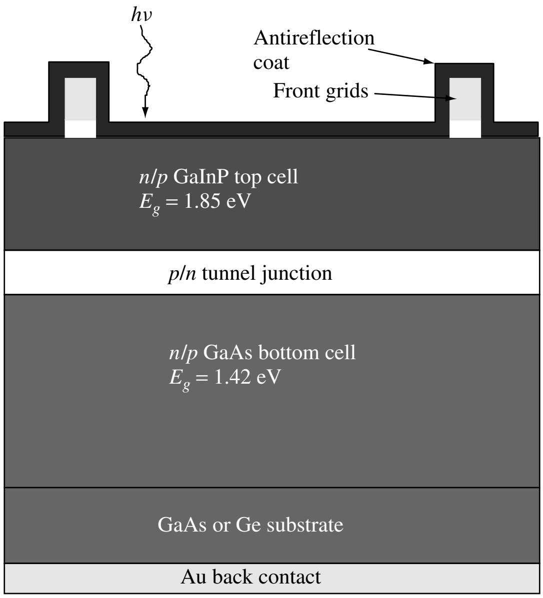

Figure 9.1 Schematic of GaInP/GaAs multijunction solar cell. When grown on a Ge substrate, there is an option for introducing a third junction in the Ge substrate, thus boosting the voltage and efficiency of the overall device. Dimensions are not to scale

It was in this context that researchers at the National Renewable Energy Laboratory (NREL) conceived and began work on the GaInP/GaAs tandem solar cell more than a decade ago [1]. A schematic of the cell is shown in Figure 9.1. The cell consists of a $Ga_xIn_{1-x}P$ top cell (with a band gap of 1.8–1.9 eV) grown monolithically on a lattice-matched interconnecting tunnel junction and a GaAs bottom cell. As shown in Figure 9.2, for $x \approx 0.5$, $Ga_xIn_{1-x}P$ has the same lattice constant as GaAs with a band gap energy between 1.8 and 1.9 eV. Prior to this, several groups were working on tandem device designs that theoretically should achieve efficiencies approaching 36 to 40% [2]. These included mechanical stacks of a high band gap top cell on a Si bottom cell and monolithic combinations of AlGaAs, GaAs, and GaInAs or GaAsP on Si. However, the mechanical stacks were viewed as too costly and cumbersome (perhaps prematurely). The defects generated by the lattice mismatch between top and bottom cells in some of the monolithic structures (i.e. GaAs and GaInAs or GaAsP and Si) were a problem that could not be solved easily. The AlGaAs/GaAs tandem cell is lattice matched with a theoretical efficiency of 36% [2]. However, the sensitivity of AlGaAs to trace levels of oxygen in all growth systems and source materials made it difficult to produce high yield and, thus, limited its use in a production environment. The novel NREL idea was to trade manufacturability (i.e. lattice-matched top and bottom cells and oxygen-tolerant device materials) for a slightly lower theoretical efficiency of 34%.

By most standards, progress was rapid (see Figure 9.3). Despite initial problems with the growth of GaInP due to metalorganic chemical vapor deposition (MOCVD) and complications associated with an anomalous red shift of the band gap energy, by 1988 reasonably good GaInP top cells could be fabricated [3–5]. In 1990, efficiencies greater