Building an All-Sulfide TaS_2/Cu_2-II-Sn-S_4/CdS Solar Cell and Putting it on Silicon

Crovetto, Andrea; Assar, Alireza; Nielsen, Rasmus; Hansen, Ole; Seger, Brian; Chorkendorff, Ib; Vesborg, Peter

Publication date:
2020

Document Version
Publisher's PDF, also known as Version of record

DTU Nanotech
Department of Micro- and Nanotechnology

DTU Physics
Department of Physics

HZB Helmholtz Zentrum Berlin

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Building an All-Sulfide TaS_2/Cu_2-II-Sn-S_4/CdS Solar Cell and Putting it on Silicon

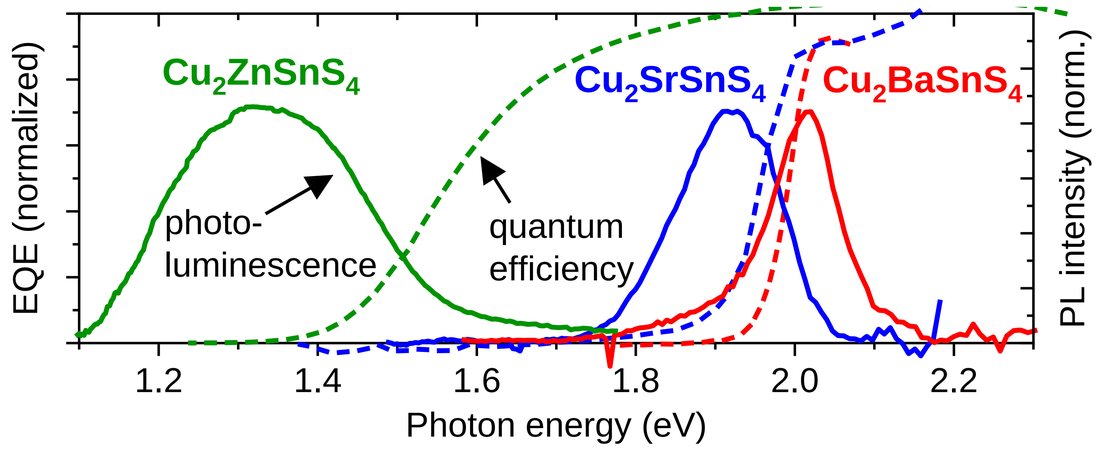
Andrea Crovetto*[1,2,3], Alireza Hajijafarassar[4], Rasmus Nielsen[1], Ole Hansen[4], Brian Seger[1], Ib Chorkendorff[1], Peter Vesborg[1]

[1] DTU Physics, Technical University of Denmark, [2] Helmholtz Zentrum Berlin (Germany) [3] National Renewable Energy Laboratory (USA) [4] DTU Nanolab, Technical University of Denmark

Cu_2-II-Sn-S_4 photoabsorbers

- Cu_2ZnSnS_4 is earth-abundant and non-toxic but it suffers from tail states and defects
- When replacing **Zn** (Group IIB) with **Sr or Ba** (Group IIA):
  1. Band gap increases from 1.5 eV to 2.0 eV
  2. Less tail states. Smaller photoluminescence - band gap shift

Cu_2SrSnS_4 and Cu_2BaSnS_4: ideal top absorbers for tandem solar cells?



Single-junction cells with a TaS_2 back contact

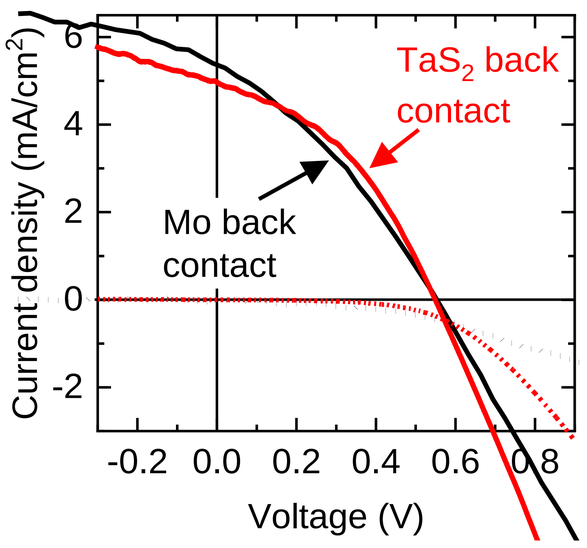
- Mo is the standard hole contact in $CuInSe_2$-inspired cells. However:
  1. Wider band gap absorbers require a a higher work-function hole contact
  2. The interfacial MoS_2 layer has a lower band gap than Cu_2SrSnS_4 and Cu_2BaSnS_4 ➔ losses are likely

