Non-Intrusive Cell Quantum Efficiency Measurements of Accelerated Stress Tested Photovoltaic Modules

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Cell-Module Quantum Efficiency (C-M-QE) Technique
• Different from Cell QE and Full Module QE
• Measures QE of specific location on individual cell within module
• Avoids backsheet penetration, enabling multiple measurements during multi-step stress tests
• Beneficial for analysis of failures due to stress testing
• Technique involves voltage and light biasing of module, see Figure 1

Cell QE, Full Module QE, and Cell-Module Quantum Efficiency (C-M-QE) comparison
• Cell QE requires electrical connection to the individual cell. In a module, this requires backsheet penetration to access the cell's terminals, preventing subsequent stress tests.
• Full Module QE illuminates entire module. Result is current-limiting cell response at each wavelength. Different cells may limit current at different wavelengths. Stress tests may change which cell is limiting.
• Cell-Module QE enables one to measure QE at a location of interest, apply stress, and measure the same location again.

References and Acknowledgement

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Figure 1. C-M-QE System configuration

Figure 2. The Arizona State University Photovoltaic Reliability Laboratory C-M-QE system

Measurement Validation
• QE scaling affected by extent of stress, see Figure 3
• Scaling artifact understood to be due to stress-induced cell shunting
• Authors are interested in exploring use of pulsed voltage and/or pulsed light bias to counteract signal loss due to cell shunting [1]

Figure 3. Example QE Measurements showing scaling artifact. Green spot superimposed on EL image indicates tested location

Use case example
• QE of an encapsulated silicon solar cell coupon before and after PID stress, see Figure 4
• Scaling understood to be due to stress-induced cell shunting
• Explanation of permanent loss of blue response explained elsewhere [2]

Figure 4. Cell QE Measurements showing wavelength-dependent PID-induced loss [3]

Summary
• Useful Cell-Module QE measurements require module-level light and voltage bias.
• Cell-level light bias not found to have significant influence on QE measurement of crystalline Si module.
• QE of stressed cells reveals information about wavelength-dependent module failure mechanisms.