conditions. Because modules can have a substantially inferior performance under low light levels when they have a low shunt resistance, modules are tested at an irradiance of 200 Wm^{-2} (~only 20% of 1 sun). Modules exposed outdoors under short circuit conditions to 60 $kWh\,m^{-2}$ of total solar irradiation are required to sustain a loss in power of less than 5% to reveal any synergistic degradation effects that may not be detected by other tests. The hot-spot test is designed to ensure that modules will not fail when hot spots occur because of mismatched cells, partial shading, or interconnect failures. A hot spot is a localized region in a module that is operating at a significantly higher temperature (~5–40°C) than the rest of the module. The hot-spot test consists of five 1-h exposures at 1000 Wm^{-2} irradiance under the worst-case hot-spot condition. The modules must also survive a hail test of 25-mm-diameter ice balls directed at 11 impact locations with a velocity of 23 ms^{-1} [159, 163]. Modules are also subjected to a twist test to detect module defects that might arise when the module is mounted on a nonplanar surface. The twist test consists of supporting the module on three of its corners and deflecting the fourth corner 1.2° with respect to the plane defined by the other three corners [159, 160]. Modules are also expected to withstand wind, snow, or ice loads without mechanical or electrical failure. The static-load test simulates a wind load of 130 $km\,h^{-1}$, with a safety factor of 3, and consists of mounting the module in the manner prescribed by the manufacturer and applying a force of 2400 Pa uniformly to the front surface for 1 h and then the rear surface for 1 h. The insulation test is a safety test designed to determine if the current-carrying parts of the module are sufficiently well isolated from the module edges or frame and requires a resistance of greater than 50 MΩ at 500 V DC resistance to ground, and less than 50 μA current to ground at an applied voltage of 1000 V plus twice the maximum system voltage [159, 160]. For frameless modules, ground is obtained by attaching a metal conductor to the outside perimeter. The wet-leakage-current test is a stringent safety test to ensure that the current-carrying parts are well isolated, preventing a ground-fault condition from occurring even when the module is wet. The wet-leakage test is also designed to verify that moisture does not enter the active part of the module, where it might cause delamination or corrosion. The module is placed in a tank of water with resistivity of 3500 Ω-cm or less at 22°C ± 3°C and a surface tension less than 3 Nm^{-2} and the leakage current at 500 V is measured. The maximum allowed leakage current for the wet-leakage test (sometimes called the wet hi-pot test) is 10 μA plus 5 μA times the surface area in m^2. The wet-leakage test is performed before and after the various stress tests. The number of modules, sequence of events, and the pass/fail criteria are specified in the standard documents [156, 157]. Thin-film module testing procedures also require the $I-V$ characteristics under SRC to be measured periodically during light exposure (between 800–1000 Wm^{-2}, between 40–50°C) until the module power changes by less than 2% over 3 consecutive periods of at least 48 h [160, 166].

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