Here, we will present some preliminary results of this model to illustrate the influence of material parameters, such as grain-size and grain-boundary recombination, on cell performance. This model can also be used to study effects of material parameters on the minority-carrier lifetime and carrier transport. We consider a sample with a columnar (two-dimensional) grain structure, which may have many regions of different lifetimes due to different defect distributions, separated by GBs. The sample is illuminated with light to generate photocarriers. The procedure for solving the 2-D continuity equation, subjected to appropriate boundary conditions, is discussed in References [19, 70, 71]. However, some physical insight can be gained by addressing the boundary conditions involving different region types.

8.3.3.1 Boundary/interface conditions

Because we are dealing with multiregion samples, there are two different boundaries: the surfaces of the entire sample and the boundaries between adjacent regions (grains) in the sample. These will be referred to as *boundary condition* and *interface condition*, respectively.

At the surface of the sample, the boundary condition is

$$D\frac{\partial n}{\partial \vec{n}} = Sn, \tag{8.4}$$

where S is the surface-recombination velocity, $\vec{n}$ is a unit vector, n is the concentration of electrons, and D is the diffusion coefficient.

At the interfaces between different regions, the boundary conditions depend on the types of the regions. The GBs between Type I or II regions can be treated as a surface with specific recombination velocities. At the interfaces, the following interface condition applies

$$n_1 = n_2 \tag{8.5}$$

$$D_1\frac{\partial n_1}{\partial \vec{n}} - D_2\frac{\partial n_2}{\partial \vec{n}} = Sn_{1or2} \tag{8.6}$$

Here, S is the "effective" surface-recombination velocity. However, if one of the grains is heavily defected, Type III, its boundary will have a finite width due to the field extending into the adjacent grain. This condition is illustrated in Figure 8.22. If the lifetimes of electrons and holes are τ_e and τ_h, respectively, in the Type III region, we can extend the algorithm of Fossum and Lindholm to the bulk region to express the electron current (in p-type samples) at the edge of the interface space-charge region [72].

The interface between a Type IV and a Type I (or Type II) region can be treated as a high–low junction because of their Fermi levels.

Because a solar cell involves an n/p junction for carrier collection, we must also consider how the junction is influenced in different region types. The fabrication of such a junction will influence the nature of the depletion regions, but all the equations developed earlier, including boundary conditions, still apply in the quasi-neutral region (QNR) of