4.3 PHOTOVOLTAIC CONVERTERS

4.3.1 The Balance Equation of a PV Converter

In 1960, Shockley and Queisser (SQ) published an important paper [2] in which the efficiency upper limit of a solar cell was presented. In this article it was pointed out, for the first time in solar cells, that the generation due to light absorption has a detailed balance counterpart, which is the radiative recombination. This SQ efficiency limit, detailed below, occurs in ideal solar cells that are the archetype of the current solar cells. Such cells (Figure 4.2) are made up of a semiconductor with a VB and a CB, more energetic and separated from the VB by the band gap, ε_g. Each band is able to develop separate quasi-Fermi levels, ε_{Fc} for the CB and ε_{Fv} for the VB, to describe the carrier concentration in the respective bands. In the ideal SQ cell the mobility of the carriers is infinite, and since the electron and hole currents are proportional to the quasi-Fermi level gradients, it follows that the quasi-Fermi levels are constant. Contact to the CB is made by depositing a metal on an n^+-doped semiconductor. The carriers going through this contact are mainly electrons due to the small hole density. The few holes passing through this contact are accounted for as surface recombination, assumed zero in the ideal case. Similarly, contact with the VB is made with a metal deposited on a p-doped semiconductor. The metal Fermi levels ε_{F+} and ε_{F-} are levelled, respectively, to the hole and the electron quasi-Fermi levels ε_{Fv} and ε_{Fc} at each interface. In equilibrium, the two quasi-Fermi levels become just one.

The voltage V appearing between the two electrodes is given by the splitting of the quasi-Fermi levels, or, more precisely, by the difference in the quasi-Fermi levels of majority carriers at the ohmic contact interfaces. With constant quasi-Fermi levels and ideal contacts, the split is simply

$$qV = \varepsilon_{Fc} - \varepsilon_{Fv} \tag{4.18}$$

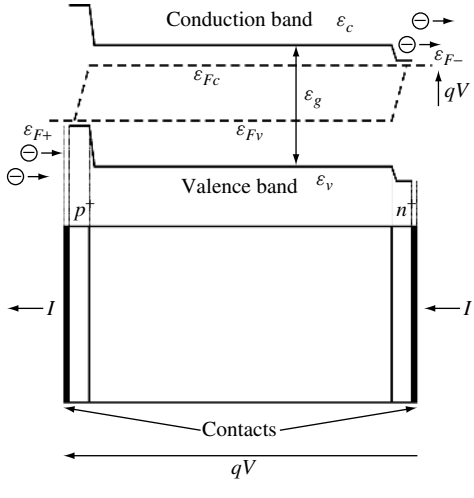

Figure 4.2 Band diagram of a solar cell with its contacts