Physical properties of Cu-substituted YMn₂ intermetallic antiferromagnet.

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Abstract

This work presents the results of growth and characterization of single crystals of the antiferromagnet pure YMn₂ and doped with suitably chosen chemical substitutions, using a Sn-flux technique. We particularly inspect the effects of copper (Cu) substitutions in the manganese site of YMn₂, and study the dependency of the magnetic response of the material as function of the Cu-concentration. Comparing our results with the ones previously reported for polycrystals of YMn₂ with regarding distinct kinds of chemical substitutions, we discuss the interplay between the new chemically induced structural, electronic and magnetic properties of this intermetallic compound.

Key words:

Intermetallic compound, antiferromagnetism, phase transitions

Introduction

¹This work presents the results of growth and characterization of single crystals of the antiferromagnet pure YMn₂, and with suitably chosen chemical substitutions, using a Sn-flux technique. Former results regarding on-site doping using scandium and aluminum, executed in polycrystals of Y_{1-x}Sc_xMn₂ and Y(Mn_{1-x}Al_x)₂, and of pure samples under hidrostatic pressure, have shown that the localized magnetism of the 3d electrons of Mn evolves to a itinerant spin fluctuation (ISF) phase resembling the ground state of iron-arsenide and Cu-based superconductors. Furthermore, the presence of strong magnetic fluctuations and interesting spin dynamics resembles those of unconventional superconductors around the quantum critical point. We intend to synthesise pure and Cu-doped single crystals, and investigate Cu influence in the magnetic ordering, and explore the possibility of finding magnetically mediated superconductivity.

Results and Discussion

Through structural (X-ray powder diffraction - XRD) and elemental (energy or wavelength dispersive X-ray spectroscopy – EDS or WDS) we have found that using in-flux growth we have been able to prepare single crystals of YMn₂. However, we have identified the presence of unwanted phases such as MnSn₂ and YSn₂. Even after changing thermal treatment we still have found traces of YSn₂ contamination. So, we dedicated some efforts to synthesize our pure YMn₂ sample through arc-melting process, in order to establish some route of comparison. Using this method we have obtained 63% of Y and 36% of YMn₂.

Image 1. XRD of the arc-melting sample, which displayed 63% of hexagonal Y (*a* = 3.6575(4) Å, *c* = 5.7584(7) Å) and 36% of cubic YMn₂ (*a* = 7.6872(6) Å).

We have also synthesized Cu-doped samples, and measured the magnetization as function of temperature at 1 T, electrical resistivity and heat capacity of the samples. Our data suggested that there are two magnetic transitions, a antiferromagnetic (AFM) transition similar to pure YMn₂ at *T*₁ = 100K which comes out of a newly identified ferromagnetic phase with a transition at *T*₂ = 360K.

Image 2. High field measurement of the polycrystalline sample of YMn₂ and Y.

For the doped samples, our data exhibits a possible suppression of the AFM ordering, while shifting critical temperatures of *T*₂, as a function of *x*. This result indicates that the Cu ions affects the magnetic interaction between the Mn spins. Since Cu could have magnetic and nonmagnetic ions depending on its valence, it might be used to tune the phase diagram of YMn₂.

Conclusions

We have successfully grown chemically substituted YMn₂ samples with Cu and are improving in developing the route to synthesize pure YMn₂ single crystals. These crystals will be used to characterize the structure and magnetic, electric and thermal responses, studying the consequences of Cu substitution in the Mn site.

Acknowledgement

We thank FAPESP (Grant #2016/06775-2), CNPq, Capes and Unicamp for the financial support, and the various opportunities to present this work to the scientific community.

¹ Nakamura, Y.; Shiga, M. and Kawano, S. *Physica* 120B, 1983, 202, 215.