Two-scale impedance simulation for failure detection in PV modules

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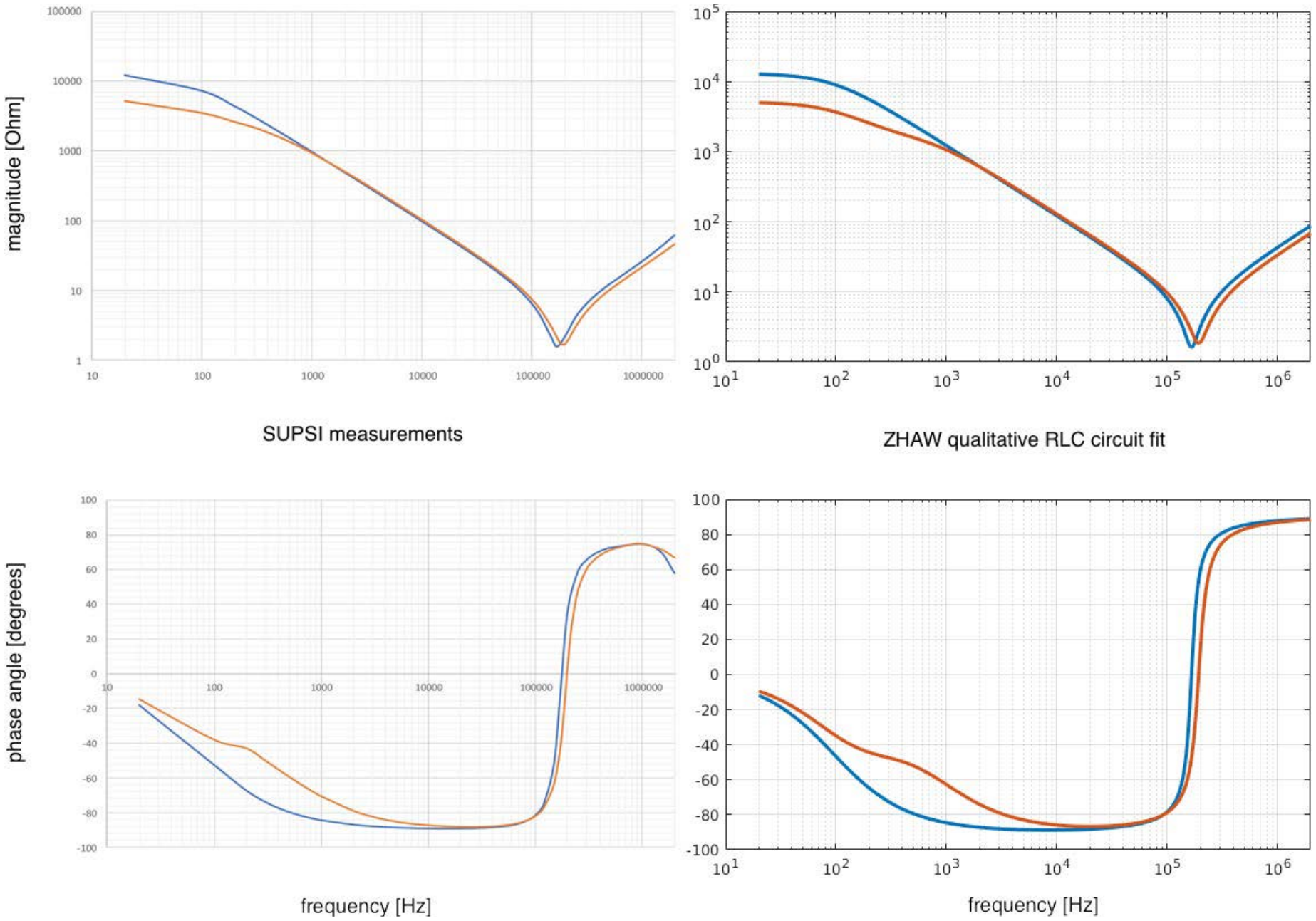
