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Structural effects on superconducting properties of Sn doped CaAlSi

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Abstract – We have studied the Sn doped $CaAlSi_{1-x}Sn_x$ ($0<x<0.05$) compounds. Magnetization measurements shown that the superconducting transition temperature is depressed very quickly with the increase of Sn content, already the sample with x=0.05 is not superconductor at all. The X-ray analysis shown only a slightly decrease of the lattice parameters (less than 0.5%). These results could indicate a strong influence of the structural effects on the superconducting properties of this kind of compounds. The 4.2K ^{119}Sn Mössbauer spectra show no evidence of magnetism for all compounds.

Since the discovery of superconductivity at 39 K in the intermetallic compound MgB_2, by Nagamatsu et. al. [1], materials with layered crystal structures similar to that of AlB_2 have been investigated as possible candidate for new high-T_c superconductors. Among them, CaAlSi is a superconductor with a relative high superconducting transition temperature T_c~7.7K [2]. New class of layered superconductors, ternary silicide CaAlSi (T_c~8 K) with same structure have their hexagonal sublattice composed of alkaline-earth metals (Ca,Sr,Ba), and the graphite-like networks are composed of (Al, Si) or (Ga, Si) atoms. The SrAlSi compound has T_c=5.1 K while the BaAlSi is not superconductor at all. A linear correlation between T_c and the lattice parameters have been reported for these compounds. Therefore this class of compounds may serve as model systems for elucidating the relationship between superconducting properties and crystal structure.

In principle, the isoelectronic Si and Sn atoms could be interchanged without modifying their electronic structure leading only to a structural change. In this work we have studied the Sn doped $CaAlSi_{1-x}Sn_x$ ($0<x<0.05$) compounds. Magnetization measurements show that T_c is depressed very quickly with Sn content and the sample with x=0.05 is already not superconductor at all. The X-ray analysis show only a slightly decrease of the lattice parameters (less than 0.5%). The ^{119}Sn Mössbauer spectroscopy results indicate only one site for Sn atoms, but this result does not rule out the possibility that Sn occupies the Al site (Al and Si have equivalent crystal sites). The 4.2K Mössbauer spectra do not display any magnetic interaction for all the compounds. The slightly change of the lattice parameters and the quickly depress of T_c with the increase of Sn concentration could indicate a strong influence of the structural features on the superconducting properties. Another possible explanation is that Sn is substituting the Al or the Si atoms, modifying their complex superstructure (modulated corrugations of the Si-Al graphite-like nets) [3] or creating local disorder. These effects would be of fundamental importance for the establishment of a superconducting state in these compounds.

References

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