Synthesis and physical properties of Ca$_{1-x}$RE$_x$FeAs$_2$

with $RE = $ Ce, Nd, Sm, Eu and Gd

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[Introduction] Recently new 112 type iron-based superconductors – Ca$_{1-x}$RE$_x$FeAs$_2$ have been reported for $RE = $ La$^1$ and Pr$^2$. This structure has a monoclinic space group $P2_1/m$, and is composed of two Ca(RE) planes, anti-fluorite Fe$_2$As$_2$ layers, and As$_2$ zigzag chain layers. The highest $T_c$ reported for this new phase is 43 K for a Sb-doped Ca$_{0.85}$La$_{0.15}$FeAs$_2$ sample$^3$. Various studies on these new superconductors are needed in order to investigate their superconducting properties. In this study we report the synthesis and characterization of Ca$_{1-x}$RE$_x$FeAs$_2$ compounds with $RE = $ Ce, Nd, Sm, Eu and Gd.

[Experimental] The Ca$_{1-x}$RE$_x$FeAs$_2$ samples were synthesized by the high-pressure method. Phase identification was carried out by XRD. Magnetization properties were examined by a SQUID magnetometer and electrical resistivity was measured by the AC four-point-probe method using Physical Property Measurement System.

[Results] 112 phase was successfully formed in all the samples synthesized under moderately high pressure ~2 GPa, small silvery crystals embedded in a uniform opaque black matrix in the bulk samples. From the XRD analyses the samples are composed of Ca(RE)–112 phase with FeAs and FeAs$_2$ impurity phases. As shown in Fig. 1, Nd, Sm, Eu and Gd doped samples exhibited diamagnetism suggesting superconductivity, while the Ce doped sample showed a paramagnetic like behavior down to 2 K without any traces of superconductive transition.

![Fig. 1: ZFC magnetization curves for Ca$_{0.85}$RE$_{0.15}$FeAs$_2$ (RE = Ce, Nd, Sm, Eu, Gd) bulk samples.](image)
The $T_{\text{c onset}}$s evaluated for the Nd, Sm, Eu and Gd doped samples are 13.5 K, 15 K, 10 K and 14 K, respectively. Any clear trend of $T_c$ varying the $RE$ doping is not observable probably due to difference in actual doping levels of $RE$ in the 112 crystals among these samples.