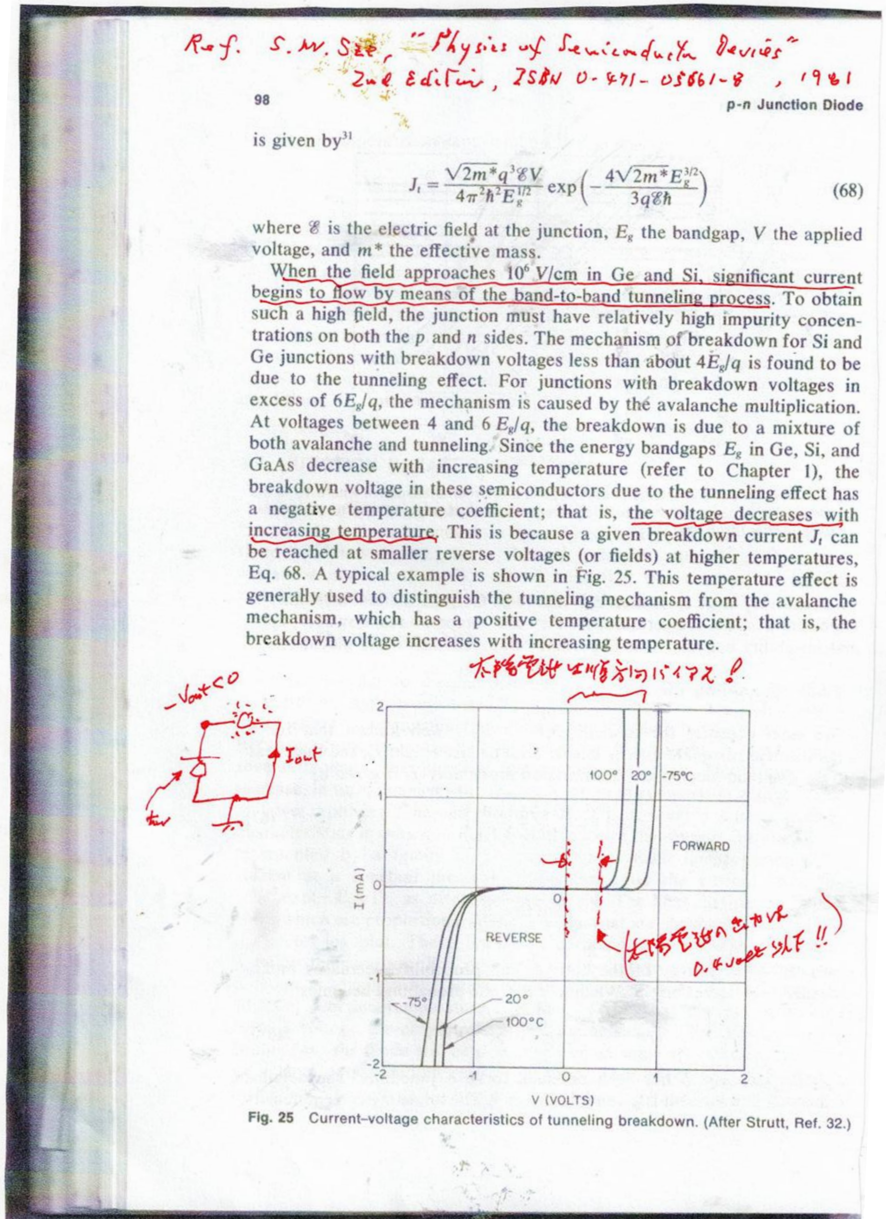
https://pdf.elspublishing.com/paper/journal/open/ESP/2025/esp20250003.pdf

How_to_make_Multi_Junction_Solar_Cell_Yoshiaki_Hagiwara.html



Ref. S.M. Sze, "Physics of Semiconductor Devices" 2nd Edition, ISBN 0-471-05661-8, 1981

98 p-n Junction Diode

is given by[31]

$$J_t = \frac{\sqrt{2m^*}\,q^3 \mathscr{E} V}{4\pi^2 \hbar^2 E_g^{1/2}} \exp\left(-\frac{4\sqrt{2m^*}\,E_g^{3/2}}{3q\mathscr{E}\hbar}\right) \quad (68)$$

where $\mathscr{E}$ is the electric field at the junction, E_g the bandgap, V the applied voltage, and m^* the effective mass.

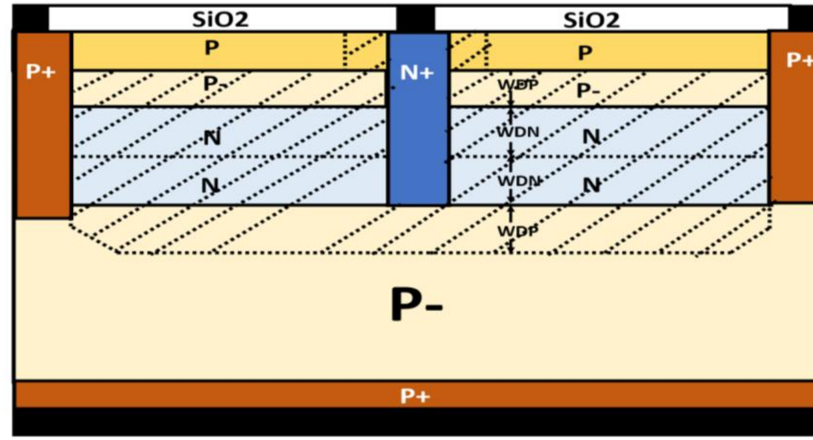
When the field approaches 10^6 V/cm in Ge and Si, significant current begins to flow by means of the band-to-band tunneling process. To obtain such a high field, the junction must have relatively high impurity concentrations on both the p and n sides. The mechanism of breakdown for Si and Ge junctions with breakdown voltages less than about $4E_g/q$ is found to be due to the tunneling effect. For junctions with breakdown voltages in excess of $6E_g/q$, the mechanism is caused by the avalanche multiplication. At voltages between 4 and 6 E_g/q, the breakdown is due to a mixture of both avalanche and tunneling. Since the energy bandgaps E_g in Ge, Si, and GaAs decrease with increasing temperature (refer to Chapter 1), the breakdown voltage in these semiconductors due to the tunneling effect has a negative temperature coefficient; that is, the voltage decreases with increasing temperature. This is because a given breakdown current J_t can be reached at smaller reverse voltages (or fields) at higher temperatures, Eq. 68. A typical example is shown in Fig. 25. This temperature effect is generally used to distinguish the tunneling mechanism from the avalanche mechanism, which has a positive temperature coefficient; that is, the breakdown voltage increases with increasing temperature.

Fig. 25 Current–voltage characteristics of tunneling breakdown. (After Strutt, Ref. 32.)

(A-type) Double P+PP-NP-P+接合型太陽電池

埋め込みN層と受光表面のP層には濃度制限がある。

P+N 接合間とN+P接合間にトンネル電流が流れない様に注意が必要。



(B-type) Double P+PP-NP-P+接合型太陽電池

埋め込みN層と受光表面のP層には濃度制限がない。

しかし、MASK工程が増加し、生産コストが増す。