The combination of properties halide perovskites (HPs) possess (e.g., high absorption coefficient, low defect density, long carrier lifetimes, etc.) should (and does) allow high-performing optoelectronic devices. Their relatively low carrier mobility, however, is one fundamental property that does not fit the expected prognosis. When comparing mobility values of HPs (1-100 cm²/Vs) with high-quality heteropolar semiconductors, such as GaAs or CdTe (10⁶-10⁷ cm²/Vs), a significant difference is revealed. Here we show that mobility temperature dependence of HPs, as well as other low-defect density heteropolar semiconductors, is found to exhibit scattering by ‘polar optical phonons’ (POP), or dipoles formed during thermal fluctuations. We explain why the mobility in soft heteropolar materials, like HPs, will never be as high as for other, more rigid, heteropolar semiconductors, but also show that their softness is responsible for the potential to be more defect-tolerant that more rigid systems.

**Charge mobility temperature dependence**

The temperature dependence of carrier mobility in HPs can be described by the following equation:

\[ \mu(T) = \frac{q}{m^* e} \frac{1}{\tau_{total}} = \frac{1}{\tau_{H1} + \frac{1}{\tau_{ADP}} + \frac{1}{\tau_{POP}}} \]

where \( \tau_{H1} \) is the carrier lifetime due to ionized impurities, \( \tau_{ADP} \) is the carrier lifetime due to acoustic phonons, and \( \tau_{POP} \) is the carrier lifetime due to optical phonons.

**Deflection potential, \( d' \)**

The deflection potential \( d' \) is given by the formula:

\[ d' = B \frac{\Delta E_g}{\Delta P} \]

where \( B \) is the bulk modulus, \( \Delta E_g \) is the change in the bandgap, and \( \Delta P \) is the change in pressure.

**Temperature dependence**

Using experimentally-based relevant parameters (from literature) such as: effective mass \( m^* \), lowest longitudinal optical phonon frequency \( \omega_{LO} \), the dielectric constant at optical \( (\varepsilon_{opt}) \) and static/low \( (\varepsilon_\infty) \) frequencies and defect density (Iionized, \( N_i \), at high temp.; neutralized, \( N_0 \), at low temp.) of \( 10^9 \) cm⁻³.

The softer the materials (i.e., lower \( d' \)), the higher the probability that the scattering will be due to POP, rather than by deformation potential or impurities.

**Exploring scattering by POP**

Scattering potential \( U_{POP}(\varepsilon) \propto \frac{q^2}{\varepsilon_{opt}} \)

Effective charge density during vibration in a heteropolar system \( q^2 \propto \varepsilon_{opt} \left( \varepsilon_{opt} - 1 \right) \propto \omega_{LO} \left( \frac{1}{\varepsilon_\infty} - 1 \right) \propto \frac{\omega_{LO}}{\varepsilon_\infty} \)

We conclude that ‘soft’ materials are regarded as such with highly-polarizable bonds (i.e., \( \varepsilon_{opt} \approx 2 \cdot \varepsilon_\infty \)), where \( d' \) is expected to be positive, suggested to possess in-band berried defect states, and therefore, defect tolerant (see 2).

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**References**

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