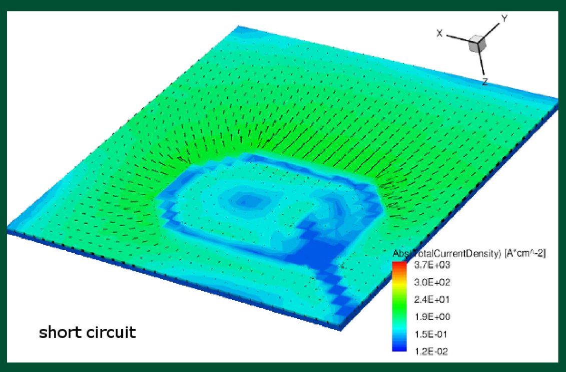
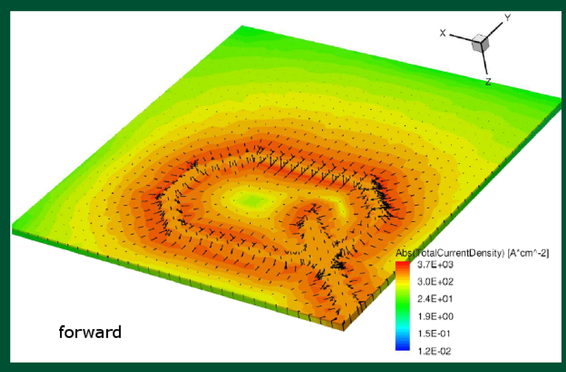


Solar Cell Simulation

from microscopic properties to external parameters



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Intro

We employ different models to investigate the connection between micro-physical features of solar cell devices and external parameters like current-voltage characteristics, the essence being solar cell energy conversion efficiency.

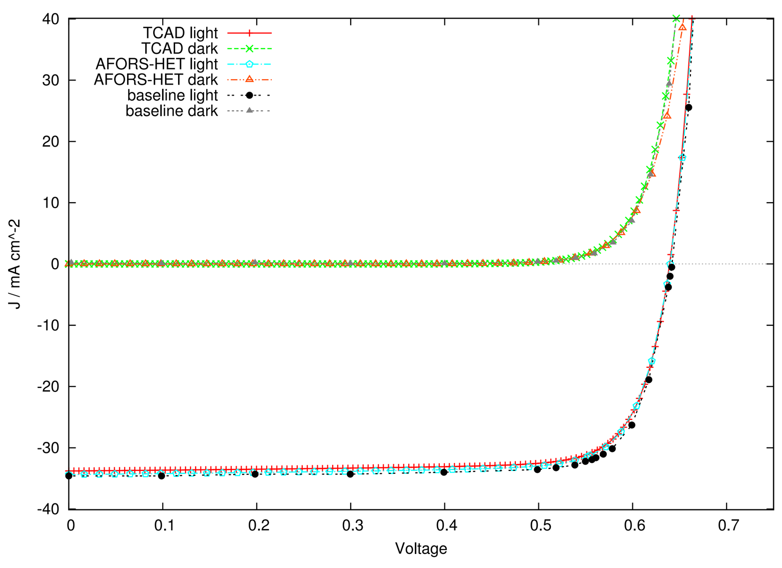
In the context of GRACIS, we are especially interested in the effects of gradients, those being embodied as variations in chemical composition (band-gap gradient, defect inhomogeneities) or simply as the presence of polycrystalline grain boundaries.

Currently used tools:

- 1D model AFORS-HET from Helmholtz-Zentrum Berlin
- 1D/1D/3D general purpose device simulator Synopsys Sentaurus TCAD (Sentaurus Device)

