

Pressure dependence of the isothermal bulk modulus of solids

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Abstract : Expressions for the isothermal bulk modulus B_T and its pressure derivatives for solids with analytical forms for their lattice potentials can be derived assuming the Helmholtz free energy to equal the lattice potential. It has been observed in the past that the first pressure derivative of B_T and the ratio B_T/P reach a common limiting value as the solid is subjected to extremely high pressures ($P \rightarrow \infty$). We have reinvestigated this high pressure limiting behaviour with some interesting results. In particular, the power law of the short-range potential yields a single common limit and not two distinct ones as reported elsewhere and the exponential law does not yield any limiting values at all.

Keywords : Bulk modulus, power and exponential laws, high pressure limits.

PACS Nos. : 05.50.+q, 64.10.+h, 62.20.Dc

Elastic property of organized lipid assembly – an electrical study

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Abstract : The Freedericksz transition is a well-studied phenomenon in thermotropic liquid crystals. Here, above a certain critical value of the applied electric field, the orientations of the directors of a sample of liquid crystal change abruptly resulting in a sharp transition in the capacitance of the sample.

Using lipid molecules that have been properly aligned on polyvinyl alcohol coated glass electrodes, we have studied the effect of electric field on the capacitance of this system. In this case, a transient pattern similar to that of Freedericksz transition in liquid crystals has been observed. From the experimental data, the value of the splay elastic constant k_{11} of this system has been calculated.

Keywords : Lipids, electrical study, Freedericksz transition.

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Refractive index measurement as a function of temperature of the mesogen trans, trans-4'-propyl-bicyclohexyl-4-carbonitrite

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Abstract : The mesogen $\text{CCH}_3(\text{C}_{16}\text{H}_{27}\text{N})$ is a member of the homologous series of trans, trans-4'-propyl-bicyclohexyl-4-carbonitrite (cyclohexylcyclohexanes or CCH's) having the structural formula $\text{C}_n\text{H}_{2n+1}-\text{C}_6\text{H}_{10}-\text{C}_6\text{H}_{10}-\text{CN}$, $n=3$ for CCH_3 .

Though much work has been done on different members of the series, the orientational order parameter $\langle P_2 \rangle$ as a function of temperature has not been reported so far for CCH_3 . With a view to determine the variation of $\langle P_2 \rangle$ with temperature and to study the effect of increasing chain length on the optical properties of this homologous series, an indigenous experiment for birefringence studies at different temperatures using a laser beam has been set up. Ordinary and extraordinary refractive indices (n_o , n_e) have been determined as a function of temperature. From these values and from density measurements, polarisabilities α_o and α_e and hence $\langle P_2 \rangle$ may be determined.

Keywords : Mesogen, thermotropic, birefringence, order parameter

PACS Nos. : 61.30.-v, 78.20.Fm, 78.20.Ci

Dielectric constants and thickness of metallic film using attenuated total reflection technique

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Abstract : Gold films of thickness 40 nm to 50 nm are deposited on ultrasonically cleaned glass slides by thermal evaporation under vacuum of 10^{-6} Torr and at the evaporation rate 1 nm/sec. The gold-coated slides are brought into optical contact with the prism using an index matching fluid. For excitation of surface plasmons a He-Ne laser source of *P* polarized mono-chromatic beam ($\lambda = 633$ nm) is employed. The prism and the sample are placed on a $\theta-2\theta$ rotation stage. The reflectance minima R_p in gold as a function of the thickness is plotted. It shows that R_p becomes nearly equal to zero at $d \sim 45.75$ nm. The gold film of approximately 45 nm thick is taken and subjected to further surface plasmon resonance (SPR) study. The resulting SPR curve was well fitted by Fresnel's theory and the value of refractive index (*n*), extinction co-efficient (*k*) and thickness (*d*) are found to be 0.2 ± 0.03 , 3.2 ± 0.05 and 45 ± 2 nm respectively. The other observations from this experiment includes : the variations of real and imaginary parts of metal dielectric constants with film thickness and SPR curve at different thickness *etc.* Our results show good agreements with similar results of silver films and agree with the data obtained by ellipsometric measurements.

