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Frequency Dependence of Modulated Surface Photovoltage (SPV) to Characterize Surface Defects

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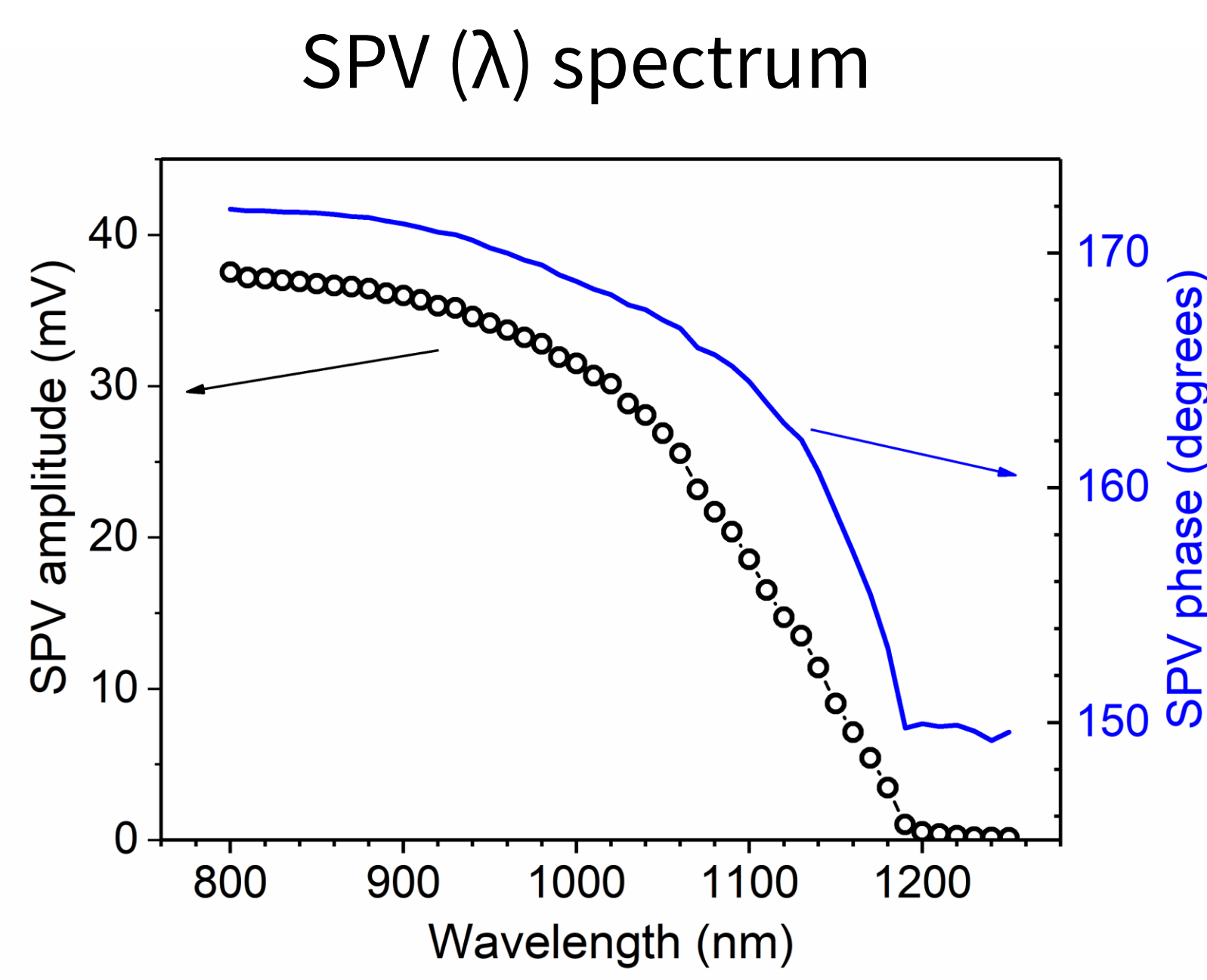
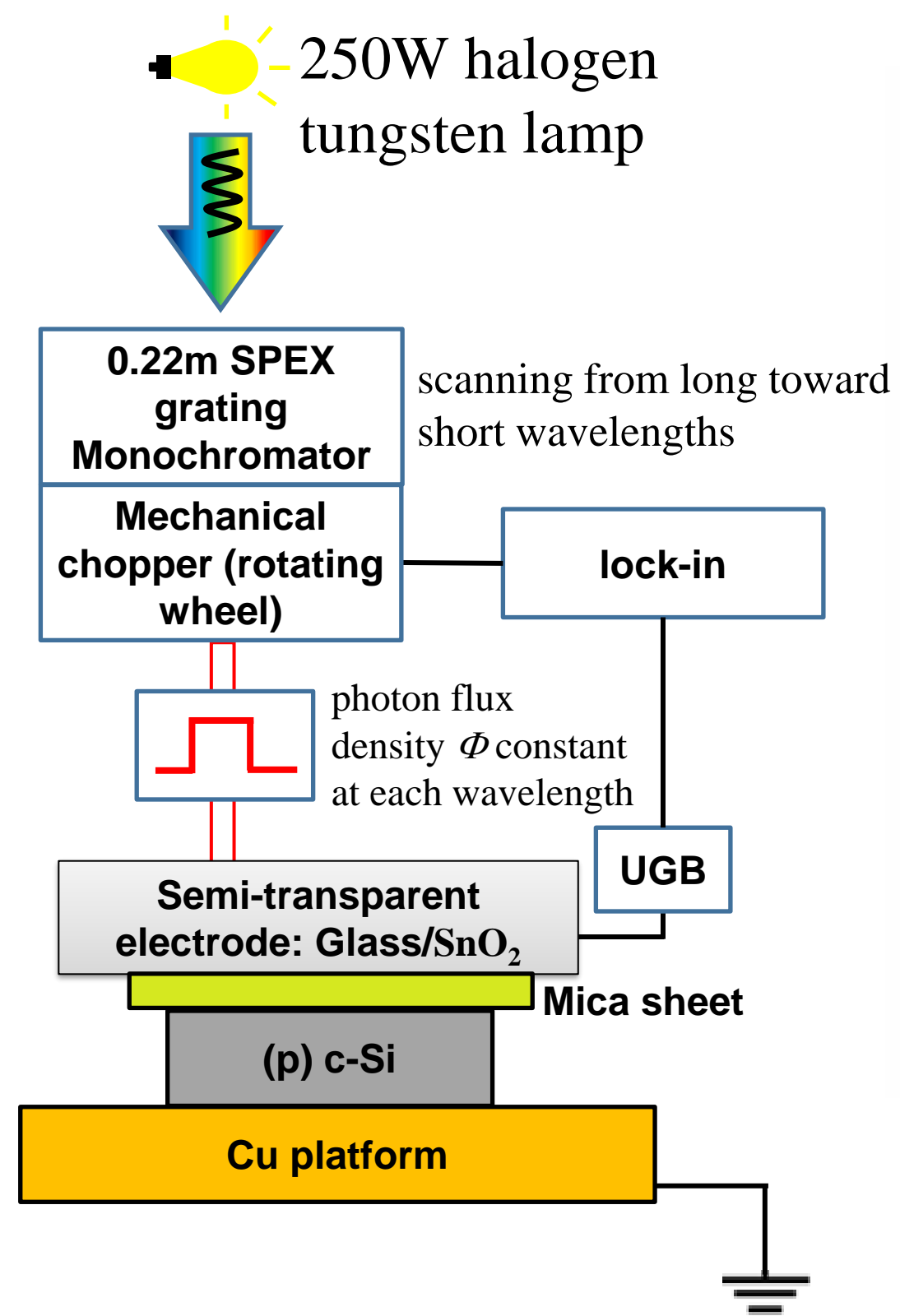