Model inter-comparison

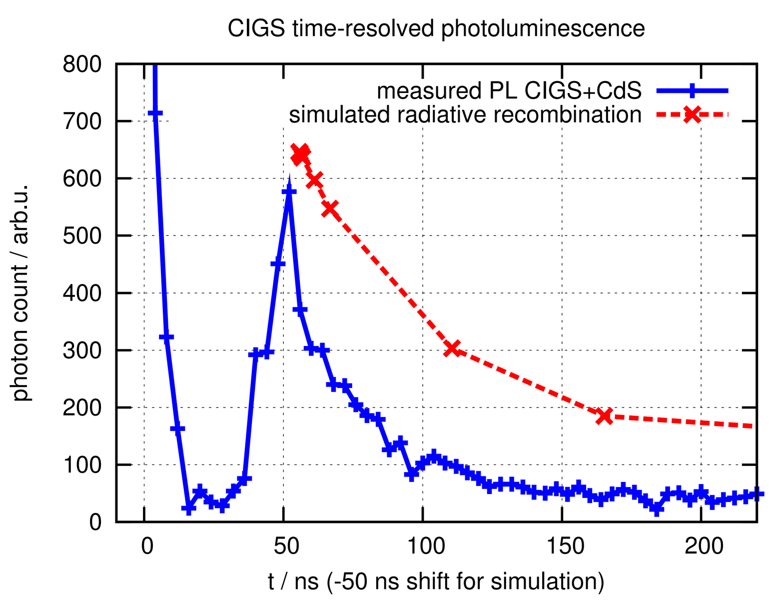
A recurring procedure is running comparable configurations in different models to verify the results against each other and/or against literature values.

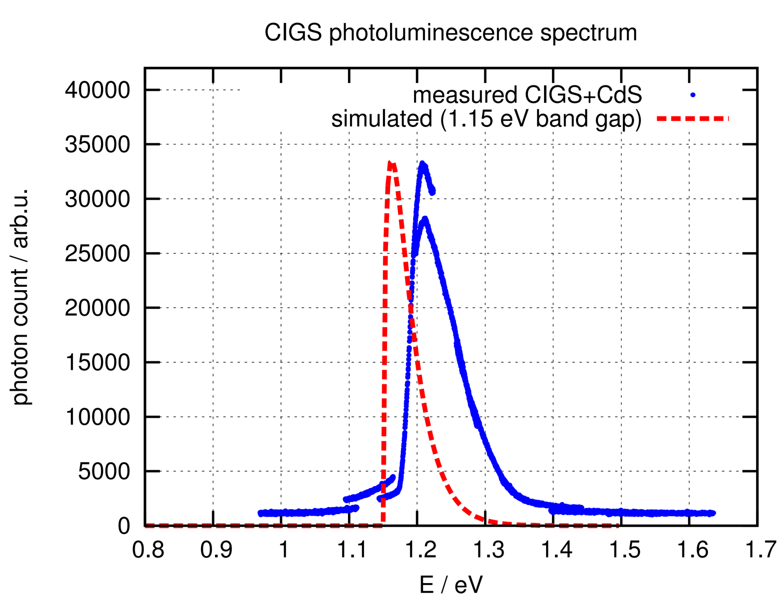


The example on the left shows an early J-V comparison of our models with the baseline set by Gloeckler et al.

Photoluminescence

In our group, the simulation efforts are also combined with experimental work on photoluminescence of CIGS layers. A measurement site for investigating time-resolved laser-induced luminescence to experimentally access carrier lifetime is being established.

