PHOTOLUMINESCENCE AND ELECTROLUMINESCENCE MAPPING OF CIGS SOLAR CELLS

OBJECTIVES

We show how the mapping of photoluminescence (PL) and electroluminescence (EL) are powerful tools to determine optoelectronic properties of thin film CIGS solar cell at the micron scale.

PHOTOLUMINESCENCE MAPPING

Setups: (1) Confocal microscope and (2) Hyperspectral imager

PL spectra can be fitted by the generalized Planck’s law, linked to the position of the quasi Fermi levels (QFL) [1]. Spectrally resolved images of the PL intensity give relative fluctuations of the QFL at a micron scale [2-3].

Electroluminescence is an excellent tool to get information about the charge carrier generation at the junction of the solar cell. It provides information on the charge carrier generation and recombination processes.

HYPERSPECTRAL IMAGING

This technique offers a complete characterization of the solar cell in a single measurement. The key advantage of hyperspectral imaging is the ability to extract a large amount of information from a single image. This includes information about the chemical composition of materials, the variation of material properties, and the spatial distribution of different materials in a scene.

Advantages:
- No lateral diffusion
- No roughness dependence
- Absolute calibration achievable

Disadvantages:
- Spatial resolution sub micron not yet achieved

ELECTROLUMINESCENCE MAPPING

Model and method

Determination of the potential of the solar cell’s surface $V_s$ in the cylindrical symmetric situation supposing a certain sheet resistance $R_s$.

Results differ from simple series resistance consideration

Determination of the corresponding electroluminescence intensity $\Phi_{EL} = \Phi_s \exp(\lambda/(\lambda+\alpha))$

Adjusting the sheet resistance value to fit the experimental data [4]

Contact resistance evaluation

EL for several reference applied voltages [4,5]

Fit to deduce the sheet resistance and the effective applied voltage.

Important contact resistance in this setup: $R_{contact} = (V_m - V_s) M(V_m)$

Sheet resistance determination

Value of sheet resistance 30 $\Omega$cm, $\lambda$ = 1 $\Omega$cm

Similar value found on current-voltage curve of the cell under AM1.5 illumination [4,5]

TOWARDS QUANTITATIVE MEASUREMENTS

Our goal

To determine the absolute value of the QFL position and thus a powerful tool to measure the open circuit voltage Voc of solar cells without any electrical connections.

Modeling light excitation and light extraction from complete solar cells: SCAPS + Optical modelisation [6]

REFERENCES

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