Keywords : Dielectric constants and thickness, metallic film, attenuated total reflection

PACS Nos. : 78.20.-e, 77.55.+f

Loss of interference in an Aharonov-Bohm ring

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Abstract : We study a simple model of dephasing of Aharonov-Bohm oscillations in the transmission of an electron across a mesoscopic ring. A magnetic impurity in one of the arms of the ring couples to the electron spin *via* an exchange interaction. This interaction leads to spin flip scattering and induces dephasing *via* entanglement. This is akin to the models evoked earlier to explain destruction of interference due to which-path information in double-slit experiments. Total transmission is found to be symmetric under flux reversal but not the spin polarization.

Keywords : Aharonov-Bohm oscillations, spin flip scattering, dephasing

PACS Nos. : 73.23.-b, 05-60.Gg, 72.10.-d.

Low field giant magneto-resistance in $\text{La}_{0.7}\text{Ca}_{0.2}\text{Ba}_{0.1}\text{MnO}_3$

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Abstract : In this paper, we have investigated the giant magneto-resistive behaviour of $\text{La}_{0.7}\text{Ca}_{0.2}\text{Ba}_{0.1}\text{MnO}_3$ in bulk form, at low applied de magnetic fields. Bulk samples have been synthesized by the solid state reaction route from La_2O_3 , CaO , $\text{Ba}(\text{NO}_3)_2$ and MnO_2 . These compounds were mixed in the desired cationic ratios and heated in the temperature range 1273K–1473K for 24 hrs with two intermediate grindings. The final sintering was carried out at 1573K for 12hrs. The structural characterization employing X-ray diffraction shows that the compound has a cubic unit cell with $a = 3.89 \text{ \AA}$. Micro-structural characteristics as revealed by scanning electron microscopy, show that the grain size is $\sim 400 \text{ nm}$. that is, the sample is micro-crystalline. The electrical transport property of this compound was evaluated by four probe technique at dc magnetic field in the range 0-3 kG. As the temperature is decreased, the resistance increases upto 230K showing a semi-conducting nature. Below this, resistance decreases and shows a metallic nature. Thus, a semiconductor to metallic transition occurs at 230K. Both zero field $\rho - T$ and $\rho - T$ at $H_{dc} = 1.5 \text{ kG}$ have similar behaviour. The magneto-resistance ratio (MRR) was calculated using the expression $\text{MRR} = [1 - \rho(H) / \rho(0)] \times 100$. MRR-T behaviour shows that MRR goes on increasing with temperature and at 77K, the maximum MRR at $H_{dc} = 1.5 \text{ kG}$ is 13 percent. As the field is increased, MRR increases and at 3kG, is 15 percent. Even at $H_{dc} = 0.3\text{kG}$, MRR is well above 9 percent. The MRR-T behaviour and the occurrence of GMR at such low fields at $H_{dc} = 0.3 \text{ kG}$, can be explained in terms of grain-boundary contributions.

Keywords : Giant magneto-resistance (GMR), low field, polycrystalline manganites

PACS Nos. : 75.80.+q, 61.10.Nz

Giant magnetoimpedance effect in glass coated amorphous $\text{Co}_{83.2}\text{Mn}_{7.6}\text{Si}_{5.8}\text{B}_{3.3}$ microwire

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Abstract : Glass-coated amorphous $\text{Co}_{83.2}\text{Mn}_{7.6}\text{Si}_{5.8}\text{B}_{3.3}$ microwire shows large change in magnetoimpedance (MI), called giant magnetoimpedance (GMI). The GMI effect of this sample has been studied up to a frequency of 11 MHz and varying a dc magnetic field (H_{dc}) within ± 140 Oe. A maximum change of 53% in MI has been observed around a frequency of 4 MHz. The application of an external stress changes the MI results to a large extent. The magnetization of the same sample has also been measured in presence of different tensile stresses to understand the domain structure and magnetoimpedance results.