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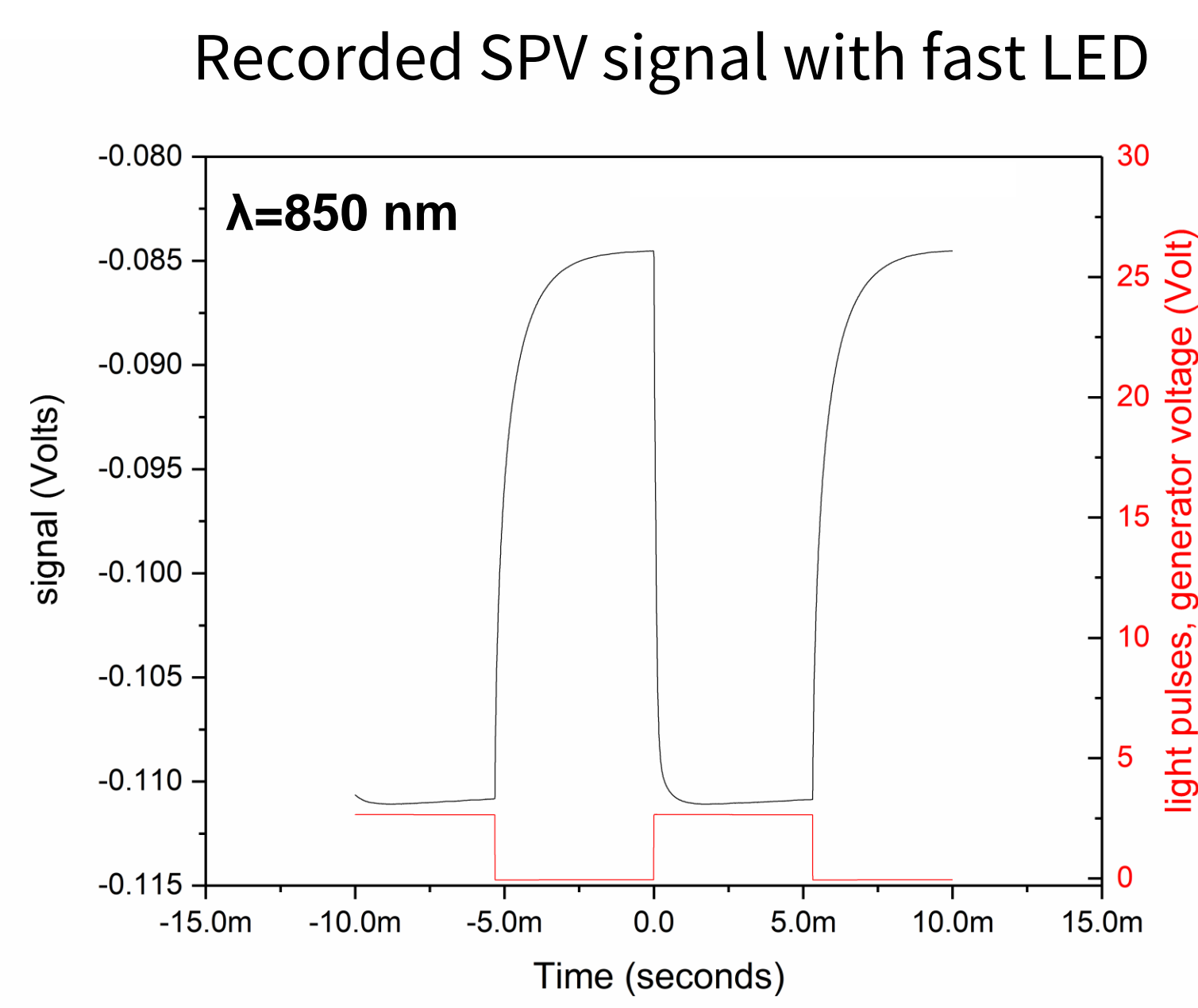
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Frequency Dependence of Modulated Surface Photovoltage (SPV) to Characterize Surface Defects

