power generation depends on improving device performance, cost-effective translation of fabrication processes to the module scale, and cell and module stability. In addition to efficiency gains in single-junction devices, band gap tailoring of the absorber by alloying with other group IIB metals can facilitate development of multijunction cells with efficiencies approaching 30%. Translating single-junction efficiency gains from batch processes to continuous module fabrication and developing monolithic multijunction modules on a single superstrate can significantly reduce production costs. Achieving this goal requires greater understanding of the relationship between processing conditions and critical material properties needed for high efficiency and good long-term stability.

Although the fundamental nature of polycrystalline CdTe is not yet fully understood, we have shown that significant progress has been made toward the development of 20% efficient single-junction thin-film cells. In addition, we have seen that several CdTe film deposition techniques yield similar device performance, by a suitable combination of postdeposition processing and back-contact formation. Reaching the 20% efficiency target and translating this to high module performance relies on determining and overcoming the mechanisms that limit the open-circuit voltage and fill factor in present-generation cells. This is simply due to the fact that the current density in champion thin-film CdTe cells has reached 80% of its theoretical maximum for AM1.5 illumination and is primarily limited by optical losses in the glass/TCO/CdS structure. The values of $V_{OC} \sim 850$ mV and $FF \sim 75\%$ appear to represent practical limits, and fall short of the expectations based on band gap. Forward current in present-generation high-efficiency CdTe/CdS devices appears to be controlled by the Shockley–Read–Hall recombination in the space charge region. Many investigations also show a profound influence of back-contact formation on both V_{OC} and FF. For module implementation, obtaining both high J_{SC} and V_{OC} is complicated by large-area control of CdTe–CdS interdiffusion and junction formation between the CdTe absorber and the TCO, since a thin CdS layer is required in the finished device. Thus, critical research directions for improving efficiency in CdTe/CdS cells are (1) identification and reduction of the density of limiting intragrain defect states; (2) increasing the p-type carrier concentration in CdTe; (3) eliminating or controlling parallel junctions that may arise because of pinholes; (4) developing robust manufacturing processes; and (5) defining and overcoming performance limitations related to back-contact formation.

In addition to its basis for single-junction devices, CdTe can be alloyed with other II^B-VI^A compounds to alter its band gap, allowing multijunction cells to be designed. The multijunction cell structures using CdTe-based wide band gap cells in monolithic structures must confront the relationship between cell geometry and both processing temperature and chemical stability. Materials based on alloys between CdTe and other group II^B-VI^A compounds allow a wide range of optoelectronic properties to be incorporated into devices by design.

Semiconducting compounds of the form II^B-VI^A provide a basis for the development of tunable materials, obtained by alloying different compounds in pseudobinary configurations. For photovoltaic heterojunction devices, semiconductors using Cd, Zn, Hg cations and S, Se, Te anions exhibit a wide range of optical band gap, suggesting their potential for use in optimized device designs by tailoring material properties (Table 14.5). The high opticalabsorption coefficients, $\sim 10^5$/cm, and direct optical band gaps of many II-VI semiconductors make them suitable for use in thin-film photovoltaic