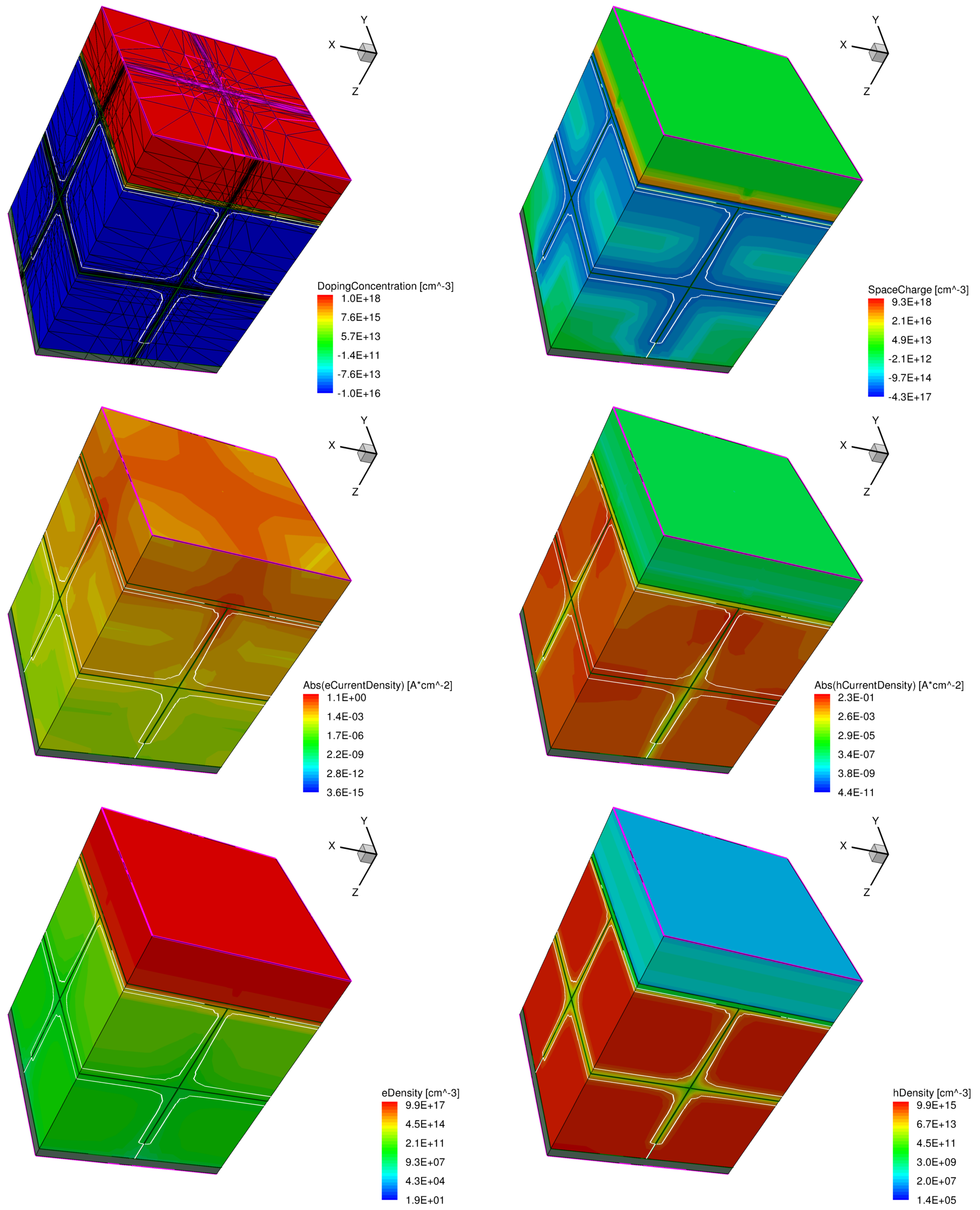




The connection between external signal and the underlying physics is being investigated using Sentaurus TCAD, with the option to include 3D structural layer features. Both the experimental and the simulation setup are under construction, but some preliminary results can be compared qualitatively.

3D Simulation

The main goal is to establish detailed 3D models incorporating the micro-physical structure of CIGS layers. A basic 3-layer setup (2 um CIGS / 50 nm Cds / 500 nm ZnO) is shown here, with cubic grains of 1 um edge length.



These plots show a selection of views on the model state under AM1.5 illumination and at operating bias (0.6 V). The grain boundaries included here consist mainly of a large surface defect density, having a negative effect on device performance (from ca. 23% for single crystal down to around 10%).

References

- Sentaurus TCAD: http://www.synopsys.com/tools/tcad/
- AFORS-HET: http://www.helmholtz-berlin.de/forschung/enma/si-pv/projekte/asicsi/afors-het/index_de.html
- M. Gloeckler et al: *Numerical Modelling of CIGS and CdTe Solar Cells: Setting the Baseline'*, 3rd World Conference on Photovoltaic Energy Conversion, Osaka, 2003
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- W. K. Metzger, R. K. Ahrenkiel, J. Dashdorj, and D. J. Friedman: *Analysis of charge separation dynamics in a semiconductor junction*, Phys. Review B 71, 035301 (2005), DOI: 10.1103/PhysRevB.71.035301

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