The Metal-insulator-semiconductor SPV experiment

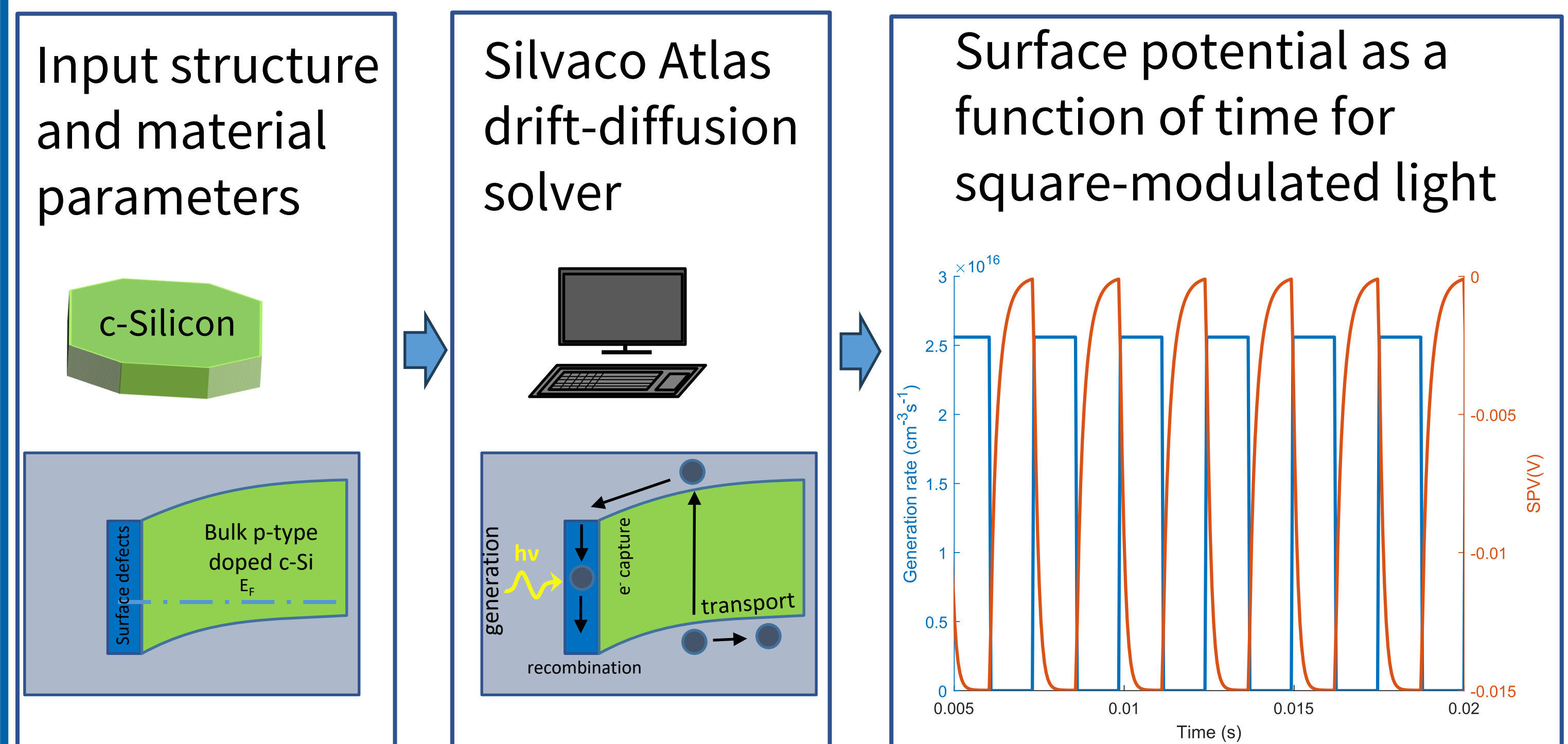


SPV = the illumination-induced change in the surface potential $\Delta V_s = V_s^{light} - V_s^{dark}$ as a result of the spatial separation of the photogenerated electrons and holes, for instance driven by the built-in electrical field in the surface space charge region of the semiconductor.

