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(G*) High carrier mobility and anisotropic electronic structure in double-helix SnIP nanowires

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SnIP is an exciting new quasi-1D van der Waals semiconductor with a unique double-helix structure at the atomic scale that shows promise as a new material for flexible electronics. However, due to the high resistivity of as-grown SnIP its true potential is not clear. In this work, we study SnIP-nanowire thin films using time-resolved THz spectroscopy (TRTS), a powerful ultrafast optical tool that enables picosecond-resolution measurement of the complex photoconductivity spectrum. Modeling the dispersion of the conductivity allows us to extract the carrier scattering rate, however, the choice of model can yield different values. We discuss our results in terms of the two most common models in the field, the Drude-Smith model and the plasmon model, and show how fluence-dependent spectroscopic studies can be used to differentiate the two experimentally. Moreover, with knowledge of the effective mass, the scattering rate enables us to calculate the carrier mobility. We performed an ab-initio study of the electronic structure in SnIP and extracted the effective mass tensor for several bands near the Fermi level. Along with the carrier scattering rate, we find a carrier mobility as high as 280 cmˆ2 Vˆ-1sˆ-1, which is remarkably high for such a soft and flexible material and suggests that it is ideally suited for flexible electronics. Moreover, we find a large anisotropy in the electronic structure, which is due to the low symmetry and unique bond arrangement in SnIP. In the effective mass approximation, the preferred transport direction is band dependent, with preferential electron and hole transport parallel and perpendicular to the double-helix axis, respectively. Furthermore, we show that over a wide range of energies the conduction band dispersion shows quasi-2D behavior and discuss possible experimental evidence of this in our TRTS data.

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