbul, Turkey

Abstract

Electron paramagnetic resonance (EPR) spectroscopy is a versatile and powerful technique for investigating defect structures in a wide variety of materials, particularly oxides, where defects play a key role in defining their electronic, magnetic, and optical properties. In this seminar, I will provide a brief introduction to EPR spectroscopy within the context of solid-state materials science, focusing on its ability to study defects in semiconductor nanomaterials, perovskites, and 2D materials. EPR is not only effective in characterizing intrinsic and extrinsic defect states but is also highly sensitive to variations in crystal field parameters, which differ across material types—from perovskites like PbTiO3 and lead-free alternatives to semiconductor systems such as ZnO nanomaterials. Additionally, EPR offers detailed insights into the electronic states of metal ions, making it an extensive technique for determining the concentration and nature of defect ions, whether they are extrinsically doped into solids or intrinsically present. It is also capable of distinguishing between surface and volume defects, which is crucial for understanding material behavior in various applications. We will explore how EPR spectroscopy can uncover critical details such as ion substitution, charge compensation, and oxygen vacancies, and discuss how these insights contribute to the broader understanding of material properties.

Finally, I will introduce ongoing research where ZnO and lead-free perovskites are being applied as electrode materials in all-in-one supercapacitor devices for energy storage systems. We will examine the relationship between material properties and device performance, highlighting how EPR and complementary techniques such as photoluminescence provide extensive control over defect states, enabling a deeper understanding of the functional properties of electrode materials for sustainable energy technologies.

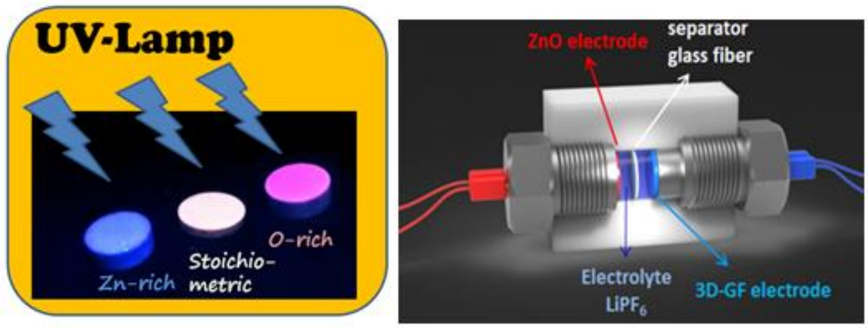

Figure 1: *(left) Defect evolution of non-stoichiometric ZnO. (right) The supercapacitor device based on ZnO and 3D graphene foam electrodes.*

Speaker

Emre Erdem is a professor of experimental physics specializing in spectroscopy and supercapacitors. He earned his B.Sc. from Ankara University in 1998, followed by an M.Sc. and Ph.D. from the University of Leipzig in 2001 and 2006, respectively. After postdoctoral research at the Technical University (TU) of Darmstadt, he led a research group at the University of Freiburg, where he focused on spectroscopic studies of functional nanomaterials and earned his habilitation in 2017. His expertise spans multifrequency EPR, photoluminescence, and impedance spectroscopy, with significant contributions to understanding point defects in semiconductors and piezoelectrics. Prof. Erdem's recent work centers on 2D materials, sustainable carbon production, and supercapacitor design. He has published over 140 papers and delivered 50+ invited talks. Prof. Erdem is Editor-in-Chief of "Experimental Results" and Associate Editor for "Scientific Reports". Currently, he holds a Mercator Fellowship at the TU Darmstadt and is director of Sabancı University's EFSUN research center.