Keywords : Giant magnetoimpedance, amorphous, microwire

PACS Nos. : 41.20 Gz, 75.30 Gw, 75.50 Cc

Influence of electron-phonon interaction on effective mass in some intermetallic compounds

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Abstract : It is well known that for ordinary metals, the electron-phonon interaction increases the quasi particle mass which is in contrast to the recent finding by Fulde *et al* that, for some Heavy Fermion systems, it decreases. To understand the effect of this interaction on effective mass, we have considered here the electron-phonon interaction in the Periodic Anderson Model (PAM) and derived a simple expression for it. This involves various model parameters namely, the position of $4f$ level, the effective coupling strength g and the electron-phonon coupling strength r . The influence of these parameters on the value of effective mass is studied. For simplicity, the numerical calculation is performed in long wavelength limit. It was found that the position of $4f$ level and electron-phonon coupling strength influence strongly on effective mass.

Keywords : Heavy Fermion (HF) systems, effective mass, electron-phonon interaction

PACS Nos. : 74.70.Tx; 71.10.; 71.38.

Crystal field and hyperfine effects in $\text{ErNi}_2\text{B}_2\text{C}$

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Abstract : Recently, neutron diffraction and Mossbauer experiments have been performed on tetragonal $\text{ErNi}_2\text{B}_2\text{C}$. From these experiments, lowest crystal field energy gap, g -values and hyperfine splitting of ^{166}Er in the sample have been estimated. But no theoretical calculations have been done to explain these values. The present paper reports the results of detail crystal field (CF) calculation and effects of hyperfine interaction of ^{166}Er in the solid state $\text{ErNi}_2\text{B}_2\text{C}$. The CF state are eight Kramers' doublets of which $\left|\pm\frac{1}{2}\right\rangle$ is the ground one having highly anisotropic g -values. The observed hyperfine splitting was also explained by considering ^{166}Er in the ligand field environment.

Keywords : Crystal field, g -values, hyperfine splitting

PACS Nos. : 71.70.Ck, 78.20.Jx, 76.80.+y

Magnetic field induced metal-insulator transition in colossal magnetoresistive $\text{Pr}_{1-x}\text{Ca}_x\text{MnO}_3$ ($x = 0.0-0.7$) material

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Abstract : In zero field $\text{Pr}_{1-x}\text{Ca}_x\text{MnO}_3$ shows thermally activated behaviour for all values of x . For $x \geq 0.3$, charge ordering occurs at 250 K, with long-range antiferromagnetic ordering at lower temperature. For a range of compositions $0.3 \leq x \leq 0.45$, a first-order magnetic-field-induced insulator-metal transition produces changes in resistivity of up to 12 order of magnitude at low temperature. These conducting states are metastable, resulting in a large hysteresis in resistivity with changes in both magnetic field and temperature.

Keywords : Magnetoresistance, perovskite manganates, insulator-metal transition

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Study of conduction current of NaCl and KCl crystals during X-ray radiation

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Abstract : The variation of conduction current with time under high constant D. C. field for NaCl and KCl crystals, has been studied. The direction of high constant D. C. field is kept parallel to the direction of X-ray by holding the crystal between two aluminium electrodes before X-ray beam. The change in conduction current due to change in direction of the D.C. field, has also been studied by changing the polarity of the field. The alkali halide crystals thus irradiated by X-ray in the presence of D.C. field, show Colour centres. The concentration of Colour centre due to presence of D. C. field is found to decrease than the concentration of Colour centres produced by X-ray irradiation only. The prominent F and M band peak position are found to be shifted in the longer wave length side due to D. C. field during X-ray irradiation.

On applying D. C. field in a direction parallel to X-ray, the conduction current is found to increase rapidly with time. It attains a peak value and then decays slowly. It reaches to a steady state after about one hour.

When the D.C. field is reversed *i.e.* applied in a direction opposite to X-ray beam, then conduction current decreases slowly for a short time, and reaches to a minimum value. Then the conduction current increases rapidly upto a peak value, after which it decreases slowly and becomes steady in about one hour.

Keywords : Colour centres, defects in solid

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Hysteresis in random field Ising model at zero temperature

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Abstract : We discuss hysteresis in the ferromagnetic random field Ising model at zero temperature. It provides a paradigm of the nonequilibrium response of a complex system which possesses infinitely many metastable states but insufficient thermal energy to move between these states over practical time scales.