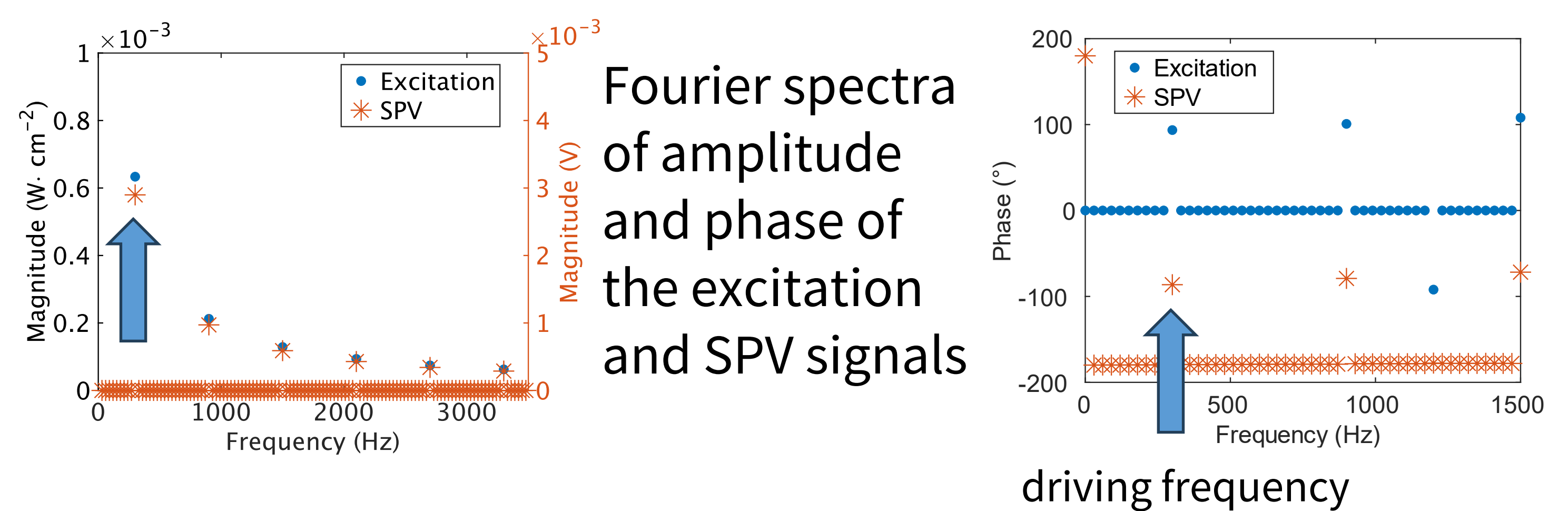


When the structure is illuminated with chopped light, the periodic changes of V_s due to the photovoltaic effect induce a periodic voltage between the capacitor plates (SnO_2 electrode and Cu platform). This voltage is fed to a high-impedance unity gain buffer (UGB) and measured by a lock-in amplifier (SR830) that extracts amplitude and phase of the fundamental frequency.

