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Superconductivity in BiS_2-based compounds[1]

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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 ~2.7 K that appears to coexist with superconductivity below 5.4 K [1]. Electron-doping appears to induce superconductivity in the BiS$_2$-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 ~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.

This work was performed in collaboration with M. B. Maple, K. Huang, B. D. White and C. T. Wolowiec.

[1] Yazici et al, Philos. Mag. 93, 673, (2012).
[2] Yazici et al, Phys. Rev. **B** 87, 174512, (2013).
[3] Wolowiec et al, Phys. Rev. **B** 88, 064503, (2013).
[4] Wolowiec et al, Journal of Physics: Condensed Matter 25, 422201, (2013).

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