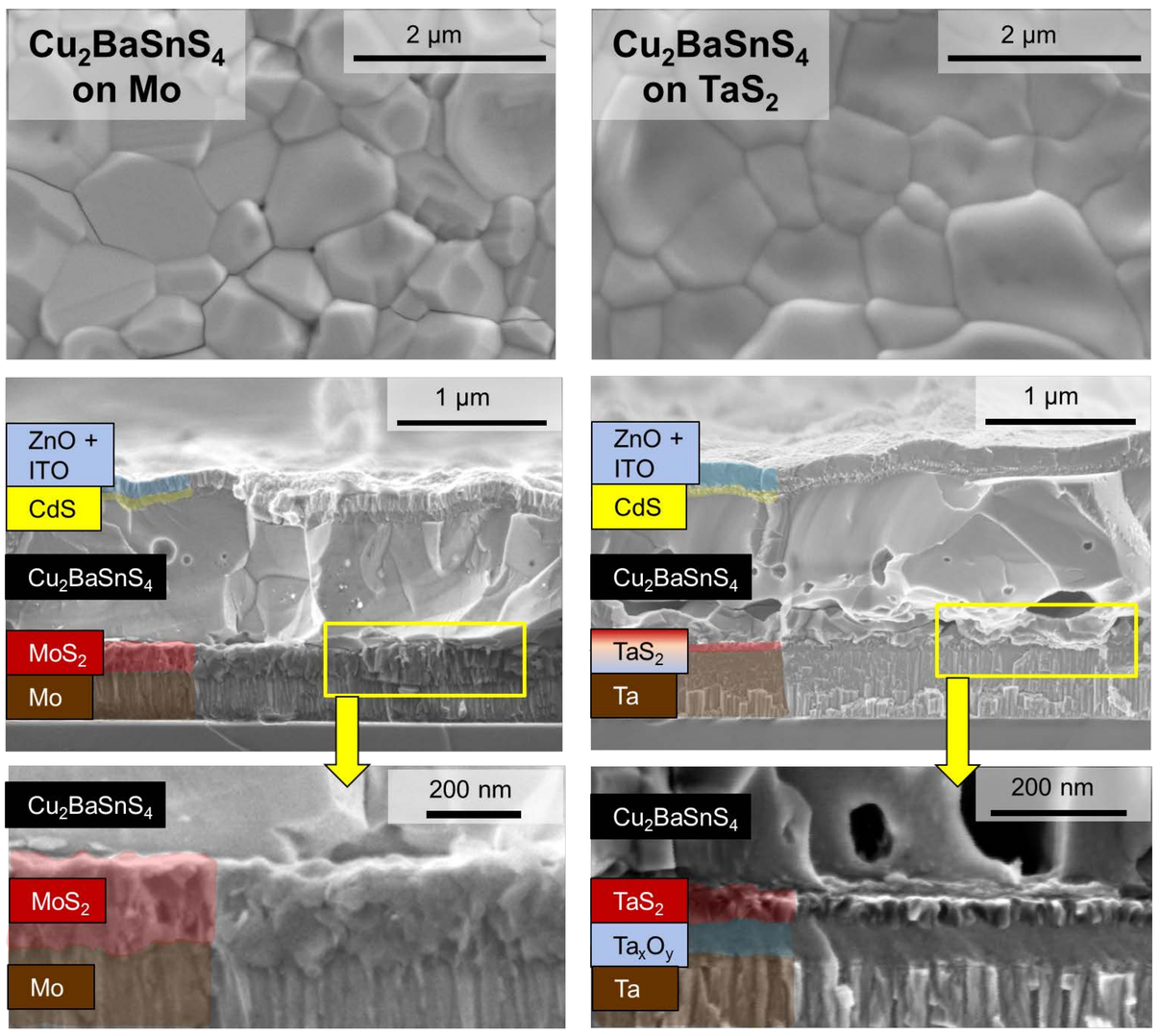
- **TaS_2** is a high work-function (5.2 eV) **metallic** compound, which forms naturally when the absorber is deposited on Ta

- Cu_2BaSnS_4 efficiency **improved** with a TaS_2 back contact!