Keywords : Ising model, magnetic hysteresis, random processes

PACS Nos. : 05.50.+q, 75.10.Nr, 75.60.Ej

AC driven thermal ratchets

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Abstract : We consider the motion of a overdamped Brownian particle in a periodic asymmetric potential with space-dependent friction coefficient. In the presence of external time periodic forcing, the system shows multiple current reversals on varying the amplitude of the external forcing and the temperature of the thermal bath. In the adiabatic regime, we find a single reversal of current as a function of noise strength which can only be accounted due to the presence of space dependent friction coefficient. For very large forcing, the current does not go to zero; instead, it asymptotically tends to a limiting value depending on the phase shift between the potential and the friction. This fact plays an important role in obtaining multiple current reversals.

Keywords : Brownian particle, periodic asymmetric potential, space-dependent friction coefficient

PACS Nos. : 05.40.-a, 05.60.-k, 82.20.-w

Optimisation of drift region width with reference to noise in Si DAR IMPATT diode

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Abstract : The noise behaviour of a Si DAR IMPATT diode is studied for different width of the v-region keeping the total diode width constant, using a realistic computer simulation method developed by us. Our results indicate that there exists an optimum width of the drift region of a DAR diode for which the mean square noise voltage of the diode would be the minimum. For a Si DAR diode designed for operation at 80 GHz the optimised width of the v-region is found to be 100 nm.

Keywords : IMPATT, DAR, noise

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RF negative resistance and avalanche noise generation distributions along depletion zones of GaAs, InP, GaInAs and GaInAsP DDDs

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Abstract : The RF negative resistance distribution and the avalanche noise generation profile have been computed for GaAs, InP, GaInAs and GaInAsP double drift IMPATT diodes. This gives the intensity of RF oscillation and noise generation within the individual space step of the depletion zone of different diodes. A double peak nature of the negative resistance profile with peaks in the drift zones and near uniform noise generation within the avalanche zone have been obtained. The GaInAs diode is expected to provide good RF performance due to its high value of diode negative resistance and low mean squared noise voltage.

Keywords : Double drift diodes (DDD), IMPATT, avalanche noise

PACS Nos. : 84.40.-x, 07.57.-c

Unzipping DNA : A hypothesis on correlation during replication

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Abstract : Based on the result of an unzipping phase transition by a force in a model of DNA, we hypothesize that the DnaA-type proteins act as a pulling agent with a force slightly less than the critical force for unzipping. The dynamic (space-time) correlation of unzipping then drives the subsequent events of replication. In such a correlation driven scenario, there is no need of a replisome as a structural unit and this elusive replisome may not exist at all.

Keywords : DNA, unzipping phase transition, biomolecules : theory and modeling

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Theory for thermodynamic properties of molecular fluid mixtures

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Abstract : The effective pair potential for molecular fluid mixture of molecules possessing tetrahedral symmetry is expressed in the Lennard – Jones (12-6) form in terms of effective diameter $\sigma_{ab}^T(T_{ab}^*)$ and well depth $\epsilon_{ab}^T(T_{ab}^*)$. The theory is applied to calculate the thermodynamic properties of CH_4 and excess thermodynamic properties of binary mixtures such as $\text{Ar} + \text{CH}_4$ and $\text{CF}_4 + \text{CH}_4$. In all these cases, the agreement is fairly good.

Keywords : Effective pair potential, excess thermodynamic properties, binary mixtures

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Theory of ultrasonic attenuation in heavy fermion compounds

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Abstract : The mechanism of the ultrasonic attenuation in heavy fermion compounds is not yet studied clearly both experimentally and theoretically. A microscopic theoretical model is proposed here to study the attenuation in the compounds like UPt_3 , CeCu_2Si_2 , CeRu_2Si_2 in their normal states. We consider the Periodic Anderson Model and incorporate phonon coupling to the hybridisation between the conduction electrons and f -electrons as well as to the f -electrons alone. The phonon Green's function is calculated by Zubarev technique. The temperature dependence of the ultrasonic attenuation coefficient (α) is calculated from the imaginary part of the phonon self-energy and the velocity of sound in the dynamic and long wavelength limit. The dependence of the parameters like the electron-phonon coupling parameters (g , r), hybridisation (v), position of f -level (d), Coulomb correlation (u), frequency (ω), is investigated numerically through plots.

