

## **Ultrafast Dynamics in Hybrid Semiconductors for Energy Applications**

Addressing the climate challenge requires functional materials that enable energy generation, storage, and conversion from renewable sources, forming the foundation for a sustainable energy infrastructure. My group focuses on advancing functional materials to enable novel energy technologies, including next-generation lighting, energy storage, and information systems. We leverage high-resolution ultrafast spectroscopy to investigate the dynamics of local optoelectronic and structural processes at femtosecond timescales. This approach not only advances material functionality but also provides new insights into fundamental phenomena critical for energy applications.

In this talk, I will discuss how we use advanced spectroscopic techniques to explore the ultrafast dynamics of photoexcited electronic states, spin populations, and atomic structure in hybrid perovskite semiconductors. Our research elucidates the origins of the exceptional optoelectronic properties of these materials, which have positioned them at the forefront of solution-processable semiconductors. I will present results on spatio-temporal imaging of excitations via ultrafast transient microscopy, as well as spin dynamics using ultrafast Faraday rotation microscopy. Additionally, I will highlight recent findings on chiral hybrid perovskites for manipulating spin-orbit interactions, and dynamics of opto-ionic excited state reservoirs with implications for neuromorphic computing. Finally, I will extend the discussion to further material systems, such as bismuth vanadate photocatalysts and organic semiconductors, demonstrating the broad applicability of our approach for investigating material dynamics.