which is replotted from the data given in Fig. 4.1. When a
generation current is taken into account in the depletion
region, this current should be proportional to the width of
the depletion region that varies with $(V_d-V)^{1/2}$. The data show a
good linearity, indicating that their reverse currents should be
limited by the generation process in the depletion region. This
proportionality between reverse current and $(V_d-V)^{1/2}$ is held
throughout the temperature range studied here. In sample 5, the
deployment region exists only on the a-Si:H side because the p c-
Si is heavily B-doped, indicating that its generation current is
produced in the deployment region of a-Si:H under reverse bias
conditions.

The reverse current is an increasing function of the p c-Si
resistivity, as shown in Fig. 4.2. Because the width of the
deployment region in c-Si increases with an increase of the p c-Si
resistivity as shown in Fig. 3.10, the contribution of the
generation current in p c-Si to the reverse current increases
with an increase of the c-Si resistivity. Those suggest that the
generation current per unit volume in the deployment region of c-
Si is greater than that in the deployment region of a-Si:H. This
may be because the bandgap (1.12 eV) of c-Si is narrower than
that (about 1.7 eV) of a-Si:H.

4-5. Summary

The current-transport mechanism of the undoped a-Si:H/p c-Si
heterojunctions has been discussed from their I-V characteristics
and their temperature dependence. The main results are
summarized as follows.

(1) The forward current, described as $\exp(-\Delta E_{af}/kT) \times \exp(AV)$, can be explained by a multistep-tunneling capture-
emission (MTCE) model, where a hole in the valence band of p c-Si
keeps flowing from one gap state to another in a-Si:H by the
multistep-tunneling process until its tunneling rate becomes
smaller than a rate either for hole releasing from the state to
the valence band or for its recombination with an electron in the
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The conduction band of a-Si:H.

(2) The reverse current, which is proportional to \((V_B-V)^{1/2}\), is reasonably ascribed to a generation process in both depletion regions of a-Si:H and c-Si. The generation current per unit volume in the depletion region of c-Si is considered to be greater than that in the depletion region of a-Si:H.