(h) Temperature Dependence of Carrier Concentrations

The variation of carrier concentration with temperature is indicated by equations $n_0 = n_i e^{(E_F - E_i)/kT}$ and $p_0 = n_i e^{(E_i - E_F)/kT}$. Initially, the variation of n_0 and p_0 with T seems relatively straightforward in these relations. The problem is complicated, however, by the fact that n_i has strong temperature dependence $\left(n_i = \sqrt{N_c N_v}\, e^{-E_g/2kT}\right)$ and that E_F can also vary with temperature. Let us begin by examining the intrinsic carrier concentration.

$$n_i(T) = 2\left(\frac{2\pi kT}{h^2}\right)^{3/2} \left(m_n^* m_p^*\right)^{3/4} e^{-E_g/2kT}$$

The exponential temperature dependence dominates $n_i(T)$ and a plot of $\ln(n_i)$ vs $1000/T$ appears almost linear, as shown in figure.

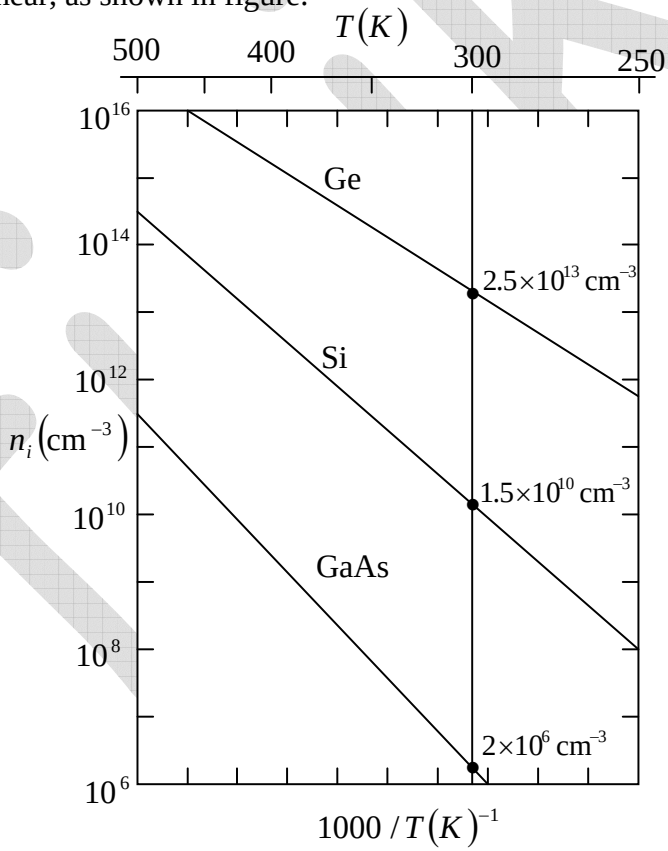

Figure: Intrinsic carrier concentration for *Ge*, *Si*, and *GaAs* as a function of inverse temperature. The room temperature values are marked for reference.