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Abstract for an Invited Paper
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Imaging energy transport and inter-particle interactions at the nanoscale

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The ability of energy carriers to move within and between atoms and molecules underlies virtually all material function. Understanding and controlling energy flow requires observing it on ultrasmall and ultrafast spatiotemporal scales, where heterogeneities and inter-particle interactions dictate material function. I will describe a novel optical ultrafast microscope based on interferometric elastic scattering that enables direct visualization of energy carrier transport in 3D with few-nm spatial precision and picosecond temporal resolution, thus acting as a contact-free, hyper-local transport measurement. I will demonstrate how this approach enables watching free charges, excitons, phonons and ions move in materials ranging from silicon to conjugated polymers via 2D transition metal dichalcogenides, cuprates and perovskites, thus providing much sought-after quantification of local mobilities for an array of photoexcited species. Finally, I will show that the extreme sensitivity of our approach to quasiparticle density provides a powerful opportunity to explore how many-particle interactions between free charges, excitons, phonons and defects emerge and contribute to material function in correlated materials.