Modulated SPV simulations

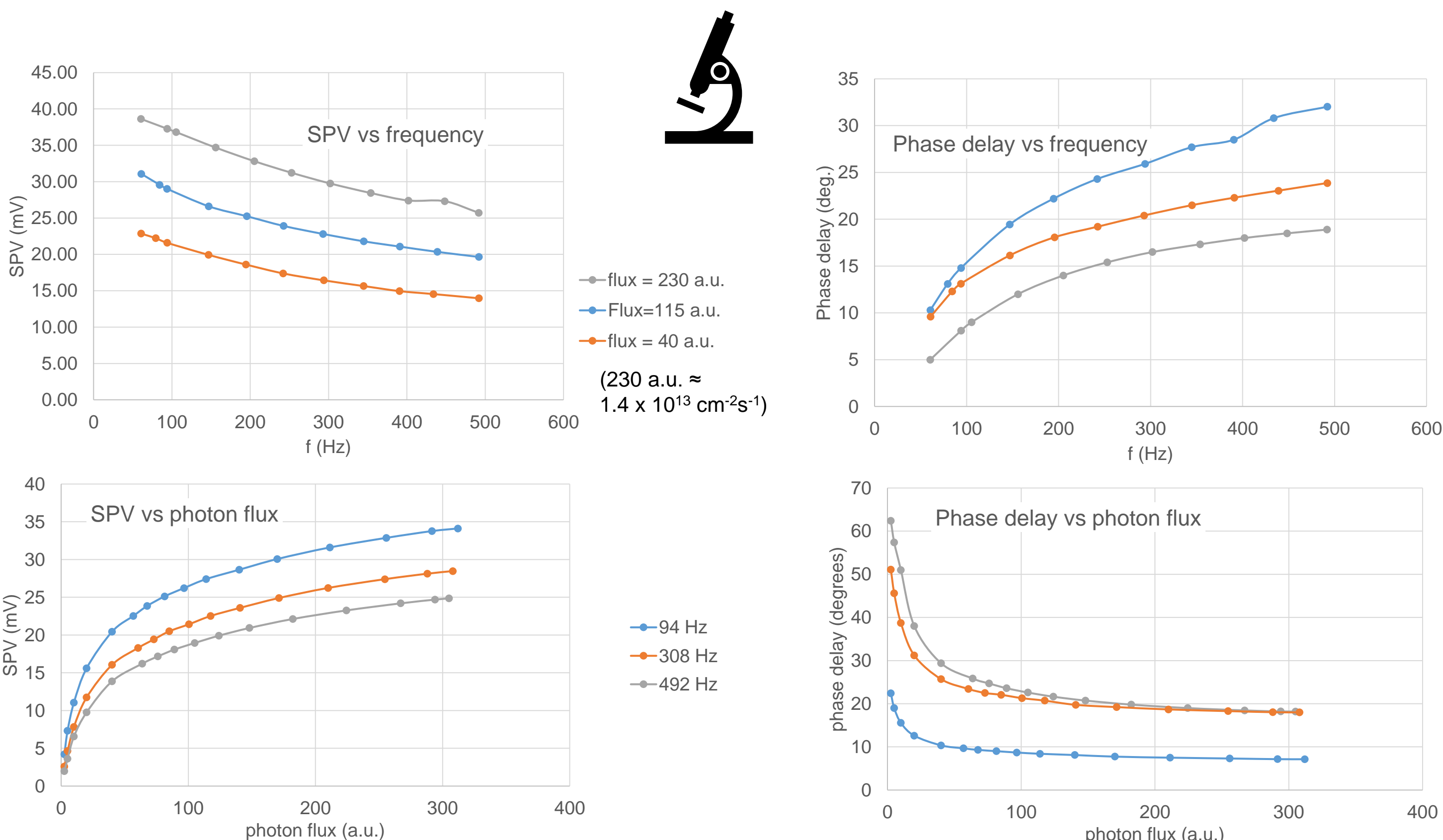


Silvaco Fast-Fourier Transform method



Extract the SPV amplitude and phase at the fundamental frequency (1st harmonic)

