Synthesis and characterization of Cu-doped Sb_2S_3 nanoparticles for application as absorber in solar cells

Antimony sulfide amorphous and crystalline nanoparticles were synthesized by hot-injection method in parrafine oil medium. Temperature and time as well as doping with Cu were used to control the crystallinity of particles. X-ray diffraction analysis confirmed the gradual growth and crystallization of amorphous particles with synthesis time and temperature, with bad incorporation of Cu(I) and Cu(II) into the structure. Most of the copper was involved in the formation of $CuSbS_2$ phase, regardles of its valence. Raman spectroscopy confirmed the formation of Sb_2S_3 phase with absent oxides. Anyway, Cu presence helped in faster crystallization and influenced the shape of particles. Scanning and transmission electron microscopy (SEM and TEM) revealed spherical shape of amorphous nanoparticles of 20-30 nm in radius and clothespin-shaped crystalline particles with a radius and length of several micrometers and approximate length-to-radius ratio of 2.5. Crystalline particles were significantly smaller in doped powders. Differential reflectance spectroscopy results were fitted to calculate a 2.0 eV indirect band gap for the amorphous phase, with some size-tunability and ~1.6 eV direct band gap for the crystalline phase not dependent on size or synthesis parameters. Synthesized powders are intended to be used as an absorber in solar cells suitable for low light conditions.

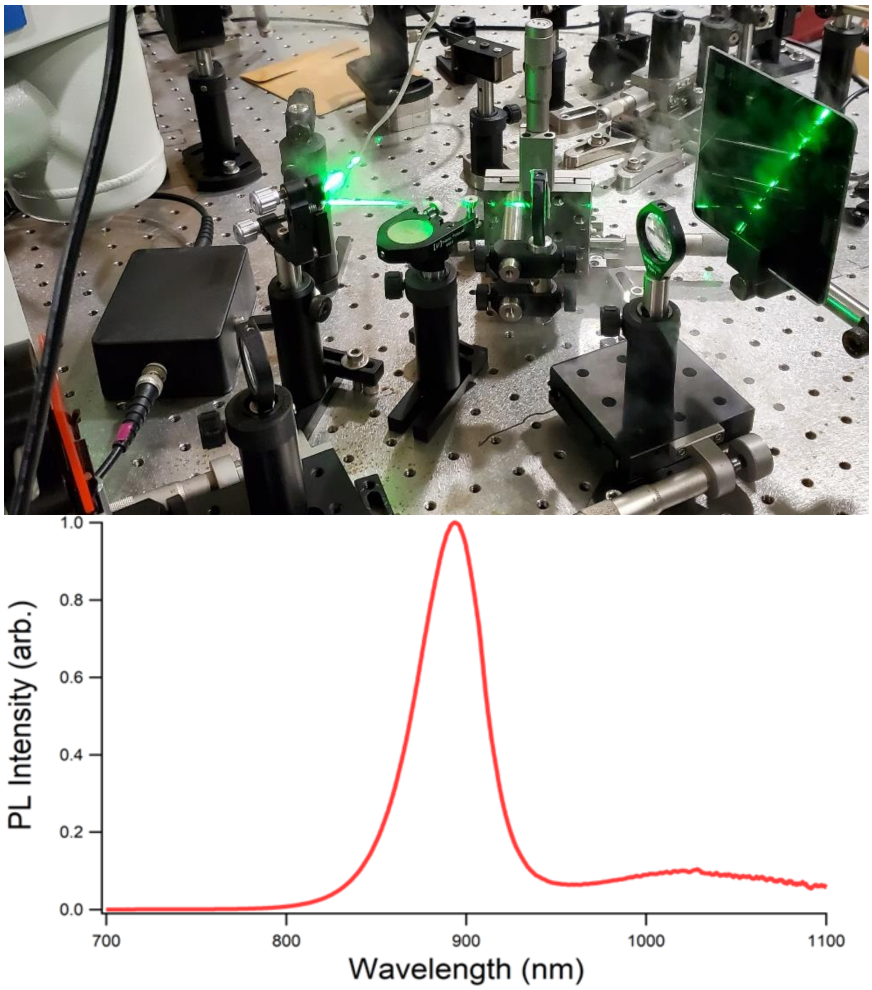
Dr. Nikola Ilić is a Research Associate at Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade. He defended his doctoral dissertation in 2018 at the department for Chemical Engineering, Faculty of Technology and Metallurgy, University of Belgrade, entitled: “Processing, properties and application of bismuth ferrite-based multiferroic materials”. During his PhD, he was focused on the investigation of ferroelectric materials, magnetics materials, multiferroics, synthesis of bismuth ferrite powders by different chemical synthesis methods and processing of ceramic materials.

