CHAPTER V

CONCLUSION

Our extension of the McMillan's calculation (7) for the proximity effect to the case when the normal side contains nonmagnetic localized impurities shows that the critical temperature of the sandwich decreases when the impurity concentration increases. The critical temperature Tc can be calculated from Eq. (4.32), where a_{-1} is given by Eq. (4.26) and (4.27). The dependence of Tc on n_I for fixed values of α is shown in Fig. 4.2. We have used T_c^B = 7.193 K (for Pb), Γ_d = 0.75 eV, $E_d = 0$, $\Gamma_S = 0.2\ \Delta_B$, $\Gamma_N = 0.8\ \Delta_B$, Δ_B being the order parameter of the bulk superconductor of film S ($\Delta_B = 1.76\ k_B T_c^B$). The expression for α is obtained by Tang and Roongkeadsakoon (5), and is given by

$$\alpha = \Delta_d / \Delta_{ph}$$

$$= - N_d(o)\ U_{eff}\ b_D / \ 1 - n_I N_d(o)\ U_{eff}\ b_\infty \qquad (5.1)$$

where

$$b_D = \frac{\Gamma'_N}{\Gamma_S + \Gamma'_N}\left[\psi\left(\frac{1}{2} + \frac{\Gamma_S + \Gamma'_N}{2\pi k_B T_c}\right) - \psi\left(\frac{1}{2}\right)\right]$$

$$b_\infty = \frac{N_d(O)}{N_N(O)}\left[\frac{\Gamma_N}{\Gamma_S + \Gamma_N}\psi\left(\frac{1}{2} + \frac{\Gamma_S + \Gamma_N}{2\pi k_B T_c}\right) + \frac{\Gamma_S}{\Gamma_S + \Gamma_N}\psi\left(\frac{1}{2}\right)\right]$$

ψ being the digamma function (25), $\Gamma'_N = \Gamma_N / \left[1 + n_I N_d(0)/N_N(0)\right]$, and U_{eff} being the effective d-d Coulomb interaction defined by Schrieffer and Mattis (66):

$$U_{eff} = \frac{U}{1 + \frac{U}{E_d} \tan^{-1}\left(\frac{E_d}{\Gamma_d}\right)}$$

The expression (5.1) for α shows clearly its physical origin. Analytical expression for T_c was obtained by Tang and Roongkeadsakoon (5).

The jump of the specific heat ΔC at the transition temperature decreases as transition-metal impurities are doped. Therefore the magnitude of the decrease of ΔC due to impurities is another interesting subject. ΔC of the sandwich can be calculated from Eq. (4.41), where $B_o(n_I,T)$ and $B_1(n_I,T)$ are given by Eq.(4.34) and (4.35) respectively. $\Delta C/\Delta C_o$ vs. T_c/T_{co} is plotted in Fig. 4.3 for α = -1 and -4. The parameters used in the calculations are T_c^B = 7.193 K (for Pb), Γ_d = 0.75 eV, E_d = 0, $\Gamma_S = 0.2\ \Delta_B$ and $\Gamma_N = 0.8\ \Delta_B$. Due to the complex nature of the coefficient a_1 and a_{-1} [see Eqs. (4.26) - (4.31)], It was not possible to obtain analytical expressions for $B_1(n_I, T)$. Thus, $B_1(n_I, T)$ had to be evaluated numerically. This was done first by solving Eq. (4.32) to obtaine the values of T_c that correspond to the given values of Γ_S, Γ_N, Γ_d and n_I. The numerical values of Γ_S, Γ_N, Γ_d, n_I and T_c were then substituted into the coefficient a_1 and a_{-1} so that they could be used in the calculation of $B_1(n_I,T)$. The numerical values of $B_1(0, T_{co})$, $B_1(n_I, T_c)$ and $\partial B_o(n_I, T_c)/\partial T_c$ were then substituted into Eq.(4.41) to obtain the ratio of the specific heat jump $\Delta C/\Delta C_o$