अतिचालकता एवं निम्न तापिती

अतिचालकता समूह अभिलक्षण की विविधता एवं अतिचालक पदार्थों की सुविश्लेषण श्रृंखला के निर्माण में व्यस्त रहा है। Bi₂Sr₂CaCu₂O₈ (Bio-2212) तंत्र का विभिन्न परिस्थितियों जैसे गलत शामिल (मेल्ट-कैंचड), N₂ तापानुशीलन एवं O₂ तापानुशीलन द्वारा संश्लेषण किया गया, नमूने में होल सांद्रता की विभिन्नता आकर्षक तापमानीत्व परिभाषित दिखाई है। MgB₂-x(nC)x नमूनों की बड़ी श्रृंखलाओं में क्रांतिक अतिचालक प्राचूल्य के निर्धारण के लिए उच्च क्षेत्र चुम्बक एवं चुम्बकीय परिवर्तन मापन का निर्णयन किया गया, विशेष रूप से MgB₂ नमूनों की तुलना में नेनो कार्बन (nC) अपनाए जो क्रांतिक प्राचूल्यों जैसे H₂, H₂, एवं J(H) में संतुष्टजनक वृद्धि के परिमाण दिए हें। स्थूल MgB₂ एक्स-रीटर नमूनों की श्रेणी, 5% तक जलवायु में Mg मिलाकर तैयार की गयी जिसमें दुर्लभ :- युक्तित क्रोणीय प्रकृति में सुविश्लेष्ठ अंतर देखा गया। विविध नमूनों में सामान्य अवस्था में आकलित धारावाही अनुप्रस्थ परिच्छेद का अतिचालक अवस्था गुणों जैसे Jc एवं Tc जो कोई सहसंबंध नहीं देखा गया।

अतिचालक आइल्स आक्सिटनिउटाइड्स जैसे SmFe₀.₉ Co₀.₁ AsO एवं Nd Fe AsO₀.₈ Fe₀.₂ नए संश्लेषण मार्ग द्वारा सफलतापूर्वक अनुक्रमित किए गए।
The superconductivity group has been engaged in preparing an exhaustive range of superconducting materials and variety of characterizations. The Bi$_2$Sr$_2$CaCu$_2$O$_8$ (Bi-2212) system was synthesized under different conditions of melt quenched, $N_2$-annealed and $O_2$-annealed. The hole concentration variation in the samples led to interesting thermopower results. The high field magnetization and magneto transport measurements were carried out to determine the critical superconducting parameters in a large range of MgB$_{2-x}$(nC)$_x$ samples. The nano carbon (nC) doping resulted in substantial enhancement of critical parameters like $H_{c2}$, $H_{irr}$ and $J_c(H)$ in comparison to the pure MgB$_2$ sample. Series of ex-situ samples of bulk MgB$_2$ were prepared with addition of excess Mg up to 5% that showed systematic difference in the weakly coupled particle nature. The estimated current carrying cross sections in normal state were found to show no correlation with the superconducting state properties like $J_c$ and $T_{co}$ in various samples. New synthesis routes to prepare superconducting iron oxypnictides, e.g., SmFe$_{0.9}$Co$_{0.1}$AsO and NdFeAsO$_{0.8}$F$_{0.2}$ were successfully attempted.
Superconductivity and Cryogenics

We reported the temperature dependence of thermoelectric power $S(T)$ of three differently processed $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_8$ (Bi2212) samples, viz. as-processed melt quenched (Bi2212-MQ), 600°C $\text{N}_2$-annealed (Bi2212-$\text{N}_2$) and 800°C $\text{O}_2$-annealed (Bi2212-$\text{O}_2$). All the samples possess single-phase character and their superconducting transition temperatures ($T_c$) are 85 K, 90 K and 72 K respectively for Bi2212-MQ, Bi2212-$\text{N}_2$ and Bi2212-$\text{O}_2$, see Figure 7.1. Though the Bi2212-MQ and Bi2212-$\text{N}_2$ samples are in near optimum doping regime, the Bi2212-$\text{O}_2$ is an over-doped sample. $T_c^{S=0}$ values obtained through $S(T)$ data are also in line with those determined from the temperature dependence of resistance ($T_c^{R=0}$) and DC magnetization ($T_c^{\text{dia}}$). Interestingly, $S(T)$ behaviour of the optimally-doped Bi2212-MQ and Bi2212-$\text{N}_2$ samples is seen to be positive in whole temperature range, the same is found negative for the over-doped Bi2212-$\text{O}_2$ sample above $T_c^{S=0}$, see Figure 7.2. This anomalous $S(T)$ behaviour is seen in the light of the recent band structure calculations and the ensuing split

