Optoelectronic and Photovoltaic Devices course

Fifth lab – Analysis of solar cells

The aim of this set of experiments is to study the properties of solar cells as a function of the main operating parameters, including external illumination, temperature, and voltage. This goal will be achieved through the execution of a set of current-voltage measurements in different conditions. The silicon solar cell (IXOLARTM SolarBITs) is mounted on a Peltier-based temperature controller, and is placed under a LED-based light source (acting as a solar simulator), whose current can be modulated by a suitable circuit. A controlling board has been developed by the ACME team, and is directly mounted onto an Arduino Due board. The Arduino Due has two digital-to-analog converters (DACs), that are used to control the current on the LEDs, and to apply a variable voltage to the solar cell during the current-voltage measurements. Through circuits based on op-amps, the Arduino Due board can measure the voltages and current with a good resolution, in the ranges of interest. Labview is used to acquire the experimental data, i.e. the current-voltage measurements collected in different conditions.

**Room-temperature operation**

* Set the TEC temperature at 25 °C.
* Acquire the current-voltage characteristics of the solar cells in dark (i.e. in absence of external illumination)
* Plot the curve in linear and logarithmic scale

A graph of a function

Description automatically generated with medium confidence

* Extract the ideality factor and the saturation current of the solar cell, by proper fitting procedure
* Comment the experimental results, based on the theoretical considerations made during the lectures

**Extracting the main cell parameters**

* Set the illumination level to 1 Sun (maximum illumination level) and measure the current-voltage characteristics under light at 5, 10, 15, 20mA
* Extract the open circuit voltage and the short circuit current
* Plot the output power as a function of the operating voltage
* Extract the maximum output power and the fill factor of the solar cell and compare with state-of-the-art devices (find 3 datasheets on the internet and add to the report)

**Cell parameters as a function of illumination level and temperature**

* Measure the I-V curves of the solar cells at different illumination levels (0.25, 0.50, 0.75, 1.00 Sun) (DOES THIS MEAN DIFFERENT CURRENT VALUES?), and different temperature levels (25, 40, 55, 70 °C)
* Plot the variation of short circuit current as a function of illumination level, fit with the expected theoretical behavior, and comment on the observed trend through the use of formulas seen during lectures
* Plot the variation of open circuit voltage as a function of illumination level, fit with the expected theoretical behavior, and comment on the observed trend through the use of formulas seen during lectures
* How does the fill factor change with increasing temperature? Describe and explain briefly the observed effects

**Solar cell modeling via Spice**

* Extract the main parameters of the solar cell (consider the 1-diode equivalent model)
* Use the previously extracted parameters to reproduce the electrical characteristics of the solar cell by Spice (you can use LTSpice, for example)
* Compare the experimental data with the simulated ones and comment in the lab report