UNDERSTANDING AND OVERCOMING DIFFERENTIAL SPECTRAL RESPONSE (DSR) MEASUREMENT ARTEFACTS FOR SOLAR CELLS WITH POOR SHUNT RESISTANCE

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Differential spectral response (DSR) measurement employing chopped monochromatic beams and lock-in amplification are commonplace in most photovoltaic characterisation laboratories. The AC technique allows the differential current photogenerated in the device-under-test (DUT) by the beam to be distinguished from those by bias light sources. However, measurement artefacts can arise in 2-wire electrical connection schemes for DUT solar cells with poor shunt resistance relative to the connection resistance. This results in the measured external quantum efficiencies (EQE) being substantially lower than their true values. In this work, we elucidate the origin of measurement artefacts in 2-wire electrical connection schemes. Essentially, this is caused by the continuously changing operating point (or more relevantly, the terminal voltage) of the DUT due to illumination by the chopped monochromatic beam. For typical connection wires with resistance ~0.3\(\Omega\) used for measuring pseudosquare Si solar cells of area ~244cm\(^2\) and shunt resistance ~3500\(\Omega\).cm\(^2\), a measurement error of ~2\% lower EQE can result. The considerations for reducing the measurement artefacts are also discussed. Due to the different excitation power at each wavelength of the chopped beam, the EQE curve may not be adequately corrected by scaling. Also, mere voltage biasing does not resolve the issue due to the dynamically changing operating point of the DUT. Instead active DUT terminal voltage sensing and feedback to a voltage bias source is necessary to fix the terminal voltage to the required value, typically 0V (or short-circuit) for DSR measurement. This necessitates the use of 4-wire connection schemes which can be conveniently achieved by a SourceMeter. However, the speed of voltage sensing and correction must also be sufficiently fast, otherwise other measurement errors can creep in. Hence, considerations for chopping frequency, measurement noise and speed must inevitably be made.

Figure 1: Measured EQE of a n-type Si solar cell with relatively low shunt resistance. Measurement artefacts arise in 2-wire connection schemes (lower EQE) and when the chopping frequency is too high (590Hz). 4-wire connection with active voltage biasing and a sufficiently low chopping frequency (188Hz) is required to minimize the artefacts.