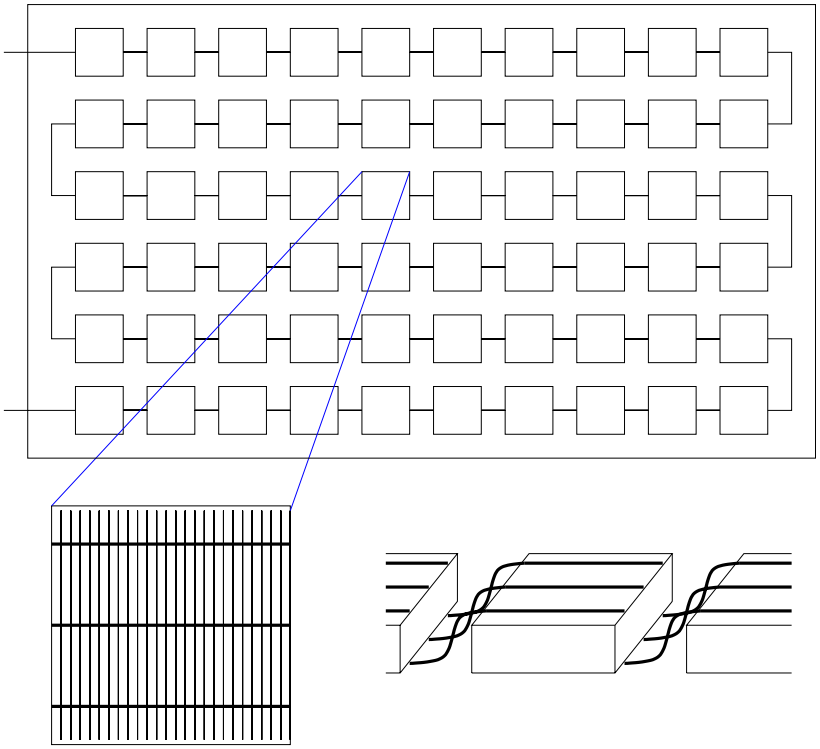
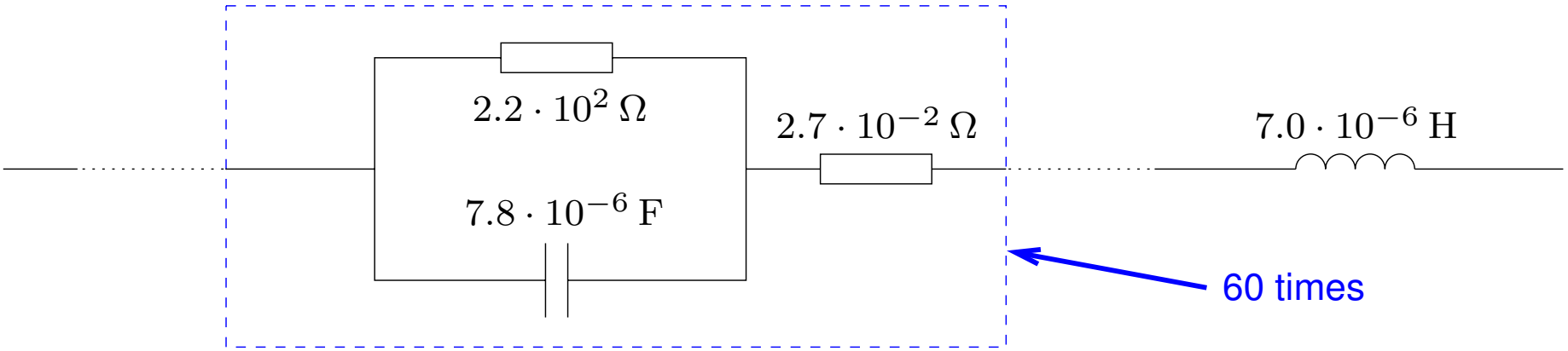
Module scale: impedance measurement and fit