Keywords : Ultrasonic attenuation, heavy fermions, electron phonon interaction

PACS Nos. : 74.25.Ld, 75.30.Mb, 63.20.Kr

Synthesis of Y-123 superconductor without Oxygen annealing

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Abstract : This paper reports the synthesis of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ superconductors without external oxygen annealing. Polycrystalline samples are synthesized with nominal compositions. $\text{YBa}_2\text{Cu}_3\text{Hg}_x\text{O}_y$ ($0 \leq x \leq 0.3$). The synthesis was carried out in an open atmosphere by two-stage, solid-state reaction method. Initially, the stoichiometric composition of Y_2O_3 , BaCO_3 and CuO was calcined twice at 925 °C for 24 hours and then the pellets of HgO added Y-123 compound were sintered at 650 °C for 24 hours. The X-ray diffraction patterns of the samples revealed monophasic Y-123 nature without any trace of Hg or related materials. The superconducting behaviour was studied by low temperature $R-T$ measurement. The HgO added samples showed metallic behavior followed by the superconducting transition. Some of the HgO added samples exhibited onset superconductivity around 100K. The scanning electron micrographs of these samples showed non-uniform grain size with substantial grain inter-diffusion.

Keywords : Y-123 superconductor, synthesis, solid-state reaction method

PACS No. : 74.72.Bk

Temperature dependence of velocity of sound in high- T_c superconductors in normal state

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Abstract : A microscopic theoretical calculation of temperature dependence of velocity of sound in high temperature superconductors is addressed in this paper. The influence of model parameters of the system in its normal phase is investigated through numerical calculations. The results at the room temperature as well as low temperatures ($\sim 25\text{K}$), are discussed. The dimensionless parameters involved in the calculations are the electron-phonon coupling (g), staggered magnetic field (h), hybridization (V), position of the f -level (d), temperature (t) and the conduction band width ($\tilde{W}$). The model Hamiltonian contains the antiferromagnetism in conduction electrons of copper and the electron-phonon interaction through the hybridization between conduction electrons and f -electrons of impurity atoms. The phonon Green's functions are calculated by Zubarev's technique. The velocity of sound is calculated in the long wavelength and finite temperature limit.

Keywords : High- T_c compounds, electron-phonon interaction, acoustical properties

PACS Nos. : 74.72.-h, 63.20.Kr, 74.25.Ld

Synthesis and structural characteristics of Hg-Ba-Ca-Cu-O high temperature superconductor

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Abstract : The $\text{HgBa}_2\text{CaCu}_2\text{O}_{6+d}$ (Hg:1212) and $\text{HgBa}_2\text{Ca}_2\text{Cu}_3\text{O}_{8+d}$ (Hg:1223) phases of Hg-Ba-Ca-Cu-O system have been synthesised, with same starting nominal compositions $\text{Hg}_{1-x}\text{Ba}_{2-x}\text{Ca}_x\text{Cu}_3\text{O}_z$, at ambient pressure, employing single step direct oxides route. The X-ray diffraction (XRD) and transmission electron microscopic (TEM) investigations revealed that the material sintered at 720°C for 6 h contained dominantly tetragonal Hg : 1212 phase with lattice parameters $a = b = 3.86 \text{ \AA}$ and $c = 12.76 \text{ \AA}$; whereas materials sintered at 750°C for 8h contained dominantly tetragonal Hg : 1223 phase with lattice parameters $a = b = 3.86 \text{ \AA}$ and $c = 15.87 \text{ \AA}$. The $R - T$ measurements of the as – synthesised materials showed transition temperatures in the range of 90 – 110K. In this paper, details of synthesis parameters and structural – microstructural features of the as – synthesised materials have been described and discussed.

