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Magnetic and Structural properties of $\text{Eu}_3\text{Ir}_4\text{Sn}_{13-x}\text{Ga}_x$

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Abstract

The intermetallic compound $\text{Eu}_3\text{Ir}_4\text{Sn}_{13}$ presents a peculiar structural distortion at $T^* \sim 57\text{K}$ and an antiferromagnetic transition at $T_N \sim 11\text{K}$.^[1] Previous studies have shown that, under hydrostatic pressure T^* increases and T_N barely changes.^[2] This structural transition is present in many Sn-based 3-4-13 compounds, some of which present superconducting states that are favored under pressure. In this work, we will show how Ga-substitution affects both transitions and compare with the results under hydrostatic pressure. Furthermore, we will study if the change in the carrier density due to the chemical substitution affects the electronic properties of the compound.

Key words:

Chemical substitution, Structural transition, $\text{Eu}_3\text{Ir}_4\text{Sn}_{13}$.

Introduction

The compound $\text{Eu}_3\text{Ir}_4\text{Sn}_{13}$ presents an antiferromagnetic transition at $T_N \sim 11\text{K}$ and a structural transition at $T^* \sim 57\text{K}$. The crystal structure is cubic and contains a polyhedron made of tin ions in its center, the structural transition consists in the displacement some tin ions.

Previous studies have shown that the magnetic transition is almost unaffected by hydrostatic pressure, however the structural transition is strongly suppressed.^[2]

In this work, $\text{Eu}_3\text{Ir}_4\text{Sn}_{13}$ crystals will be doped with different amounts of gallium in tin sites. Due to its smaller size Ga ions should behave as a chemical pressure. Moreover, since gallium has one conduction electron less than tin the compound's electronic properties might be altered.

The samples were grown by Sn self-flux technique with the percentage of gallium varying from $x=0.03$ to $x=0.6$.

Results and Discussion

Figure 1 shows that the structural transition is suppressed by doping, the transition temperatures T^* are around 53K ($x \sim 0.03$), 47K ($x \sim 0.07$) and 42K ($x \sim 0.15$). Also, the anomaly seems to get larger and less defined as the value of x increases.

Figure 1. Heat capacity of $\text{Eu}_3\text{Ir}_4\text{Sn}_{13-x}\text{Ga}_x$ for $x=0.03$, 0.07 , 0.15 .

Figure 2. Heat capacity of $\text{Eu}_3\text{Ir}_4\text{Sn}_{13-0.6}\text{Ga}_{0.6}$.

For $x \sim 0.6$ we see two distinct anomalies in the heat capacity measurement shown in figure 2, this bumps seem more well-defined than the one for $x \sim 0.07$. This probably means that doping causes a second structural transition that grows apart from the first transition when the doping value increases.

On the other hand, the magnetic transition is almost identical in all doped samples.

Currently, no alteration has been observed in the electronic properties of $\text{Eu}_3\text{Ir}_4\text{Sn}_{13}$, however a study using Ge as a dopant instead of Ga would be necessary to be sure, once Ge has the same number of conduction electrons as Sn.

Conclusions

Therefore, doping with gallium, suppresses the structural transition and barely changes the antiferromagnetic transition, similarly to the results obtained under hydrostatic pressure.

Higher percentages of Ga reveal a peculiar behaviour of the structural transition that might be due to the existence of a second structural transition.

Acknowledgement

¹ J. R. L. Mardegan et al, IEEE TRANSACTIONS ON MAGNETICS 49, (2013).

² J. L. Mendonça-Ferreira et al, Journal of Physics: Conference Series 592, 012046(2015).