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Photoconductivity of SnIP Semiconducting Inorganic Double Helices

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Recently synthesized, tin iodide phosphorus (SnIP) is the first of a new class of materials with carbon-less double-helix structure [1]. Unlike DNA, which consists of two equal-radius helices, the SnIP double helix consists of an outer SnI chain with 0.98 nm diameter wrapping around an inner P chain. Bulk SnIP consists of bundles of needles weakly bound through Van-Der Waals forces to form long needles. SnIP is predicted to be a semiconductor, which is validated by diffuse reflectivity and photoluminescence measurements that indicate a band gap of 1.8 eV [1].

Interestingly, the weak inter-helix bonding means that the SnIP needles have favorable mechanical properties, and an individual SnIP needle can be bent to 90 degrees, which, combined with the predicted high mobility (greater than 2000 cm2 V-1 s-1 [2]), suggests possible applications in flexible electronics. Additionally, the quasi-1D crystal structure suggests an effective reduction of dimensionality, which should result in highly anisotropic transport properties where photoexcited electrons are confined to move along the axis of the helices.

Here we present recent results probing bulk and delaminated SnIP needles with time-domain terahertz spectroscopy (THz-TDS) and time-resolved THz spectroscopy (TRTS) [3]. TDS measurements reveal the presence of a strong vibrational mode in the middle of the THz spectrum. Comparison with quantum chemical calculations shows that motion in this frequency range can be assigned to vibrations of the outer SnI helix. TRTS measurements, using both sub gap and above gap excitation, reveal recombination dynamics that follow a stretched exponential and power law decay respectively, with lifetimes of tens of picoseconds. An increasing lifetime with excitation fluence suggests that these dynamics are governed by saturation of trap states at high injection levels. Finally, we will discuss progress towards synthesis of aligned SnIP samples suitable for exploration of the anisotropic photoconductivity.

[1] D. Pfister et al., "Inorganic Double Helices in Semiconducting SnIP," Adv. Mat. 28, 9783 (2016).
[2] X. Li et al., "Landscape of DNA-like inorganic metal free double helical semiconductors and potential applications in photocatalytic water splitting," J. Mater. Chem. A 5, 8484 (2017).
[3] P. U. Jepsen et al.., "Terahertz spectroscopy and imaging - Modern techniques and applications," Laser Photonics Rev. 5, 124 (2011).

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