implications for tandem-cell design are complicated [21]. In general, it is found that series tandem cells are quite sensitive to fluctuations in air mass in particular. Fortunately, efficiency at high air mass is relatively unimportant because the net power output is small under these conditions. Overall, a well-designed multijunction cell is expected to outperform a single-junction cell by a comfortable margin even when spectral fluctuations are taken into account. (It is interesting to note that spectral fluctuations are less of a concern for voltage-matched devices than for current-matched devices, because a change in a subcell current is reflected only logarithmically in the corresponding change in voltage.)

9.5.7.2 Chromatic aberration

A related issue of concern for series-connected multijunction cells is the chromatic aberration of the spectrum that can be caused by the concentrating optics in concentrator modules, especially the Fresnel lenses used by some concentrator configurations. Such aberration will not only change the spectrum from the incident solar spectrum, but may also result in a position-dependent variation in the spectrum across the receiver. It is found that the detrimental effect of such spatial variations may be mitigated by making the emitters of the bottom subcells highly conductive [22]. This aids current matching by lateral conduction between adjacent areas of a cell.

9.5.8 AR Coating Effects

9.5.8.1 Introduction

Our discussion has so far assumed for simplicity that there is no reflection of the incident light from the front surface of the cell. However, without an antireflective (AR) coating, III-V cells typically have large reflectances on the order of 30% in the spectral region of importance for converting the solar spectrum. AR coats can reduce this reflectance to ~1%, but only over a limited spectral range; this limitation has important implications for tandem-cell current matching. An examination of AR coating issues is therefore especially important for III-V multijunction cells.

9.5.8.2 Calculation

For analyzing the effect of AR coating parameters on multijunction performance, it is useful to have a realistic numerical model for the reflectance. Here, we use the relatively simple model of Lockhart and King [23]. This model calculates the normal-incidence reflection of a three-layer coating. Each layer is assumed to be lossless so that the index of refraction n_j of the jth layer, along with its thickness d_j, fully characterizes the optical properties of the layer. The layers are numbered $j = 1$ to 4, with $j = 4$ being the top layer and $j = 1$ being the substrate. For example, for a two-layer MgF_2/ZnS coat on a GaInP cell with an AlInP window layer, layers 4/3/2/1 are MgF_2/ZnS/AlInP/GaInP, respectively. The reflection R as a function of wavelength λ is given by

$$R = |(X - 1)/(X + 1)|^2 \tag{9.17a}$$