PEROVSKITE PHOTOVOLTAICS

Electrons stay hot

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Organic–inorganic halide perovskites have been demonstrated to possess long-lived high energy electrons (known as 'hot' electrons) that could be exploited in hot carrier solar cells, the efficiencies of which could surpass that of conventional cells. The large dynamic lattice disorder in perovskites is associated with the existence of long-lived hot electrons because of the coupling of electronic excitations and lattice vibrations, commonly referred to as electron–phonon interactions, although the physics behind this is not yet clear. If phonons, particularly their acoustic or 'in-phase' modes that are responsible for heat dispersion, have short lifetimes then hot electrons will cool slowly. This enabled the harvesting of their extra energy before it is converted into heat. Now, Michael Toney and colleagues in the United States, United Kingdom and South Korea provide strong evidence showing acoustic phonon lifetimes to be less than 20 ps, which is significantly shorter than those of other semiconductors such as Si or GaAs.

By means of high-resolution inelastic neutron spectroscopy, the researchers probe the dispersion and lifetime of acoustic phonons in deuterated methylammonium lead iodide ($MAPbI_3$) single crystals. They observe that acoustic phonons have short lifetimes, which vary from 1 to 20 ps across the Brillouin zone, and a mean free path of 0.5 to 7 nm, which translates into inefficient heat dissipation. This behaviour is ascribed to a strong three-phonon interaction induced by the motions of the organic cations coupled with the Pb–I framework. As a consequence, hot electrons are inhibited from dissipating their extra energy. These findings underpin the potential of hot-carrier perovskite photovoltaics and offer guidance on how to enhance and harvest long-lived hot electrons.

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