Frequency and flux dependence of SPV



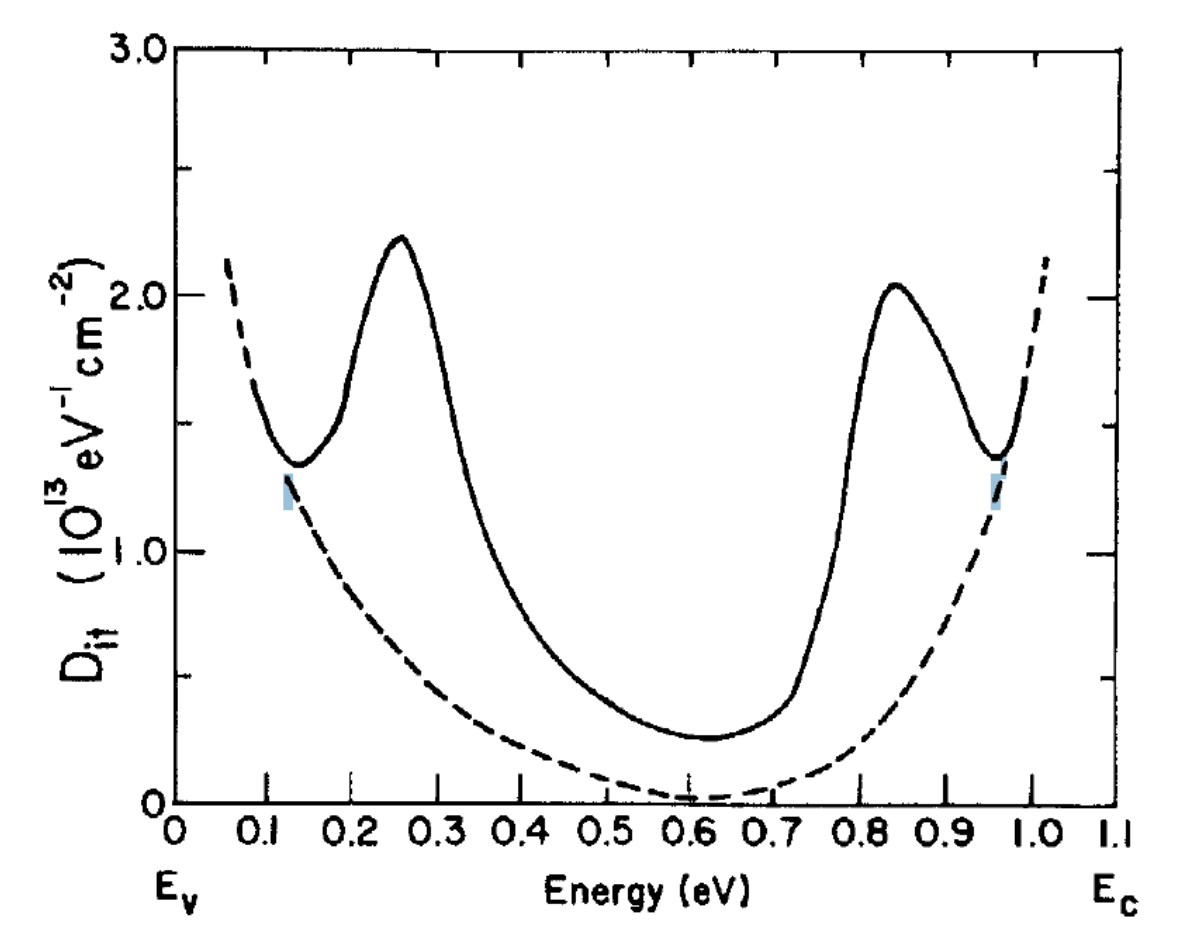
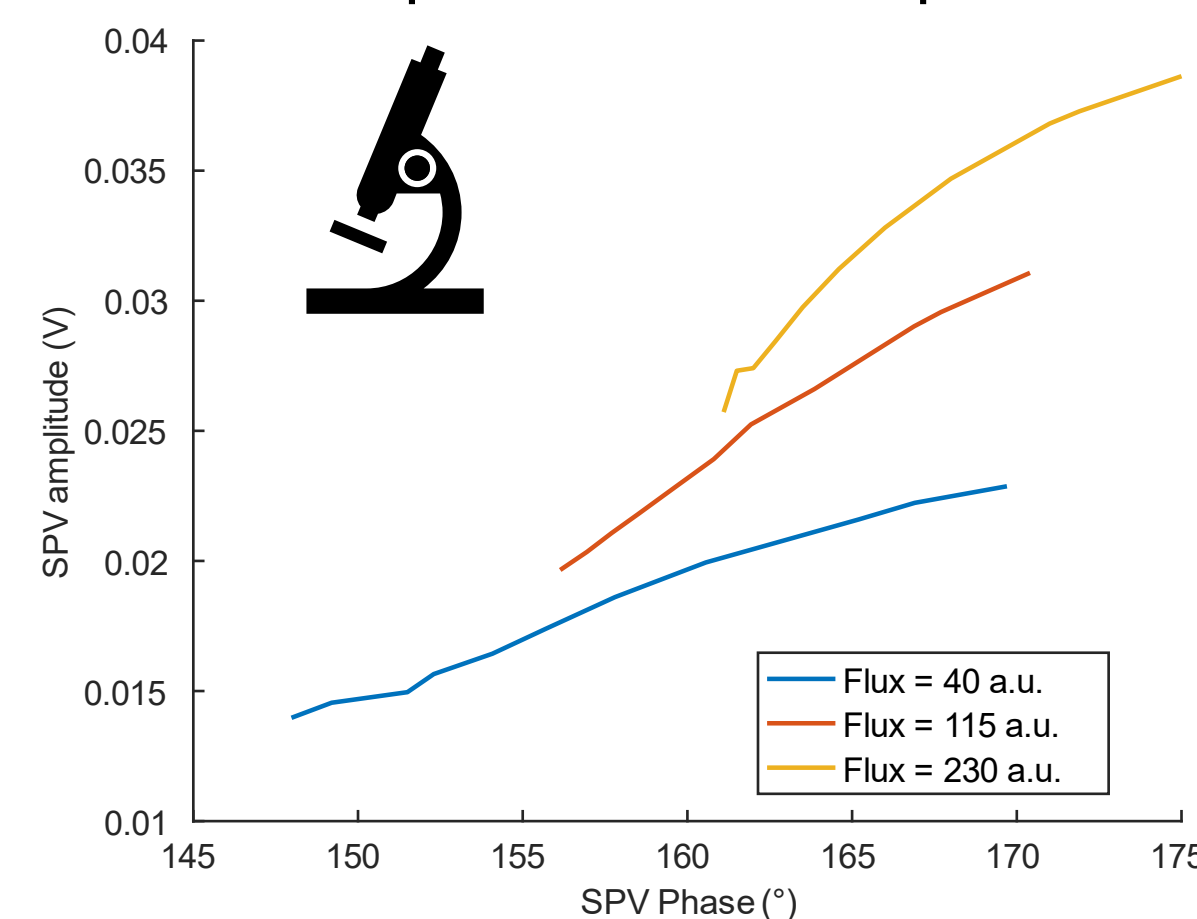
Interpretation with the DD model

The model reproduces the measured surface defect density of states across the Si bandgap

