Physics of Semiconductor Devices

2nd Edition

S.M. Sze

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be efficiently converted in the low-gap semiconductor. Figure 23 shows the normalized spectral responses of several $Ga_{1-x}Al_xAs$–GaAs solar cells, all having the same junction depths and doping levels. As the composition x increases, the bandgap E_{g1} increases; therefore, the spectral response extends to higher photon energies.

One interesting heterojunction solar cell is the conducting glass–semiconductor heterojunction. The conducting glasses include oxide semiconductors, such as indium oxide (In_2O_3, with $E_g = 3.5$ eV and electron affinity $\chi = 4.45$ eV), tin oxide (SnO_2, with $E_g = 3.5$ eV and electron affinity $\chi = 4.8$ eV), and the indium tin oxide (ITO, a mixture of In_2O_3 and SnO_2, with $E_g = 3.7$ eV and electron affinity $\chi = 4.2$ to 4.5 eV). These oxide semiconductors in thin-film form have the unique properties of good electrical conductivity and high optical transparency. They serve not only as part of the heterojunction but also as an antireflection coating.

The energy-band diagrams for an ITO/Si solar cell are shown[29] in the insert of Fig. 24. The top layer is an n-type 4000 Å ITO with 5×10^{-4} Ω–cm and the substrate is a 2 Ω–cm p-type silicon. The curves in Fig. 24 near 1 mA/cm² are all parallel to each other. The slope $d(\ln J)/dV$ is about 24 V^{-1} independent of temperature. This slope suggests a multistep tunnel process in this heterojunction. Conversion efficiencies in the 12 to 15% range

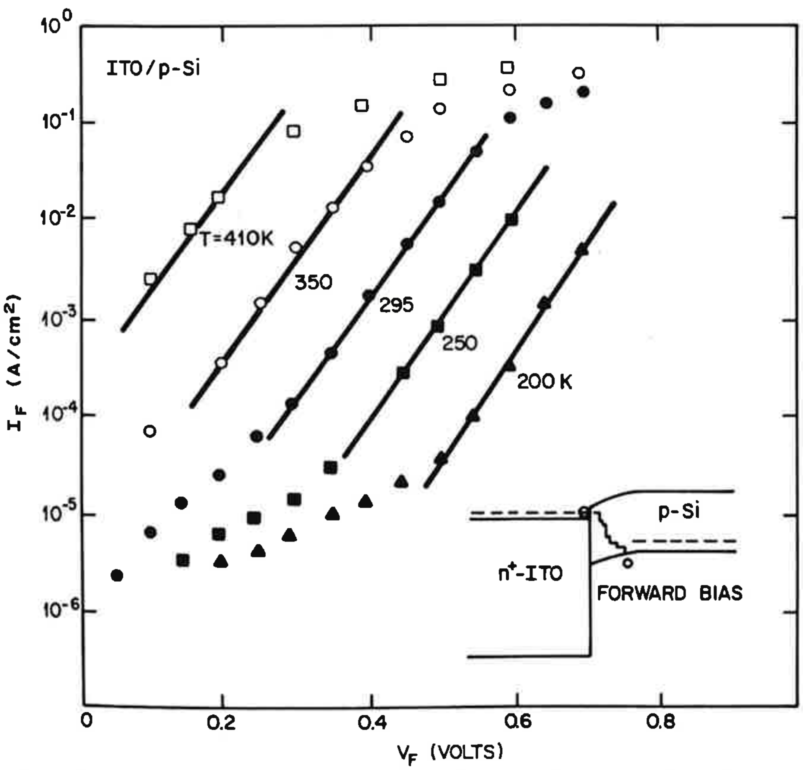

Fig. 24 Current–voltage characteristics of a ITO-Si heterojunction. The insert shows the band diagram under forward bias. (After Sites, Ref. 29.)