Predictive Phase and Point Defect Control in PV Semiconductors (PV-4)

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Scientific Achievement:

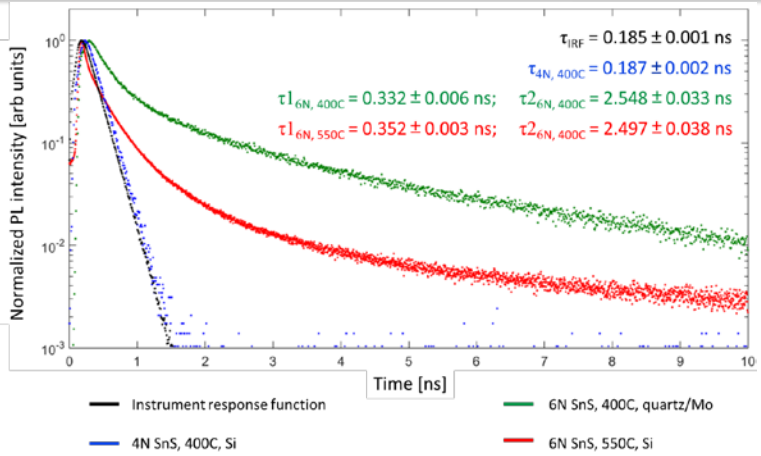
We hypothesized that extrinsic point defects are a limiting factor in tin sulfide (SnS). Our baseline material, grown using 99.99% ("4N") pure material, exhibits ~100 ns minority-carrier lifetime. We grew SnS using 6N pure feedstock and observed luminescence decays > 1 ns, constituting a significant improvement over the baseline.

Significance and Impact:

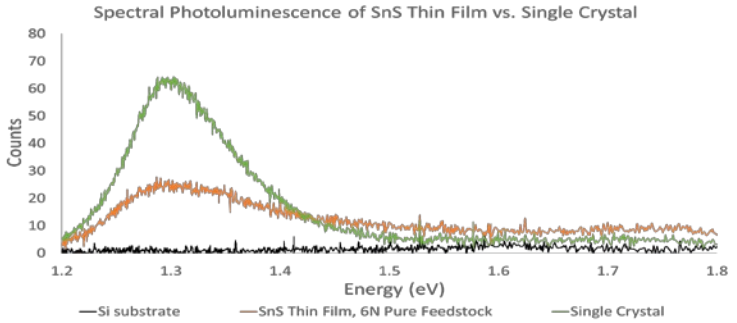
Device modeling for SnS photovoltaics indicates that > 1 ns lifetimes are required for 10+%-efficient devices [see publication]. We have achieved decay constants of > 1 ns, thus potentially paving the way for higher-efficiency devices.

Research Details:

- 6N pure Sn was sulfurized in H_2S gas until pure-phase SnS was achieved.
- Luminescent decay is used as a proxy for minority-carrier lifetime. This is measured using time-correlated single photon counting (TCSPC).
- Films grown using 6N material exhibit > 1 ns decay constants, constituting an ~1 order-of-magnitude improvement over baseline.
- Spectral photoluminescence confirms luminescence from the 1.3-eV direct bandgap of SnS.
- Initial impurity content analysis indicates a reduction of Sb in films from 6N feedstock, but quantification over a wider range of elements is necessary.



Luminescent decay of SnS films grown using 4N and 6N-pure feedstocks. Films from 6N feedstock show decay constants above 1 ns.



Spectral photoluminescence of SnS films from 6N feedstock compared vs. SnS single crystals. A peak is seen at 1.3 eV, corresponding to the SnS direct bandgap.

Publication(s): Mangan, N.M., Brandt, R.E., Steinmann, V., Jaramillo, R., Li, J.V., Poindexter, J.R., Hartman, K., Sun, Leizhi, Gordon, R.G., and Buonassisi, T., A path to 10% efficiency for tin sulfide devices, *Photovolt. Spec. Conf. PVSC 2014 IEEE 40th*, 2373–2378, 2014.

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