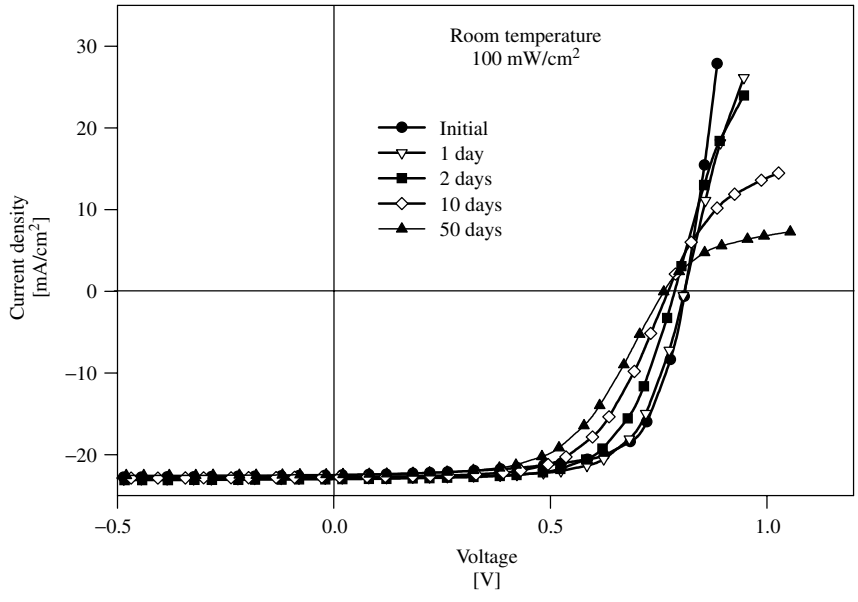

Figure 14.23 $J-V$ of CdTe cells following extended exposure to 100°C at V_{OC} [168]

showing an increase in rollover as temperature is decreased or as time at open-circuit 100°C stress is increased. As the temperature of the $J-V$ measurement is reduced, the acceptor concentration decreases, resulting in the back-barrier height exerting a greater effect, as shown in Figure 14.20. The rollover in the stressed devices could likewise be due to a reduction in carrier density in the CdTe layer.

There is conflicting evidence of the dependence of CdTe cell performance changes with stress temperature, but one study [169] has deduced an empirical activation energy near 1 eV, which predicts that $J-V$ changes at 100°C are accelerated 500 to 1000 times compared to a typical annual range of outdoor temperatures for solar panels. Hence, one would not expect significant performance changes for modules until they had been deployed in the field for many years.

Additional "stress" studies have shown that reductions in cell efficiency are smaller when the voltage bias is held at short circuit or maximum power, rather than at open circuit [169–171], or when less copper is used in the back contact [166]. The movement of copper out of the back-contact region is faster when forward bias reduces the electric field within the cell [169, 171–173], and it has at least two effects on cell performance. One is the increase in back-barrier height, similar to the copper-free case. The second is a detrimental effect on cell performance due to copper movement toward the front junction, probably enhanced by grain-boundary paths. There is no general agreement, however, on whether the copper causes an increase in CdTe recombination states, a change in the CdS layer, or possibly an increased overlap of the front and rear junctions by creating conducting filaments.

There are a variety of possible optical losses before the photons reach a CdTe solar cell's absorber, and there are additional optical losses due to incomplete absorption of