Synopsis

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Title of the thesis: Superconductivity: Penetration depth and physical properties.
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The introductory chapter I, of the thesis contains an overview of various properties that are related to the superconductors. A general review of superconductors is given in this chapter. Specific heat, London penetration depth and physical properties of high-$T_c$ superconductors have been reviewed. There are a total of five chapters in the thesis including the introductory chapter.

In chapter II, we have calculated the penetration depth in a mixed wave superconductor. At low temperatures the ground state has $d_{x^2-y^2}$ symmetry which at elevated temperatures becomes of the type of $s$ wave. We have used the experimental measurements of the surface resistance of $Bi_2Sr_2CaCu_2O_{8+δ}$ crystals of $T_c \sim 20K$ at microwave frequencies to extract the London penetration depth as a function of temperature. It is found that the experimental data is consistent with the interpretation of $d_{x^2-y^2}$ wave at low temperatures becoming $s$ wave at high temperatures. The $d_{x^2-y^2} + is$ wave is estimated to start changing over to $s$ at a temperature of $\sim 40K$. The theoretically calculated values of the penetration depth as a function of temperature are
in reasonable agreement with those extracted from the experimental measurements.

In chapter III, we have reexamined the electron-phonon interaction from the viewpoint of its dependence on the crystal structure, particularly on the position of atoms in the unit cell. It is found that the strength of the interaction depends on the number of Cu-0 layers per unit cell only when there are defects. Accordingly the transition temperature depends on the variable number \( n \) of Cu-0 layers per unit cell. The larger the number of layers, the larger is the transition temperature. We find that the lattice waves can be treated by spherical Bessel functions so that the electron-phonon interaction oscillates as a function of number of layers of Cu-0 planes. The transition temperature of the superconductor then oscillates as a function of \( n \) having a large value at \( n = 3 \) and smaller value at \( n = 4 \). We predict that the next maximum value of \( T_c \) occurs at \( n = 7 \). The predicted variation of \( T_c \) as a function of \( n \) is in reasonable agreement with the experimental values.

In chapter IV, we described about two new processes that occur in a superconducting film when it is used as a detector of x-rays. One of these processes is the scattering of the x-ray by a single electron which gives rise to the broadening of the x-ray line. Another process describes the breaking of a Cooper pair by the x-ray which also contributes to the width of the x-ray. The line width arising from the single electron process depends on \( T^4 \) whereas that arising from the pair breaking process varies almost as \( T^6 \) at low temperatures. Lines occur at \( \hbar \omega_q \pm 2\Delta \), and at \( \hbar \omega_q \) where \( \hbar \omega_q \) is the energy of the x-ray and \( 2\Delta \) is the gap of the superconductor.
In chapter V, the orbit-lattice interaction which gives rise to a Berry's phase factor in the wave function is described. This phase depends on the symmetry of the potential and on the band gap of the system. Thus in the case of a lattice distortion the exponent of the phase factor vanishes above a transition temperature.

The thesis on the whole discusses the physical properties of superconductors from various viewpoints and the related theory that explains the experimental observations that are made in the literature. The work described in the chapters II - IV is new and projects our own efforts in search for interpretation of physical phenomena.