Nanoscale Imaging of Hybrid Metal Halide Perovskites for Photovoltaic Applications

University of Warwick, Department of Physics
Supervisor: Dr. Rebecca Milot

In recent years, hybrid metal halide perovskites, which adopt the crystal structure as seen in the figure below, have shown extraordinary success as active layers in solar cells. With power conversion efficiencies in excess of 26%, solar cells based on polycrystalline perovskite thin films rival existing silicon technologies.[1-2] Due to the rapid development of the field, much remains to be discovered about the basic physical and chemical properties of perovskite thin films and how these properties determine photovoltaic device efficiency. Specifically, there is a poor understanding of how bulk optoelectronic properties are influenced by the polycrystalline nanostructure of perovskite thin films, as the observance of grain boundary effects on charge-carrier mobility and photoluminescence quantum yield appears contradictory to efficient device performance.[3] Using ultrafast spectroscopy and microscopy techniques, the overall goal of this research project will be to create a map of charge movement within perovskite thin films with sub-micron spatial resolution and sub-ps time resolution in order to analyze loss mechanisms due the presence of grain boundaries and non-uniform chemical composition. Additionally, it will survey a range of technologically relevant materials designed to increase the stability of perovskite materials.

The main experimental focus of the project will be on optical-pump/THz-probe (OPTP) spectroscopy, an ultrafast technique that directly probes mobile charge-carriers and allows for simultaneous determination of the charge-carrier mobility and charge-carrier dynamics on a sub-picosecond timescale.[4] This technique has proven essential for studying the time-dependent optoelectronic properties of many types of semiconductors including hybrid metal halide perovskites.[5] In order to better compare bulk and nano-scale properties, the student work with a THz near-field scattering microscope for improved spatial resolution below the diffraction limit of THz radiation. Additionally, they will utilize many of the other spectroscopy and microscopy instrumentation at the university including the resources of the Warwick Centre for Ultrafast Spectroscopy (go.warwick.ac.uk/WCUS) and the Spectroscopy and Microscopy Research Technology Platforms. For specific questions regarding the project, please email Rebecca.Milot@warwick.ac.uk. More information about the Warwick Ultrafast and THz photonics group can be found on our group website: go.warwick.ac.uk/ultrafast.

References

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