The high field magnetization and magneto transport measurements are carried out to determine the critical superconducting parameters of $\text{MgB}_2$ system. The synthesized samples are pure phase and the lattice parameters evaluation is carried out using the Rietveld refinement. The $R-T(H)$ measurements are done up to a field of 140 kOe. The upper critical field values, $H_{c2}$ are obtained from this data based upon the criterion of 90% of normal resistivity i.e. $H_{c2}$ = $H$ at which $\rho$ = 90% $\rho_N$; where $\rho_N$ is the normal resistivity i.e., resistivity at about 40 K in our case, see Figure 7.3. The Werthamer-Helfand-Hohenberg (WHH) prediction of $H_{c2}(0)$ underestimates the critical field value even below the field up to which measurement is carried out. After this the model, the Ginzburg Landau theory (GL equation) is applied to the $R-T(H)$ data which not only calculates the $H_{c2}(0)$ value but also determines the dependence of $H_{c2}$ on temperature in the low temperature high field region. The estimated $H_{c2}(0)$ = 157.2 kOe for pure MgB$_2$ is profoundly

Fig. 7.1 R(T) of various Bi-2212 samples

Fig. 7.2 S(T) of various Bi-2212 samples

Fig. 7.3 $R(T)$ of various Bi-2212 samples
enhanced to 297.5 kOe for the x=0.15 sample in MgB$_{2-x}$C$_x$ series, see Figure 7.4. Magnetization measurements are done up to 120 kOe at different temperatures and the other parameters like irreversibility field, $H_{irr}$ and critical current density $J_c(H)$ are also calculated. The nano carbon doping results in substantial enhancement of critical parameters like $H_{c2}$, $H_{irr}$ and $J_c(H)$ in comparison to the pure MgB$_2$ sample.

Series of ex-situ samples of bulk MgB$_2$ were prepared with addition of excess Mg up to 5% and varying sintering temperatures between 700°C to 950°C. All the samples were subjected to XRD and SEM characterization as well as thermoelectric power $S(T)$, resistivity $\rho(T)$ and magnetization $M(B)$ measurements at 4.2 and 20 K and applied fields $B=0 - 8$ T. Various normal and superconducting state properties show weakly coupled particles in the samples. The samples typically show high values of $\rho(300 \, \text{K})$ that varies between 0.12 and 254 mΩcm. And the critical current density $J_c(4.2 \, \text{K}, 1 \, \text{T})$ show low values that varies between $1.8 \times 10^7$ to $1.7 \times 10^8$ A/m$^2$. The temperature dependence of resistivity in the normal state scales perfectly among the samples, to within a multiplication factor. Following Rowell’s analysis, this indicates a difference in normal state connectivity, i.e., effective current carrying cross section ($A_F$), which is found to vary from 0.02% to 7% in different samples.
Surprisingly, no correlation between the $J_c$ and $T_{c0}$ as a function of AF is found in our samples (Fig.7.5). However, $J_c(B)$ of all the samples can be scaled within a multiplication factor at both 4.2 and 20 K until cross over fields $B_{cr} \sim 2$ and 1.3 T, respectively. The $J_c(B)$ of the samples follow a $B^{-1}$ dependence until $B_{cr}$, at both $T=4.2$ and 20 K, beyond which it decreases rapidly towards zero with increasing B. The superconducting transition measured resistively in the presence of B shows an enhanced broadening. We further attempt to delineate the role of the intra-particle and inter-particle regions in determining the $J_c(B)$

![Graph](image1)

**Fig.7.5.** Variation of (a) $T_{c0}$ and (b) Normalized $J_c$ ($B=1T$) at $T = 4.2$ and 20 K as a function of $A_F$ for different MgB$_2$ samples.

and $\rho(T,B)$ properties of our weakly coupled samples.

We reported superconductivity in the SmFe$_{0.9}$Co$_{0.1}$AsO system being prepared by most easy and versatile single step solid-state reaction route. The parent compound SmFeAsO is non-superconducting but shows the spin density wave (SDW) like antiferromagnetic ordering at around 140K. To destroy the antiferromagnetic ordering and to induce the superconductivity in the parent system, the Fe$^{2+}$ is partially substituted by Co$^{3+}$. Superconductivity appears in SmFe$_{0.9}$Co$_{0.1}$AsO system at around 14K. The Co doping suppresses the SDW anomaly in the parent compound and induces the superconductivity. Magnetization measurements show clearly the onset of superconductivity with $T_c^{dia}$ at 14K, see Figure 6. The isothermal magnetization measurements exhibit the lower critical fields ($H_{c1}$) to be around 200Oe at 2 K. The bulk superconductivity of the studied SmFe$_{0.9}$Co$_{0.1}$AsO sample is further established by open diamagnetic M(H) loops at 2, and 5K, see inset Figure 7.6. Normal state (above $T_c$) linear isothermal magnetization M(H) plots excluded presence of any ordered magnetic impurity in the studied compound.

![Graph](image2)

**Fig. 7.6** $M(T)$ and $M(H)$ of SmFe$_{0.9}$Co$_{0.1}$AsO system