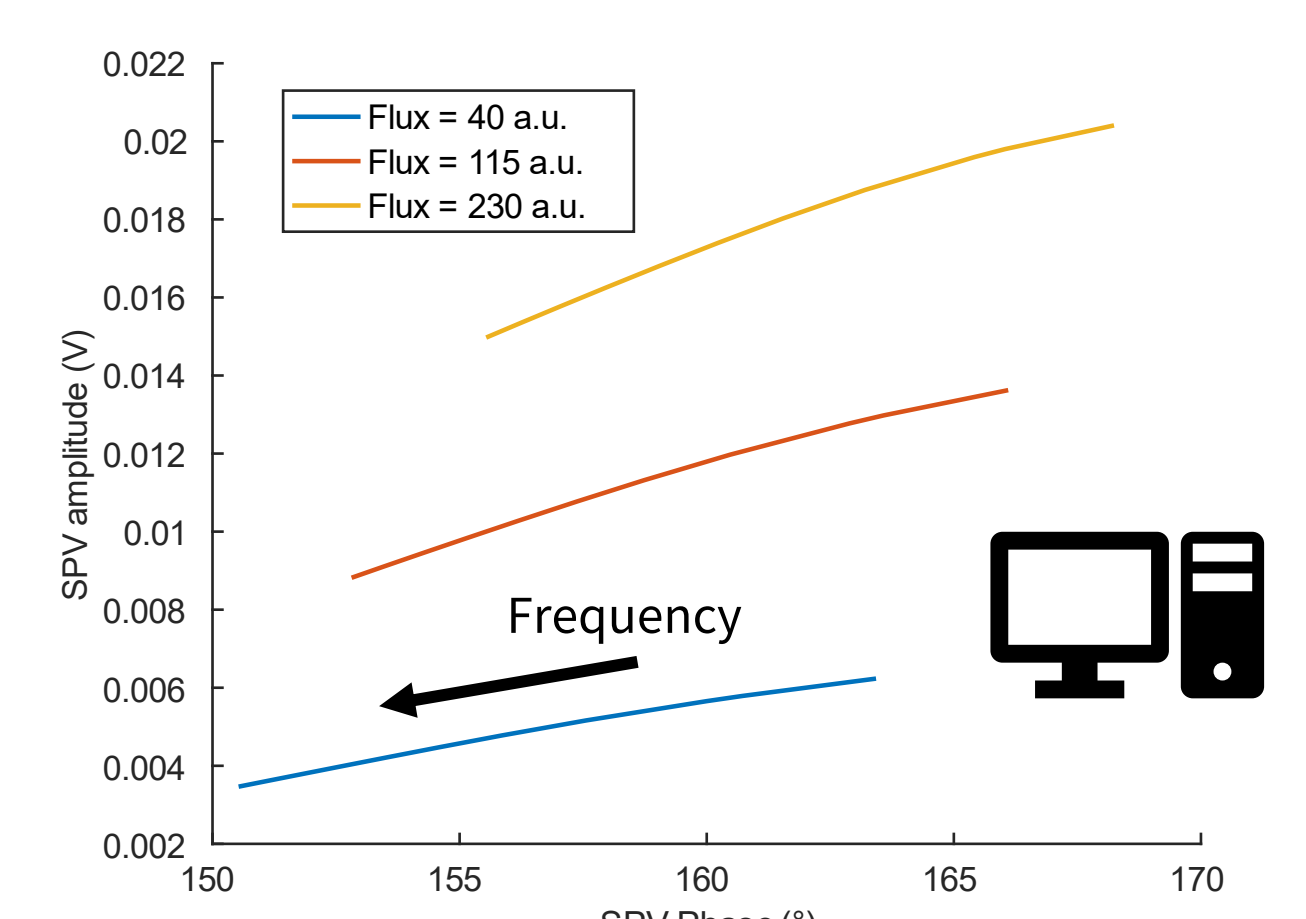
Amplitude/Phase curves experiment vs model:

Similar trends were achieved by varying p-doping, defect density, and capture cross-sections.

Other defect distributions could lead to a better reproduction of experimental data



Journal of Applied Physics 56, 2844 (1984); doi: 10.1063/1.333819



REFERENCES

V. Donchev, **Surface photovoltage spectroscopy of semiconductor materials for optoelectronic applications**, Mater. Res. Express. 6 (2019) 103001. <https://doi.org/10.1088/2053-1591/ab3bf>.
Bojar A, Regaldo D, Alvarez J, Alamarguy D, Donchev V, Georgiev S, Schulz P, Kleider J-P. **Surface photovoltage characterisation of metal halide perovskite on crystalline silicon using Kelvin probe force microscopy and metal-insulator-semiconductor configuration**. EPJ Photovolt. 13 18 (2022).
Donchev V, Regaldo D, Georgiev S, Bojar A, da Lisa M, Kirilov K, Alvarez J, Schulz P, Kleider JP. **Surface Photovoltage Study of Metal Halide Perovskites Deposited Directly on Crystalline Silicon**. ACS Omega. 2023 Feb 24;8(9):8125-8133.