From 2014 until today, Nikola Ilić has been a co-author of 26 papers in international peer-reviewed journals in the field of material science and three book chapters. According to the Scopus Citation Index Database, the papers are cited 482 times with h-index 12.

At the moment he is involved in the synthesis and characterization of Sb_2S_3 based powders for application in photovoltaics, as well as photocatalytic activity of $BiFeO_3$-based powders for decomposition of organic molecules dissolved in water.

Photoluminescence Techniques as Tools for Studying Carrier Recombination in Photovoltaic Materials

Increasing demand for solar electricity merits further research to understand and overcome the limitations of current photovoltaic materials and devices (solar cells). As the open-circuit voltage for record devices made on several absorbers (such as cadmium telluride and antimony sulfide) is the primary limiting factor to power conversion efficiency, understanding the pathways for charge carrier recombination is a critical step in future research. Optical characterization offers a powerful set of methods which nondestructively probe and evaluate the recombination mechanisms in a material. Steady-state measurements can be used to compare the impacts of specific device processing steps on the photogenerated carrier recombination rate, and also allows for quantification of the photoluminescence quantum yield. Spectrally-resolved photoluminescence can be used to identify specific defect-based recombination centers in a material, providing information vital for improving the material synthesis. Time-resolved measurements directly probe charge carrier lifetime(s) as well as quantify the recombination rates associated with different charge recombination mechanisms. This presentation will provide an introduction to steady-state and time-resolved photoluminescence techniques, with a focus on applications in characterizing photovoltaic materials.



(Top) Cadmium telluride sample under measurement, excited using a 532 nm (green) laser. Condensed water vapor from liquid nitrogen was used to show the excitation beam path. (Bottom) Normalized steady-state photoluminescence spectrum of the same cadmium telluride sample.

Tyler Brau graduated from Gustavus Adolphus College in 2019 with a B.A. in Physics and a B.A. in Chemistry. After graduating, he worked as an assistant researcher under Dr. Dwight Stoll for two years. In the fall of 2021, Tyler joined the Department of Physics and Astronomy at the University of Toledo (Toledo, OH) under Dr. Randy Ellingson as a Physics Ph.D. candidate. His research focuses on the optical and optoelectronic characterization of photovoltaic materials, including steady-state and time-resolved photoluminescence.

Sanduni Premathilaka: Abstract

Nutrient enrichment has caused the eutrophication of water bodies globally, leading to the frequent occurrences of cyanobacterial harmful algal blooms (cyanoHABs) in lakes, rivers and other waterbodies worldwide. These blooms produce various bioactive secondary metabolites, including cyanotoxins that can pollute water ecosystems and pose significant public health risks. Microcystins (MCs) are the most extensively studied cyanotoxins due to their high hepatotoxicity and prevalent presence in water reservoirs affected by cyanoHABs. To date, more than 300 MC congeners of these cyclic peptides have been identified, and it is believed that many more remain undiscovered. High-resolution mass spectrometry (HRMS) plays a critical role in detecting and identifying novel MC congeners, including those present at very low concentrations in lake water. Tandem mass spectrometry (MS/MS) and derivatization reactions further assist in identifying individual amino acids and sequencing of novel MC congeners. This presentation will discuss the results from liquid chromatography-high-resolution mass spectrometry (LC-HRMS) analyses of water samples collected during CyanoHABs in the western basin of Lake Erie.

Sanduni Premathilaka: Short Biography

Sanduni Premathilaka earned her Bachelor of Science degree with a specialization in Chemistry from the University of Ruhuna, Sri Lanka, in 2016. After graduation, she worked as an assistant lecturer in Chemistry at the same university for two years. In 2019, she joined the Department of Chemistry and Biochemistry at the University of Toledo (Toledo, Ohio) to pursue a Ph.D. in Chemistry. Currently, she is Ph.D. candidate in Dr. Dragan Isailovic's group, where she specializes in analytical chemistry. Her research focuses on the identification and structural elucidation of novel microcystin congeners in Lake Erie water using liquid chromatography coupled to high-resolution mass spectrometry.