plate. For production PV testers, the ribbons attached to grids on Si cells are simulated by using linear arrays of probes (possibly spring-loaded to a specific force). At the cell level, many PV materials will be damaged if the probe penetrates the relatively thin contact pad or misses the pad and touches the semiconductor. When the contact geometries are small, a micromanipulator and microscope eyepiece may be required, and contacting problems tend to be more difficult. The typical probe contact procedure in the PV performance characterization laboratory at NREL is to choose the appropriately sized Kelvin probe mounted on a three-axis manipulator and make contact with the device, while monitoring the resistance between the voltage and current Kelvin contact. Kelvin probes are used with an attached coaxial cable manufactured by Accuprobe Inc., with CuBe tip diameters between 12.7 μm and 127 μm and contact spacing between 50.8 and 1524 μm. For large-area cells (10 cm by 10 cm or larger) designed to have ribbons attached, differences in fill factors of more than 50% between groups can occur [2, 126]. The source of these differences can be attributed to contacting and spatial nonuniformities in the light source. Contacting-related differences occur when probes are used to simulate the ribbons, because of variations in shadowing, and distributed resistance losses. Differences in I_{SC} of 2% between NREL and other groups have been attributed to light reflected off metal probe(s), nearby operators in white lab coats and fixturing. Custom-fixturing or optics to direct the light upward is often required when both contacts are on the side not being illuminated as is the case for point-contact or wrap-around Si cells, or for superstrate structures like a-Si or CdTe on transparent conducting oxide coated glass. Achieving temperature control and Kelvin-contacting for these structures is problematic. Groups have used patterned circuit boards or Kapton to achieve contacts and temperature control. The contact area is often the junction area for small area thin-film devices on insulating superstrates allowing a metal spool with a vacuum hold down to make thermal, and electrical contact to the metallized cell and a probe or wire to make contact to the transparent conducting oxide layer. Many of the best thin-film devices have a thick layer of In metal bonded to the transparent conducting oxide around the cell border to reduce lateral series resistance losses. High-efficiency research cells on insulating substrates such as Cu(Ga,In)(S,Se) also often have an In border around the cell area to reduce resistance losses.

Evaluating the performance of concentrator cells poses several challenges. As of 2001, there are no consensus standards to evaluate concentrator cells, although ASTM and the Commission for the European Community are developing standards. Issues of temperature measurement and control are aggravated by the large heat load. Typically, concentrator cells are evaluated under flash systems with a 1-ms pulse duration or under continuous illumination. If a continuous light source is used, then the temperature of the space charge region cannot be directly measured – any temperature sensor will affect the temperature because of the small thermal mass and large light level on the sample. There can be large differences in the temperature of the space charge region (i.e. the cell temperature) and the temperature of the vacuum plate or measured front-surface temperature. One approach with the cell in the dark or minimal heat load is to first set the temperature-controlled vacuum plate to a given temperature, and then measure V_{OC} as a function of time as a high-speed shutter is opened, exposing the sample to the full light level [127]. The V_{OC} will rise as the shutter is opened and the cell is exposed to the concentrated light and will go through a maximum as the cell heats up corresponding to the V_{OC} at the known temperature measured with no heat load. The plate temperature can then be reduced until this V_{OC} is obtained. The other primary problem