top-down approach: equivalent circuit modeling

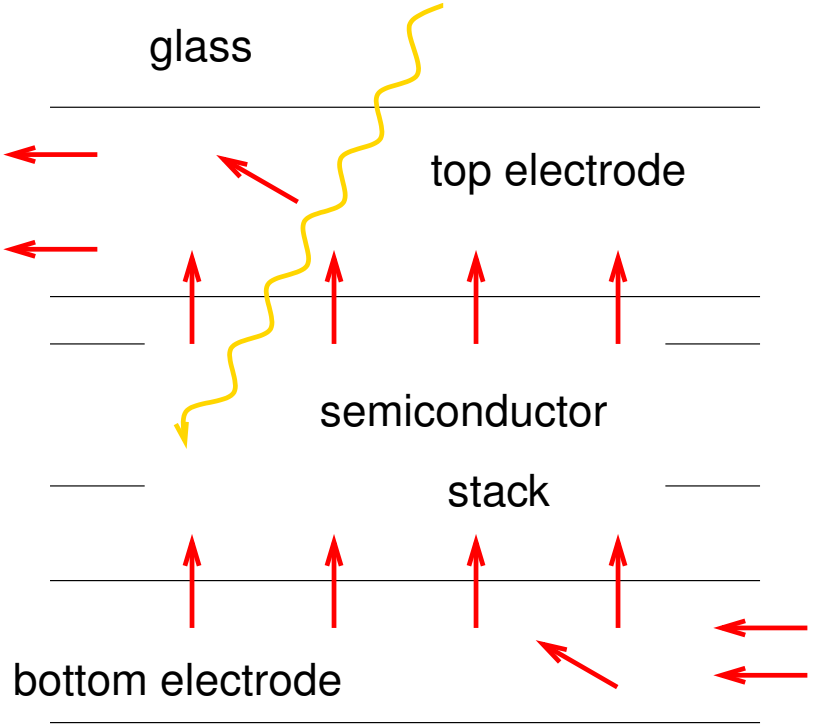


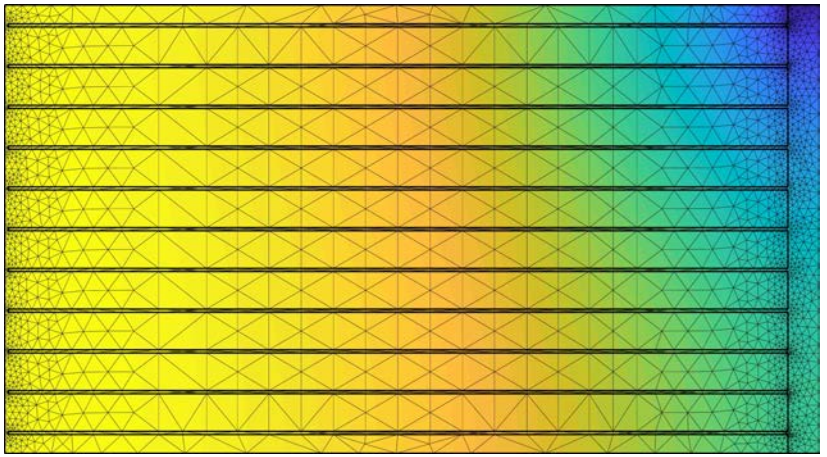
By using an RC circuit as the small-signal model for each cell, and assuming a connection in series, plus a (cumulative) inductance arising from the wires, we obtain an equivalent circuit with the following estimated parameters:



bottom-up approach: cell-scale simulation

- At ZHAW-ICP: cell-scale results from fundamental material properties, for a prescribed cell geometry.
- 1D-2D coupled mathematical model for
  - (vertical) charge transport in semiconductor stack,
  - (lateral) charge transport in electrodes.
- Numerical simulation by the finite element method.