Keywords : Synthesis, structural – microstructural characteristics, high temperature superconductivity

PACS Nos. : 74.72.Jt, 68.37.Lp, 81.20.-n

Synthesis and microstructural characteristics of Tl-based high temperature superconducting tapes

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Abstract : The superconducting tapes of Tl-Ba-Ca-Cu-O HTSC system were synthesised through doctor blade tape casting process. Their structural-microstructural characteristics were explored through X-ray diffraction (XRD) and transmission electron microscopic (TEM) techniques. A novel feature of the present synthesis route was that here in the same thalliation process, tapes of two different HTSC phases possessing single and double Tl-O layers *i.e.* $\text{TlBa}_2\text{CaCu}_2\text{O}_7$ (1212) and $\text{Tl}_2\text{Ba}_2\text{CaCu}_2\text{O}_8$ (2212) or $\text{TlBa}_2\text{Ca}_2\text{Cu}_3\text{O}_9$ (1223) and $\text{Tl}_2\text{Ba}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$ (2223), could be synthesised. The transition temperatures (T_c s) of the as synthesised tapes were found in the range of $\sim 80 - 115\text{K}$

Keywords : Tl-based HTSC tapes, synthesis, micro-structural characteristics

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Transport properties improvement and grain enlargement of $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$ superconductor by control annealing on Au foil

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Abstract : We have described a new process to prepare the aligned $\text{YBa}_2\text{Cu}_3\text{O}_{7-d}$ (YBCO) superconducting sample by unique annealing process on a gold foil. The transition temperature (T_c) of the Au doped samples is found to increase from 89 K to 94 K as the Au concentration is increased from 0.1 to 0.3%. The current density (J_c) measured from M-H curve by Bean model for aligned pellet is $\sim 2 \times 10^4 \text{ Acm}^{-2}$. Elongated aligned grains of YBCO $\sim 200 \text{ nm}$ long can be seen in the vicinity of this compound.

Keywords : Superconductivity, aligned grains, magnetization

PACS Nos. : 74.25.Fy, 74.72.Bk, 81.40.z

Interpretation of normal state in-plane resistivity of La-Sr-CuO superconductors**

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Abstract : The temperature-dependent behaviour of the normal state in-plane resistivity of optimally doped La-Sr-CuO system is analysed within the framework of Fermi liquid description. An effective two-dimensional dynamic interaction potential is developed that incorporates the screening of holes as carriers by acoustic phonons and by plasmons. The system is treated as an ionic solid containing layers of holes as carriers and a model dielectric function is set up which fulfils the appropriate sum rules on electronic and ionic polarizabilities. The coupling strength linking holes as carriers to screened phonons is derived from the residue at the pole of interaction potential. The inelastic scattering rate due to the hole-screened phonon interaction is worked out and the Drude expression is used to estimate the temperature dependent resistivity. Zero temperature scattering rate is obtained from upper critical field and the screened plasma frequency, together with scattering rate are used to obtain zero temperature resistivity. The implications of the above analysis are discussed.

Keywords : Normal state resistivity, La-Sr-CuO, screened phonons

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Anomalous behaviour of Zr-Cu metallic glass superconductors

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Abstract : The studies on the properties of binary – metallic glass alloys particularly those based on Zr have been made. An increase in the resistance is reported near the superconducting transition temperature for metallic alloys which is an anomalous behaviour for such alloys. This anomaly consists of a peak in the resistance which can reach upto 10 mW-cm. above the usual superconducting fluctuation region. Although, many such anomalous properties have been accounted for weak localization and interacting contributions, the question of origin of these effects are still highly controversial and not yet properly understood. We analyse the probable effects that can cause the fluctuation of superconducting transition temperature (T_c). We try to reinvestigate the fluctuation of superconducting transition temperature (T_c) through the deduction of superconducting gap parameter and the resistivity behavior from the evaluation of the normal state electronic property for some Zr-Cu alloys. The results have been attributed to the weak localisation and s - d exchange interactions due to the presence of localised electrons on the Cu sites.

Keywords : Resistivity peaks, transition temperature, s - d exchange interaction

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