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Title of the thesis: **Superconductivity in pure and doped iron-arsenide oxy- pnictides compounds**

ABSTRACT

The research work carried out under the course work of this thesis has mainly been focused on induction of superconductivity in the SmFeAsO compounds by 3d metals metal doping, such as Co and Ni at Fe site. Further to study the interplay between 3d electron moments (Fe, Co, Ni) with rare earth 4f electron moments, the magnetic Sm/Nd(4f) is changed with non magnetic La. Hence forth detailed physical property studies are carried out on various (La/Sm/Nd)O(Fe/Co/Ni)As/P compounds to unearth the interplay of RE(4f) and Co/Fe/Ni(3d) orbitals.

The parent undoped SmFeAsO compounds is non-superconducting and shows a structural phase transition from the tetragonal (*P4/nmm)* to the orthorhombic (*Cmma)* symmetry below 150 K along with a spin density wave like behavior at some lower temperature. The MR% of SmFeAsO, is found to be as large as 16% at 2.5 K in magnetic field of 14 Tesla (T). Nonlinear variation of MR at low magnetic fields tends to be linear at moderate magnetic fields ($H \geq 3.5$ T) . The jump in specific heat value is observed at 140 K, which is attributed to structural or SDW transition. Also, a sharp peak is obtained at $T = 4.5$ K corresponding to the anti-ferromagnetic ordering of Sm^{+3} ions in the system. The XPS studies on the compound are carried out which demonstrates the Fe to be in mixed valence state and As mainly in trivalent sate.

The spin density wave character of SmFeAsO is rapidly suppressed by successive doping of Co and Ni at Fe site and later superconductivity is induced in a narrow doping range. Our results highlight the fact that Co substitution at Fe site in $SmFe_{1-x}Co_xAsO$ shows superconductivity for the doping range $x = 0.10$ to 0.20, with highest T_c at 15 K in $SmFe_{0.85}Co_{0.15}AsO$ sample. On the other hand, superconductivity in $SmFe_{1-x}Ni_xAsO$ compounds is observed in a narrow doping window from $x = 0.04$ to 0.10 with maximum

T_c of 9 K for the $SmFe_{0.94}Ni_{0.06}AsO$ sample. The The higher doping level compositions are non-superconducting.

The average rate of decrease of transition temperature with applied magnetic field is 1 Kelvin per Tesla {$dT_c/dH \sim 1K/T$} for Co and Ni substituted $SmFe_{0.85}Co_{0.15}AsO$ and $SmFe_{0.94}Ni_{0.06}AsO$ samples. It suggests the robustness of superconductivity and a high value of upper critical field (H_{c2}) in these compounds. The estimated value of upper critical field, $H_{c2}(90\%)$ by Ginzburg- Landau (GL) theory for the samples $SmFe_{0.85}Co_{0.15}AsO$ and $SmFe_{0.94}Ni_{0.06}AsO$ are 36T and 30T respectively.

The fully Co substituted sample SmCoAsO undergoes successive paramagnetic (*PM*) – ferro-magnetic (*FM*) – anti-ferro-magnetic (*AFM*) transitions with decrease in temperature. The complex magnetism and magneto-transport behavior of RECoAsO (RE = La, Nd and Sm) is studied and inter compared for various RE (La, Sm, Nd). Isothermal magnetization shows that LaCoAsO undergoes a single paramagnetic (PM) to ferromagnetic (FM) transition near 55 K, on the other hand the NdCoAsO and SmCoAsO undergo three successive PM-FM-AFM transitions i.e. T_c^{Co} (~80 K), the Sm^{4f}-Co^{3d} and Nd^{4f}-Co^{3d} interplayed AFM below 20 K and finally Sm^{3+} and Nd^{3+} spins individual AFM at 5.4 K and below 2 K respectively. The FM-AFM transition for magnetic rare earths is mediated by $(Nd/Sm)^{4f}$ and Co^{3d} interacting moments in (Nd/Sm)CoAsO. The AFM ordering of (Nd/Sm)CoAsO is clearly reflected in magneto-transport studies. Further, the FM-AFM transition of Co spins is found to be field dependent.

We also studied the RECoPO systems in same way as for RECoAsO with RE = La, Sm and Nd. The LaCoPO shows single paramagnetic (PM) to ferromagnetic (FM) transition near 35 K, the NdCoPO and SmCoPO exhibit successive PM-FM-AFM transitions. The FM-AFM transition for magnetic rare earths is mediated by $(Nd/Sm)^{4f}$ and Co^{3d} interacting moments in (Nd/Sm)CoPO. NdCoPO shows a upward step like transition in $\rho(T)$ measurement under zero field but not for SmCoPO. The transition of Co spins from ferromagnetic (FM) to anti-ferromagnetic (AFM) in (Nd/Sm)CoPO is field dependent. The heat capacity $C_p(T)$ exhibits only the low temperature RE moments AFM ordering and as such the Co mediated transitions (FM-AFM) are not seen, indicating a continuous change in entropy and hence no peak in heat capacity.