Band transport by large Fröhlich polarons in MXenes

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Abstract
MXenes are newly emerging layered two-dimensional materials with great promise for electrochemical energy storage and (opto)electronic applications.[1] A fundamental understanding of charge transport in MXenes is essential for such applications, but has remained under debate. While theoretical studies pointed to efficient band transport[2], device measurements have revealed thermally activated, hopping-type transport[3].
Here we present a unifying charge transport picture in two model MXenes by combining ultrafast terahertz and static electrical transport measurements to distinguish the short- and long-range transport characteristics.[4] We find that band-like transport dominates short-range, intra-flake charge conduction in MXenes, whereas long-range, inter-flake transport occurs through thermally activated hopping. Our analysis of the intra-flake, i.e., inherent charge transport, shows that carrier scattering is dominated by scattering from longitudinal optical phonons with relatively weak electron-phonon coupling (coupling constant $\alpha \approx 1$) in MXenes. The weak electron-phonon coupling gives rise to the formation of large polarons in MXenes: electrons and holes locally deform the lattice, and are dressed by a lattice distortion extending over several lattice units. Our work provides insight into the polaronic nature of free charges in MXenes, and unveils intra- and inter-flake transport mechanisms in the MXene materials, relevant for both fundamental studies and applications.

Reference
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Figures

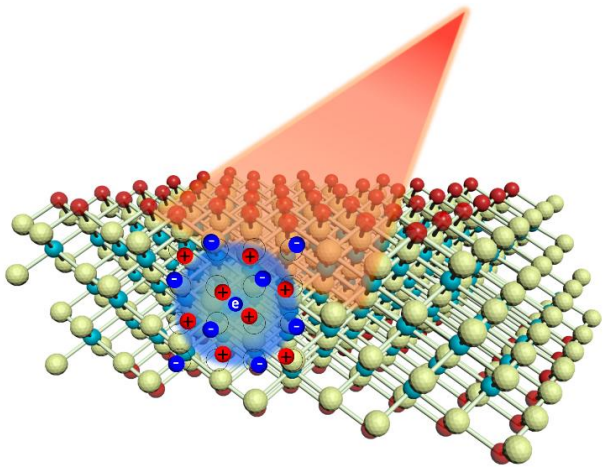

Figure 1: Schematic of large polaron formation in MXenes following optical excitations.