Available simulation software at ZHAW-ICP

We have simulation software available for both steady-state (DC) and small-signal (AC) analyses, and for both small-area and large-area devices:

	steady state (DC)	small signal (AC)
small area (1D)	✓	✓
large area (1D-2D)	✓	under development

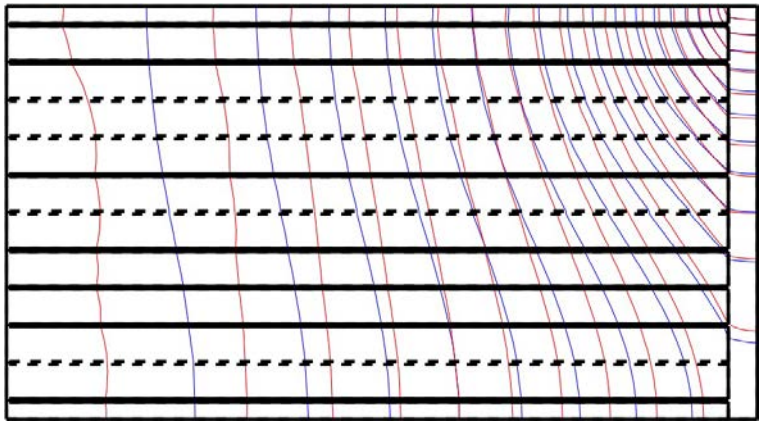
Furthermore, the software products Setfos and Laoss by Fluxim AG can be used for these simulations.

setfos 4.5
semiconducting thin film optics simulation software

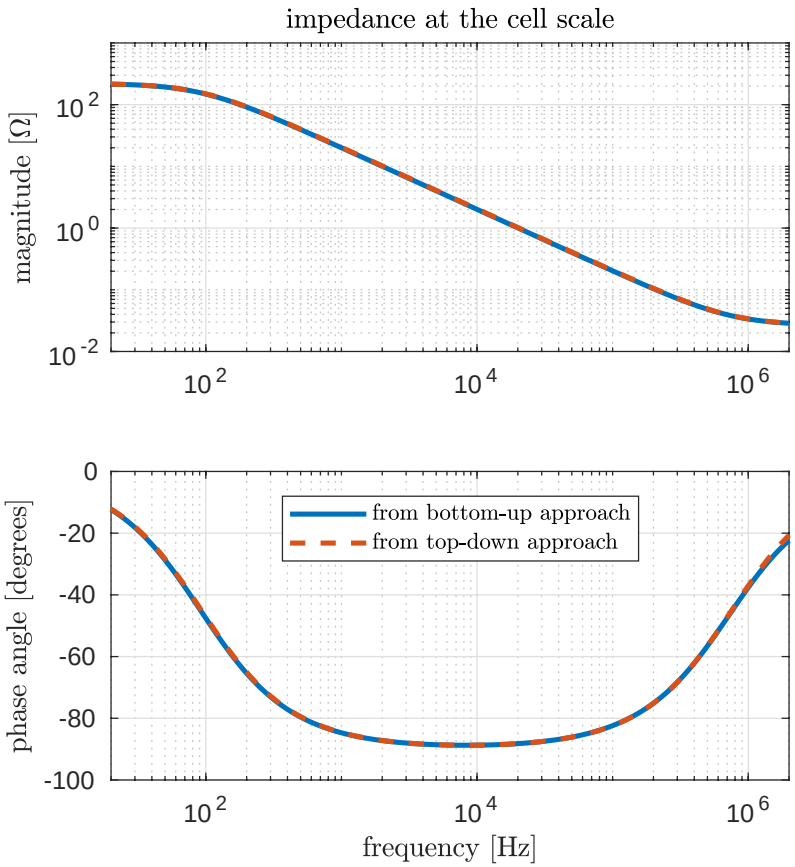
laoss 2.1
Simulation software for
design and optimization of large-area
OLEDs, solar cells and modules

cell-scale simulation results

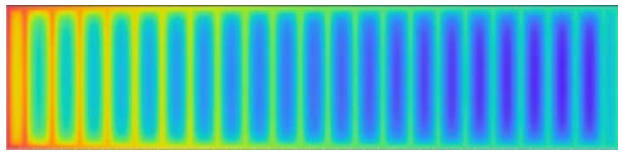
steady state:

