Materials Trends in Different Classes of Superconductors from Heavy Fermion Compounds to Iron Pnictides and Beyond

M. Brian Maple

Department of Physics and Center for Advanced Nanoscience,
University of California, San Diego, La Jolla, CA 92093 USA

E-mail: mbmaple@ucsd.edu

Abstract - In this talk, we survey the superconducting and normal state properties of three classes of correlated electron materials that exhibit unconventional superconductivity that emerges from magnetically ordered phases: heavy fermion f-electron materials, layered copper oxides (cuprates), and iron pnictides/chalcogenides. While the heavy fermion compounds have maximum superconducting critical temperatures T_c of ~ 2 K, the maximum value of T_c found in the layered cuprates is ~130 K at ambient pressure (~160 K at high pressures ~30 GPa) for $HgBa_2Ca_2Cu_3O_8$, while the maximum T_c currently observed within the iron pnictides is ~56 K for $SmFeAsO_{1-x}F_x$.

In these materials, it is widely believed that the superconductivity is unconventional and pairing of electrons is mediated by magnetic interactions. The layered cuprates and the Fe-based pnictides/chalcogenides generally have crystal structures that consist of conducting layers (CuO_2 layers for the cuprates and FePn or FeCh layers for the Fe pnictides and chalcogenides) separated by so-called "blocking layers" that control the charge carrier concentration within the conducting layers. We also discuss a new class of superconductors that have recently been discovered that are based on the semiconducting parent compounds $LnOBiS_2$, where Ln is a lanthanide element. These compounds have crystal structures that consist of conducting BiS_2 layers separated by blocking layers. The semiconducting $LnOBiS_2$ parent compounds are rendered more conducting, and, in turn, superconducting by doping the BiS_2 layers with electrons by means of the substitution of F for O or tetravalent Ti, Zr, Hf, or Th for La. The semiconducting behavior can be suppressed by application of pressure, leading to a transition to another superconducting phase with a higher T_c. The maximum T_c in the $LnOBiS_2$ based compounds is currently ~10 K for Ln = La.

Keywords (Index Terms) - Superconducting and normal state properties, heavy fermion f-electron materials, layered cuprates, pnictides, chalcogenides.