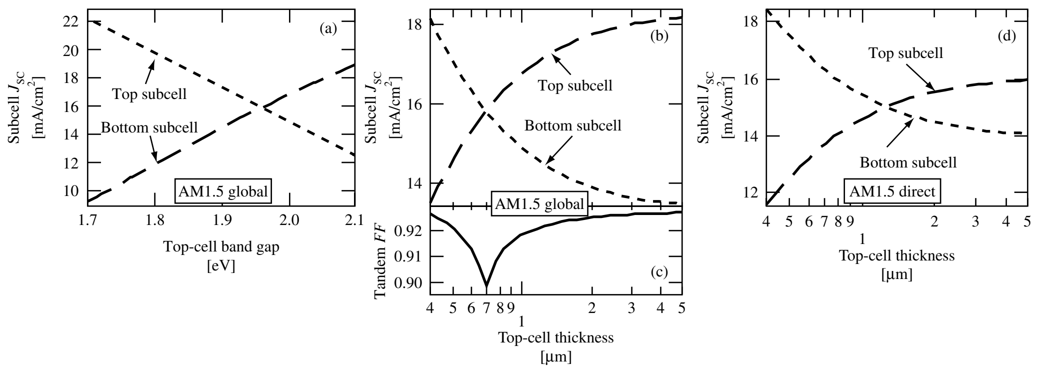

Figure 9.7 (a) J_{SCt} and J_{SCb} for an infinitely thick top subcell as a function of top-subcell band gap E_{gt} for a bottom-subcell band gap $E_{gb} = 1.42$ eV. (b) J_{SCt} and J_{SCb} as a function of top-subcell thickness for the AM1.5 global spectrum, with $E_{gb} = 1.42$ eV and $E_{gt} = 1.85$ eV. The subcells are current matched at a base thickness of 0.7 μm. (c) The corresponding tandem-cell fill factor. (d) J_{SCt} and J_{SCb} as a function of top-subcell thickness as in (b) but for the AM1.5 direct spectrum. The current-matching thickness is significantly greater than that for the global spectrum

on the top-subcell band gap. As noted above, lowering the top-subcell band gap while holding the bottom-subcell band gap constant increases the top-subcell J_{SC} at the expense of the bottom-subcell J_{SC}. Figure 9.7(a) illustrates this for the case at hand by showing J_{SCt} and J_{SCb} as a function of E_{gt} for $E_{gb} = 1.42$ eV. The J_{SC} for the series-connected combination of these two cells will be the lesser of J_{SCt} and J_{SCb}. The figure shows that this quantity is a maximum at the current-matched band gap $E_{gt} = 1.95$ eV, and falls off rapidly as E_{gt} decreases below 1.95 eV. This falloff in J_{SC} due to the bottom subcell limiting the photocurrent at low E_{gt} is responsible for the corresponding drop-off in the tandem-cell efficiency shown in Figure 9.6(a). This dependence of tandem J_{SC} and efficiency on E_{gt} would suggest that a GaInP/GaAs cell would not have a useful high efficiency. Fortunately, as will be discussed in the next section, this rapid drop-off of efficiency can be greatly alleviated by thinning the top subcell.

9.5.5 Top-cell Thinning

Because the absorption coefficient $\alpha(h\nu)$ for solar cell materials is not infinite, a cell of finite thickness will not absorb all the incident above band gap light. Some light will be transmitted (especially at photon energies near the band gap where α is small); the thinner the cell, the greater the transmission. Therefore, for a two-junction cell, thinning the top subcell will reapportion the light between the two subcells, increasing the bottom-subcell current at the expense of the top-subcell current. If, before thinning, $J_{SCb} < J_{SCt}$, then the top subcell can be thinned to make $J_{SCb} = J_{SCt}$. Because the series-multijunction cell current J_{SC} is limited to the lesser of J_{SCb} and J_{SCt}, J_{SC} and hence the cell efficiency will be maximized when the top subcell is thinned to achieve this current matching. Figure 9.7(b) illustrates this current matching for the tandem device under discussion, for the case that $E_{gt} = 1.85$ eV (GaInP) and $E_{gb} = 1.42$ eV (GaAs). The tandem current $J_{SC} \approx \min(J_{SCt}, J_{SCb})$ is maximized at a top-subcell thickness of 0.7 μm, for which the subcells are current matched. At this thickness, $J_{SC} = J_{SCt} = 15.8$ mA/cm^2, or about 85%