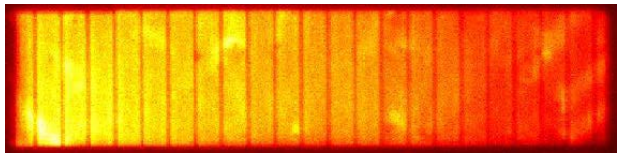


impedance:



electroluminescence (simulated in Laoss and measured):

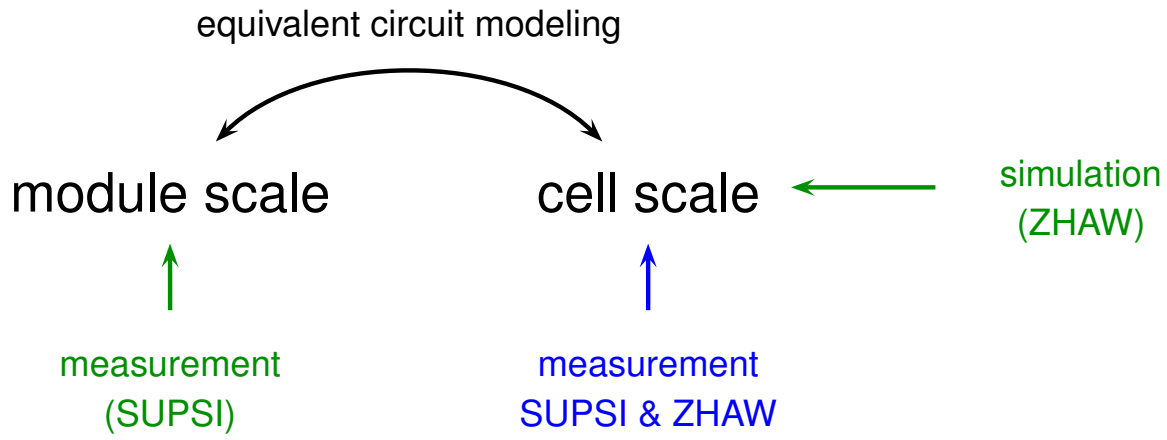




(by M. Diethelm, now at Empa, Functional Polymers group)

Summary of the proposed two-scale approach

Our proposed two-scale method joins the top-down and bottom-up approaches:



Cell-scale measurements may be carried out using hardware product Paios by Fluxim AG. V/UHF measurements at SUPSI.

paios
The revolutionary platform for all-in-one characterization of solar cells and OLEDs

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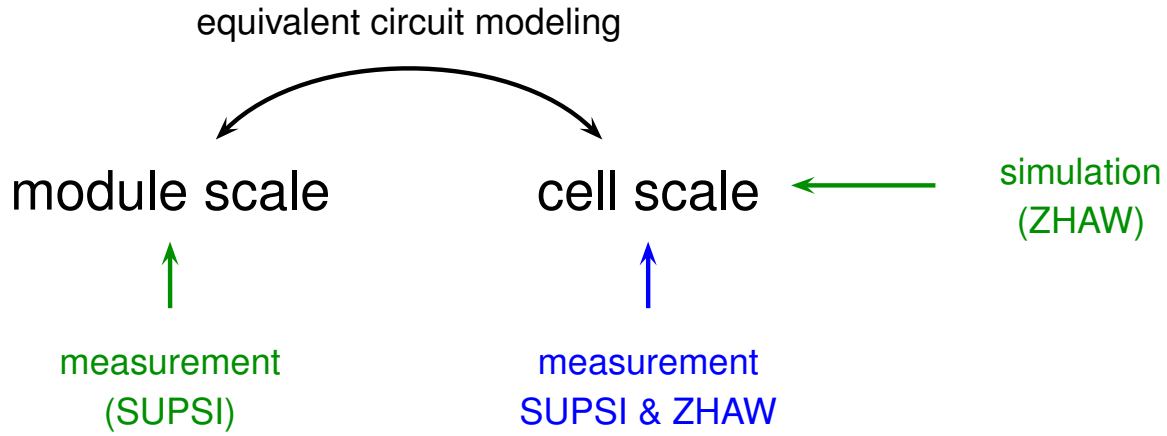

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We are looking for industry partners to collaborate in a CTI R&D project.