Net negative contributions of free electrons to the thermal conductivity of $NbSe_3$ nanowires

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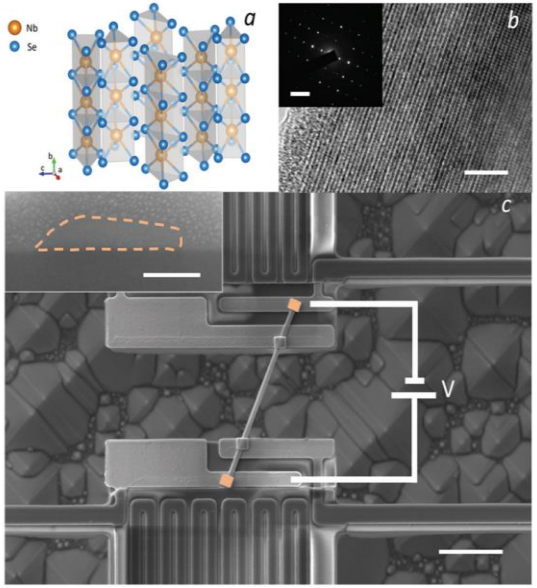
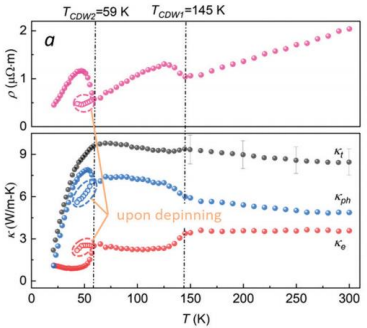
The electron and phonons are two major energy carriers in solids. It is widely believed that a higher concentration of electrons should lead to a higher thermal conductivity; however, because of the electron-phonon interaction(e–ph), the free electrons also scatter phonons to lower the lattice thermal conductivity. Since the role of e-ph interaction in thermal transport has not been well studied, the net contribution of the free electrons is still unclear. In a user project led by Dr. Li(Vanderbilt), they report the experimental studies of e-ph scattering on quasi-one-dimensional $NbSe_3$ nanowires. The $NbSe_3$ nanowires are exfoliated from the $NbSe_3$ single crystals grown by 2DCC researchers using the chemical vapor transport method. The experimental results of this user project indicate that the e-ph scattering in $NbSe_3$ nanowires is enhanced as free electrons are condensed during the charge density wave transition, thus resulting in the decrease of overall thermal conductivity. This study not only reveals a net negative contribution of the free electron due to escalated e-ph scattering, but also provides insight into the competing roles of free electrons, which could result in unexpected trends in thermal conductivity.





Upper Left: Crystal structure and HRTEM image of $NbSe_3$.
Lower left: SEM image of the suspended $NbSe_3$ microdevice for thermal and electrical measurements.
Right: Resistivity (upper) and thermal conductivity (lower). K_t, K_e, K_{ph} represent the total, electronic and lattice thermal conductivity respectively.

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