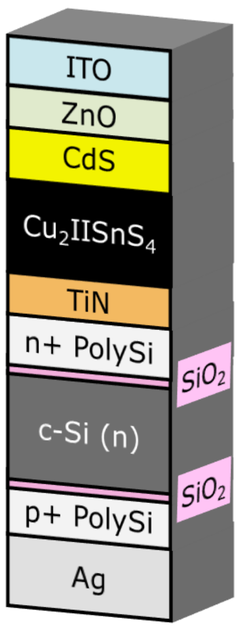
Fabrication

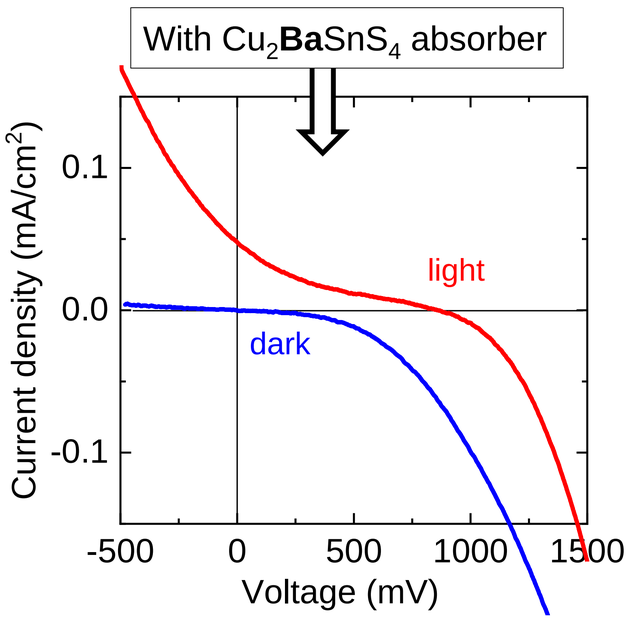
- Co-sputtering of **oxide** (Cu_2IISnO_4) precursors from metal targets
- Sulfurization at **520-550°C** in H_2S
- For tandem cells: 5-10 nm **TiN** recombination layer by ALD

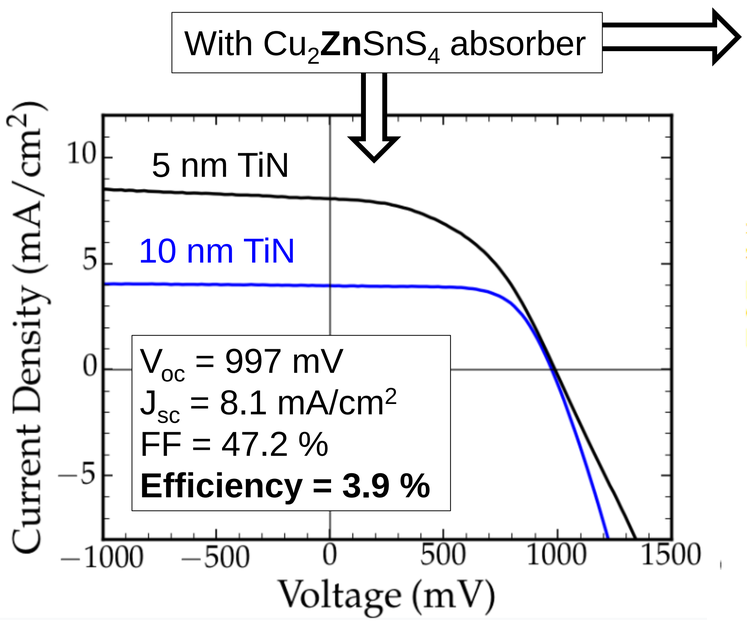


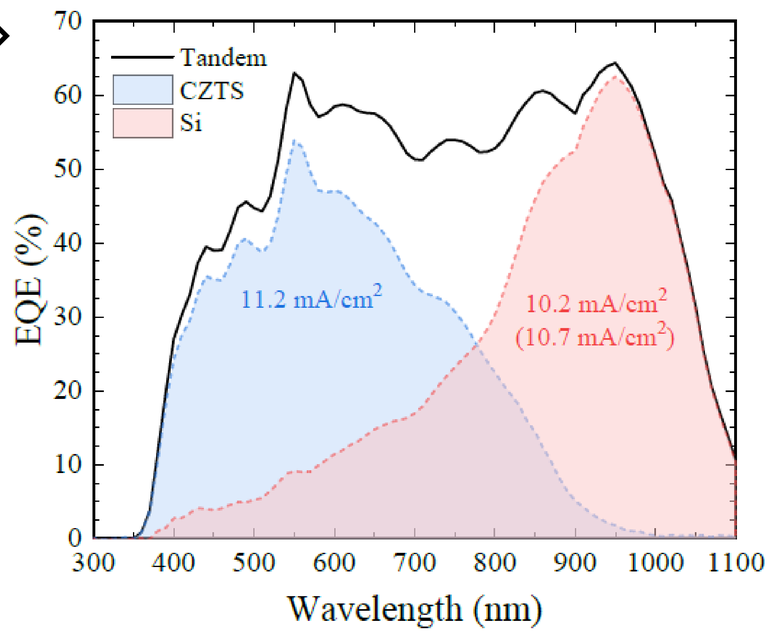


Tandem cells (monolithic) with a TiN barrier layer









Conclusion

- **Cu_2SrSnS_4** and **Cu_2BaSnS_4** are promising top absorbers for tandem solar cells
- **TaS_2** is the first successful example of a transition metal chalcogenide hole contact in solar cells!
- Monolithic tandem cells with Cu_2IISnS_4 on silicon are possible
  - ✓ **3.9%** tandem efficiency (world record) with minimal sulfurization damage to the silicon cell

More details

- A. Crovetto et al., *ACS Appl. Energy Mater.* **2**, 7340 (2019)
- Hajijafarassar, Martinho et al., *Sol. Energy Mater. Sol. Cells,* submitted

Acknowledgments

This work was supported by VILLUM Fonden (grant no. 9455) and the Innovation Fund Denmark (grant no. 6154-00008A). This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 840751.

THE VELUX FOUNDATIONS
VILLUM FONDEN × VELUX FONDEN

andrea.crovetto@helmholtz-berlin.de