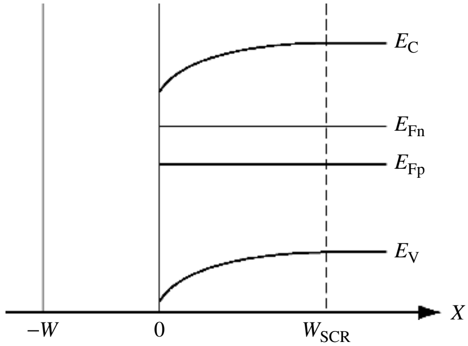

Figure 8.22 The energy band model used for boundary-condition analysis around a Type III region

the n/p junction. However, the depletion space charge region (SCR) region in different types of material need to be treated differently: SCR inside Type I regions should have the same behavior as the SCR in a normal n-p junction. In Type II or Type III regions, because there are extra charges (other than the dopant ions) and they are opposite to the charges of dopant ions, the net total charge should be less than that in the region without extra charges. The most apparent effect of the charges trapped in the p-n junctions may be the change of the width of the depletion region. This change can be easily determined by the Shockley model

$$W_{SCR} = \sqrt{\frac{2\varepsilon_{si}(N_A + N_D - 2N_x)(V_{bi} - V)}{e(N_A - N_x)(N_D - N_x)}} \tag{8.7}$$

where N_x is the extra charge density trapped in the Si. This value is the same for n-type and p-type regions, because we assume that the density of defect-related energy levels is the same in these two regions.

The calculation of the recombination current inside the space-charge region due to the Type IV can also be done following the Fossum and Lindholm algorithm.

The resultant band configurations used for device analysis are illustrated in Figure 8.23. The finite element method is used in this model. To limit the number of variables in this calculation, we assume that all the grains are similar. This assumption also brings other benefits to the calculation – since all the grains are similar, no net carrier flow will exist between grains at steady state. Therefore, the current collected by the device is just the summation of the current collected by each grain in the sample.

First, we will examine dependence of cell parameters, V_{OC} and J_{SC}, on the grain size of μc-Si thin-film solar cells. Figures 8.24(a) and 8.24(b), show the calculated values of J_{SC} and V_{OC} for two values of the GB interface recombination velocity, 100 cm/s and 1000 cm/s. The S-value of 100 cm/s corresponds to "clean" GBs. In practice, such a low value of S is hard to achieve. The μc-Si for PV applications is likely to contain impurities, which segregate at the GBs resulting in higher S-values. Thus, $S = 1000$ cm/s represents a more realistic μc-Si. The other parameters used in these calculations are given in Table 8.4. Here, G is the generation rate due to incident light and α is the