Ultrafast Microscopy of Energy and Charge Transport

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The frontier in solar energy research now lies in learning how to integrate functional entities across multiple length scales to create optimal devices. Advancing the field requires transformative experimental tools that probe energy and charge transfer processes from the nano to the meso lengthscales. To address this challenge, we have been developing ultrafast microscopy as a new means to image multi-scale energy transport across both length and time scales, coupling simultaneous high spatial, structural, and temporal resolutions. In my talk, I will focus on our recent progress on visualization of exciton and charge transport in solar cell materials.

With simultaneous femtosecond temporal resolution and nanoscale spatial precision, we have recently revealed a singlet-mediated triplet transport mechanism in certain singlet fission materials [1]. Such new triplet exciton transport mechanism leads to favorable long-range triplet exciton diffusion on the picosecond and nanosecond timescales for solar cell applications.

We have also directly visualized hot-carrier migration in methylammonium lead iodide ($CH_3NH_3PbI_3$) thin films using ultrafast microscopy approaches, demonstrating three distinct transport regimes [2]. Quasiballistic transport was observed to correlate with excess kinetic energy, resulting in up to 230 nanometers transport distance that could overcome grain boundaries. The nonequilibrium transport persisted over tens of picoseconds and ~ 600 nanometers before reaching the diffusive transport limit. These results suggest potential applications of hot-carrier devices based on hybrid perovskites.

References

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(2) Guo, Z.; Wan, Y.; Yang, M.; Snaider, J.; Zhu, K.; Huang, L. Long-Range Hot-Carrier Transport in Hybrid Perovskites Visualized by Ultrafast Microscopy. *Science* 2017, 356, 59-62.

Biography

Libai Huang is currently an Assistant Professor in the Department of Chemistry at Purdue University. She received her B.S. from Peking University in 2001 and her Ph.D. from University of Rochester in 2006. She was a postdoctoral fellow at Argonne National Laboratory from 2006 to 2008. She joined the Purdue faculty in 2014 after a stay as a staff scientist at Notre Dame Radiation Laboratory. She is leading a research program aimed at directly imaging energy and charge transport with femtosecond time resolution and nanometer spatial resolution to elucidate energy and charge transfer mechanisms.