Determining electron and phonon contributions to thermal transport in single-flake metallic $Ti_3C_2T_x$ MXene using spatiotemporal microscopy

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MXenes, a class of two-dimensional materials, promise scalable production through chemical etching of MAX phases [1,2]. Their metallic nature enables application in e.g. thermal management, sensing, electromagnetic interference shielding and energy storage. Despite these promises, there is still debate about some key properties, even for the most-studied variant, $Ti_3C_2T_x$. Substantially varying values for the in-plane thermal conductivity are reported, while the roles of electrons and phonons in this transport remain unclear [3,4].
One of the reasons for this variation in reports is that earlier thermal measurements have been performed on thin films of many overlapping flakes, which obscures the intrinsic material properties. To resolve this issue, we study the in-plane thermal conductivity of single-flake $Ti_3C_2T_x$ MXene using spatiotemporal microscopy [5,6,7]. This technique directly visualises heat transport in space and time in few-micrometer sized areas. These measurements show thermal diffusivity of 0.05 cm^2s^{-1}, corresponding to an in-plane thermal conductivity of 13.5 $Wm^{-1}K^{-1}$.
To unravel the roles of electrons and phonons in this thermal transport, we calculated the electronic contribution with the Wiedemann-Franz law. Using the THz conductivity [8], we find that the electronic contribution is less than 50% of the thermal conductivity. This phonon-domination contrasts with the usual behaviour of metals, where electrons dominate, and opens new ways to control thermal transport in MXenes for, e.g. active thermal management.

References

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