Superconductivity in Bi$_2$-based compounds

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Polycrystalline samples of $LnO_{0.5}F_{0.5}BiS_2$ ($Ln = La$, Ce, Pr, Nd, Yb) were synthesized by solid-state reaction. These compounds form in a tetragonal structure with space group $P4/nmm$ conforming to the CeOBiS$_2$ crystal structure. Electrical resistivity, magnetic susceptibility and specific heat measurements were performed on all of the samples. All of the compounds exhibit superconductivity in the range 1.9 K - 5.4 K, and the YbO$_{0.5}F_{0.5}BiS_2$ sample was also found to exhibit magnetic order (probably antiferromagnetic order) at $\sim$2.7 K that appears to coexist with superconductivity below 5.4 K [1]. Electron-doping appears to induce superconductivity in the Bi$_2$-based superconductors as partial substitution of F for O is necessary to observe superconductivity. This was further demonstrated in a study where trivalent La$^{+3}$ was partially substituted with tetravalent Th$^{+4}$, Hf$^{+4}$, Zr$^{+4}$, and Ti$^{+4}$, all of which induced superconductivity [2]. We also observed that substitution of divalent Sr$^{+2}$ for La$^{+3}$ (hole doping) does not induce superconductivity [2]. Electrical resistivity measurements were also performed under applied pressure on $LnO_{0.5}F_{0.5}BiS_2$ ($Ln = La$, Ce, Pr, Nd) up to $\sim$3 GPa and down to 1 K. These studies revealed a universal behavior where the systems are tuned away from semi-conducting behavior towards metallic behavior. The superconducting states were stabilized by applied pressure, so that $T_c$ increased in all of the rare earth members listed. At a critical pressure $P_c$, $T_c$ increases rapidly from a low $T_c$ phase to a distinct high $T_c$ phase, after which additional pressure no longer suppressed the semiconducting behavior in the normal state [3,4]. In addition, the metallization of NdO$_{0.5}F_{0.5}BiS_2$ also occurs at $P_c$.

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