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Unusual superconductivity up to 49 K in single crystalline R-doped $CaFe_2As_2$ (Ca122) at ambient with R = rare earth

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Abstract. The discovery in 2008 of the Fe-pnictide and Fe-chalcogenide superconductors has generated immense interest. They crystallize in four different structures, namely, the 1111-phase (RFeAsO, where R = rare earth) with the ZrCuSiAs structure (P4/nmm); the 122-phase ($AeFe_2As_2$ and AFe_2As_2, where Ae = alkaline earth and A = alkaline) with the $ThCr_2Si_2$ structure (I4/mmm); the 111-phase (AFeAs, where A = alkaline) with the PbFCl structure (P4/nmm); and the 11-phase ($FeSe_{1-x}$) with the PbO structure (P4/nmm). The highest Tc's of these compounds are 57 K, 38 K, 20 K and 10 K for the 1111, 122, 111 and 11 structure classes with different electron or hole- ping at ambient. Until now, no effort has been successful to raise the maximum Tc of Fe-pnictides or -chalcogenides to above the 60's K as predicted. In view of the unsettled superconducting behavior of Ca122 under pressure, we have investigated the electron-doping effect on Ca122, in contrast to previous studies on the 122 class where only hole-doping has been carried out. We have detected superconductivity up to 49 K in single crystalline $CaFe_2As_2$ via electron-doping by partial replacement of Ca by rare-earth. The superconducting transition observed suggests the possible existence of two phases: one starts at ~ 49 K with a low critical field ~ 4 Oe, and the other at ~ 21 K, with a much higher critical field > 5 T. Our observations are in strong contrast to previous reports of doping or pressurizing layered compounds $AeFe_2As_2$ (or Ae122), where Ae = Ca, Sr or Ba. In Ae122, hole-doping has been previously observed to generate superconductivity with a transition temperature (T_c) only up to 38 K and pressurization has been reported to produce superconductivity with a T_c up to 30 K. The unusual 49 K phase observed appears to be filamentary or interfacial in nature. The associated superconducting transition at 49 K behaves as Josephson-Junction-coupled-like, suggesting the existence of a superconducting phase above 49 K in the R-Ca-Fe-As compound system. The results will be presented and the implications discussed.