XXIV congresso de iniciação científica da unicamp
19a21out Campinas Brasil

Study of structural and magnetic properties presented by $Tb_{1-x}Pr_xNi_2$ compounds

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Abstract

On the search for better cores for cryogenic magnetic refrigeration, magnetic and structural properties, such as synchrotron x ray diffraction and magnetization of $Tb_{1-x}Pr_xNi_2$ were studied. The results show the linear behavior of the lattice parameter and the Curie temperature.

Key words:

Magnetism, Magnetocaloric effect, Structural properties

Introduction

This project was elaborated to evaluate the structural and magnetic properties of $Tb_{1-x}Pr_xNi_2$ compounds and its applications on cryogenic magnetic refrigeration. Magnetic refrigeration is based in the magnetocaloric effect, which consists in the material ability to change its temperature due to a variation on the applied magnetic field in an adiabatic process.

Results and Discussion

For the preparation of the $Tb_{0.5}Pr_{0.5}Ni_2$ alloy, nickel 99.7%, praseodymium 99.9% and terbium 99.9% were melted in an arc furnace in an atmosphere of Ar. Then, synchrotron x ray diffraction data were collected to determinate the quality of the compound, based on Rietveld refinement[1]. An analysis of the diffraction pattern peaks position done with Mathematica software presented a = 7.2332 ± 0.0001 Å as the lattice parameter "a" of the compound. Later on, optical metallography showed that the compound presented 3 different phases identified as $Tb_{0.5}Pr_{0.5}Ni$, $Tb_{0.5}Pr_{0.5}Ni_2$ (majority phase) and $Tb_{0.5}Pr_{0.5}Ni_3$. Furthermore, magnetization thermal variation from 10 to 320 K at an applied magnetic field H = 200 Oe measurements were taken. Curie temperature T_c = 20.5 K was obtained analyzing the differential plot of the magnetization vs temperature.

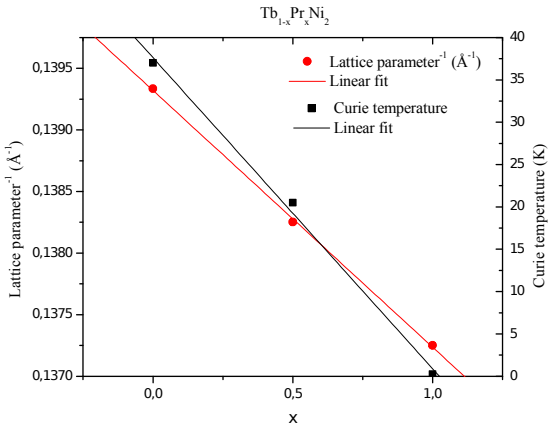

Image 1. Lattice parameter and curie temperature vs composition.

The lattice parameters of $TbNi_2$[2] and $PrNi_2$[3] has, respectively, 0.056 Å and 0.053 Å difference from $Tb_{0.5}Pr_{0.5}Ni_2$ lattice parameter "a". The curie temperature of $PrNi_2$[4] is much lower than$TbNi_2$[5], causing and abrupt fall as terbium is replaced by praseodymium. A fit of lattice parameters and curie temperatures shows that both of them vary linearly with x, $y = (-208 \pm 5)10^{-5}x + (13932 \pm 3)10^{-5}$ and $y = (-37 \pm 2)x + (38 \pm 1)$ describes the liner variation of the lattice parameters and the Curie temperatures, respectively.

Conclusions

It is possible to conclude that praseodymium rich alloys of $Tb_{1-x}Pr_xNi_2$ have a low Curie temperature, therefore better for cryogenic magnetic refrigeration. Also, the replacement of terbium by praseodymium causes an abrupt fall of nearly 40 K on the curie temperature, while the lattice parameter vary 0.109 Å, both of them with linear behavior.

Acknowledgement

We acknowledge financial support from CNPq – Conselho Nacional de Desenvolvimento Científico e Tecnológico – Brazil, and SAE Unicamp – Serviço de Apoio ao Estudante, Universidade Estadual de Campinas – Brazil and LNLS – Laboratório Nacional de Luz Síncrotron, Centro Nacional de Pesquisa em Energia e Materiais (CNPEM) – Brazil.

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