Tunable photodetectors via *in situ* thermal conversion of TiS_3 to TiO_2

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Low-dimensional semiconductors are attracting the interest of the scientific community working on optoelectronic devices. These materials can be interesting to explore for band engineering given the large surface-volume ratio which gives access to the entire material for modification. TiS_3 is a layered semiconductor which attracted much attention recently thanks to its stunning electronic and optoelectronic properties and its technologically relevant bandgap of 1.1 eV [1]. The layered nature of TiS_3 gives an easy route for the intercalation of oxygen allowing an efficient oxidation of the material. This process is accompanied by a large change in the material bandgap and structure [2].

In this presentation we explore the possibility of thermally converting TiS_3 nanoribbons to the oxide counterpart in a controlled way. We first study the oxidation of TiS_3 in powder form and for single nanoribbons deposited on a glass substrate. Using Raman spectroscopy and optical analysis we can monitor the material properties as a function of time while heating up to 350 °C. We find that an individual TiS_3 nanoribbon converts to crystalline TiO_2 in approximately 15 minutes. Control experiments performed on TiS_3 nanoribbons fully encapsulated between hexagonal boron nitride flakes confirm the intercalation of oxygen leading the conversion process. After establishing the change in material properties we perform controlled oxidation of a TiS_3 nanoribbon phototransistor. We monitor the change in current-voltage characteristics of the device and in spectral photoresponse. The device, which in its pristine state has a cut-of frequency above 650 nm, experiences a blue-shift reaching a final cut-off frequency of 450 nm. Various intermediate states are observed, demonstrating the tunability of the material bandgap.

References

[1] Island, J.O., et al., *TiS_3 transistors with tailored morphology and electrical properties,* Advanced Materials, 2015, **27**: p. 2595.
[2] Iyikanat, F., et al., *Vacancy formation and oxidation characteristics of single layer TiS_3, J. Phys. Chem. C*, 2015, **119**: p. 10709.

Figures

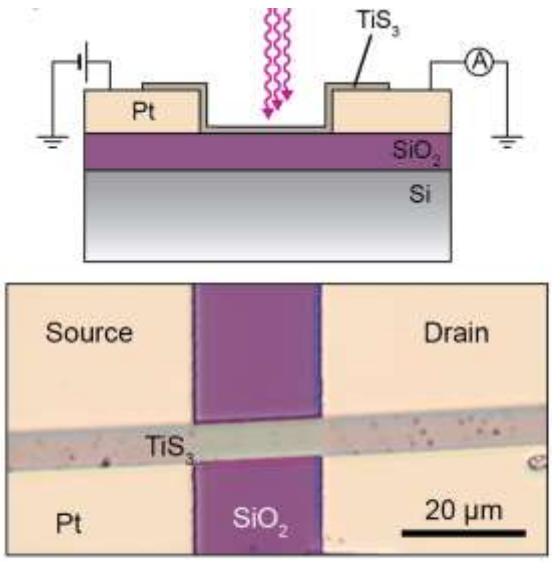

Figure 1: Schematic of a TiS_3 photodetector (top) and optical microscope image of a real device (bottom).