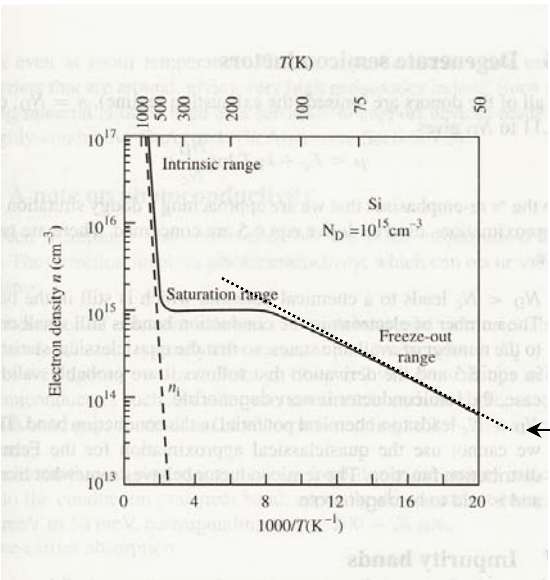
SSP Exercise 7 Solutions

1. Add impurity atoms with +1 valence relative to host semiconductor; excess electron is ionised by thermal energy and electron donated to conduction band. Add impurity atoms with -1 valence relative to host semiconductor; excess hole ionised by thermal energy and accepted by valence band. **[5]**

2. (i) $n_{\mathrm{D}}^{+} = N_{\mathrm{D}}\left[\dfrac{1}{\exp((\varepsilon_{\mathrm{D}} - \varepsilon_{\mathrm{F}})/k_B T) + 1}\right]$

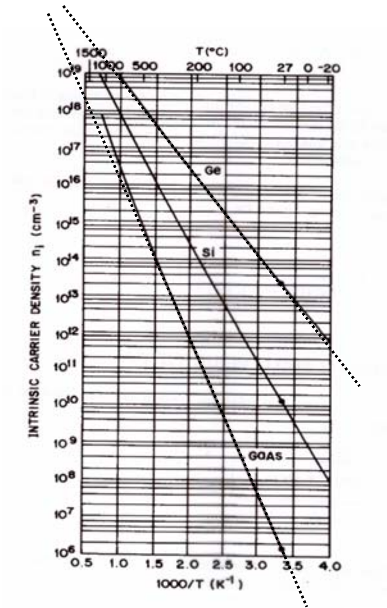
In the freeze-out region the conduction band electron density will be equal to n_{D}^{+}, and $\exp((\varepsilon_{\mathrm{D}} - \varepsilon_{\mathrm{F}})/k_{\mathrm{B}}T) \gg 1$, therefore the low temperature region of the right-hand graph will be of gradient $((\varepsilon_{\mathrm{D}} - \varepsilon_{\mathrm{F}})/k_{\mathrm{B}})$.



The measured gradient is ~ 245

$\Rightarrow (\varepsilon_{\mathrm{D}} - \varepsilon_{\mathrm{F}}) \approx 20$ meV **[4]**

(ii) and (iii) $n_{\mathrm{i}} = W^{\frac{1}{2}} T^{\frac{3}{2}} . e^{-\frac{\varepsilon_{\mathrm{g}}}{2 k_{\mathrm{B}} T}}$, therefore the gradient of the left-hand graph will be *approximately* ($-\varepsilon_{\mathrm{g}} / 2k_{\mathrm{B}}$)



For Ge, the measured gradient is ~ 5450

$\Rightarrow$ $\varepsilon_{\mathrm{g}} \approx 0.9$ eV **[3]**

For GaAs, the measured gradient is ~ 9800

$\Rightarrow$ $\varepsilon_{\mathrm{g}} \approx 1.7$ eV

[3]