Magnetic, electric and electronic structure of $(Gd_{1-y}R_y)(Ni_{1-x}Cu_x)_5$, (R = Y, Yb) intermetallic compounds

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We have investigated the changes in the lattice parameters, the magnetic, electrical and the electronic structure properties of $GdNi_5$ compound upon the substitution of both Cu for Ni as well as Y and Yb for Gd. The $Gd(Ni_{1-x}Cu_x)_5$ compounds were prepared with x= 0.0, 0.5, 1.0, 1.5, 2.0, 3.0, 4.0 and 5.0. The $(Gd_{1-y}R_y)Ni_5$ compounds were prepared with y= 0.0, 0.2, 0.5, 0.8 and 1.0 when R=Y and y= 0.0, 0.2, 0.4 and 0.5 when R=Yb. All samples were prepared by arc melting in an argon atmosphere. The purity of the starting materials was 99.99% for Ni, Cu, Y and Yb and 99.9% for Gd. According to X ray diffraction data all alloys were homogeneous, single phase and of the hexagonal $CaCu_5$ –type of structure.

Magnetic properties of rare-earth (R) intermetallic compounds RNi_5 and RCu_5 are conditioned by weak magnetic or nonmagnetic state of their 3d band, which is nearly filled in the RNi_5 compound and completely filled in the RCu_5 one. Therefore, magnetic ordering of these compounds takes place owing to indirect f-f exchange interactions between R ions at low temperatures. $GdNi_5$ is a ferromagnet below the T_C = 32K, whereas $GdCu_5$ shows an antiferromagnetic order below T_N = 26K and posseses some peculiar properties which are connected with the incommensurate magnetic structure arises from the weakly negative interaction between Gd nearest neighbours [1]. This complex magnetic structure for $GdCu_5$ also reflects in the temperature-dependence of the electrical resistivity $\rho(T)$ [2].

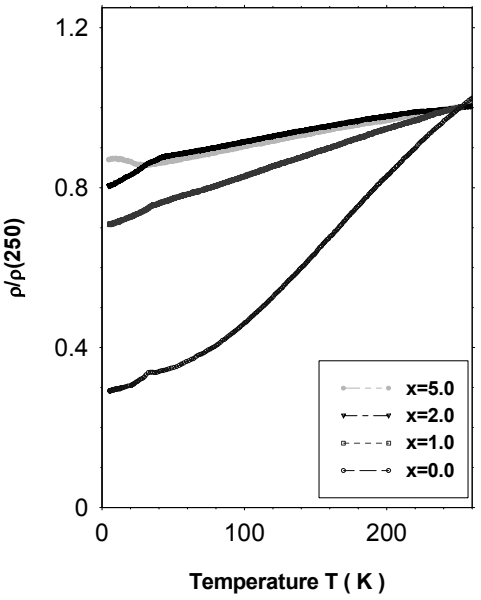

Fig. 1. Electrical resistivity of $GdNi_{5-x}Cu_x$.

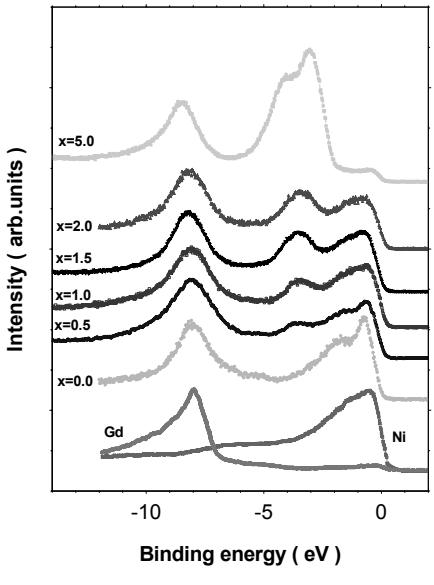

Fig. 2. Valence band for $GdNi_{5-x}Cu_x$.

In this work we present the $\rho(T)$ curves in $Gd(Ni_{1-x}Cu_x)_5$ compounds (Fig.1). We also present the influence of the Ni/Cu substitution on the electronic structure, measured by means of X-ray Photoelectron Spectroscopy (XPS). Both valence band and core level spectra were analyzed. It was found that valence band spectra at the Fermi level are dominated by hybrydized Ni 3d and Gd 5d states (Fig. 2). The position of the Cu 3d states was about 3.5-4eV below the Fermi level and was not influence by Ni/Cu substitution. In the Ni2p core level spectra the small satellites are visible, what is an indication that Ni atoms can carry a magnetic moment.

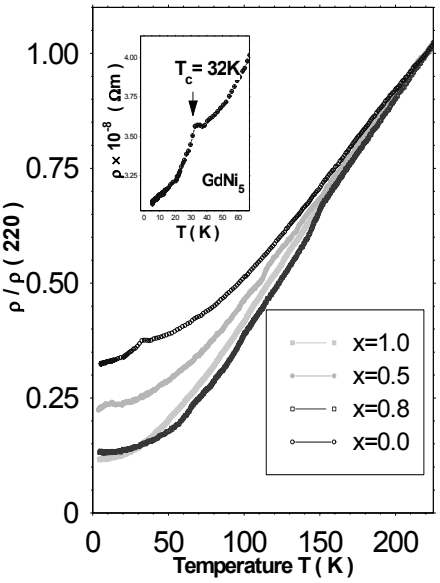

Fig. 3. Electrical resistivity of $Y_xGd_{1-x}Ni_5$.

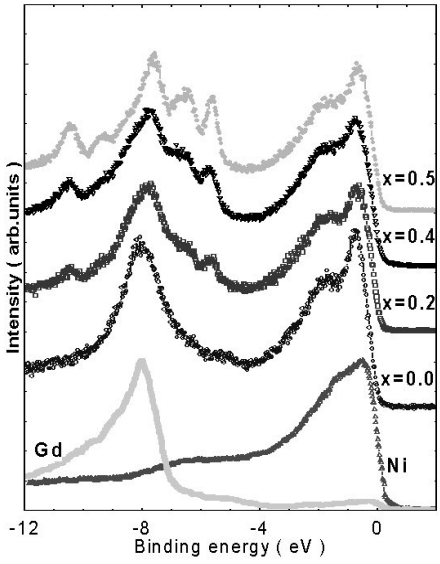

Fig. 4. Valence band for $Yb_xGd_{1-x}Ni_5$.

Due to the substitution of Y/Yb for Gd in $(Gd_{1-y}R_y)Ni_5$ compounds the character of the magnetic phase trnsitions has been changed from ferro to ferrimagnetic, a drop of the Curie temperature T_C as well as an increase of the cell volumne was observed. The Y/Yb substitution was also reflected in the temperature dependence of the electrical resistivity (Fig.3) and in the change of the value of the residual resistivity. The electronic structure measured by XPS indicated a hybridization effects between Gd 5d, Ni3d and Y4d states near the Fermi level in $(Gd_{1-y}Y_y)Ni_5$. In case of the $(Gd_{1-y}Yb_y)Ni_5$ compounds the complex multiplex structue of Yb^{3+} states dominated the energy region around 8 eV below E_F (Fig. 4).

[1]. J.M. Barandiaran, D. Gignoux, J. Rodriguez-Fernandez, D. Schmitt, Physica B **154** (1989) 293.
[2]. L.D. Tung, K.H.J. Buschow, J.J.M. Franse, P.E. Brommer, H.G.M. Duijn, E. Brück, N.P. Thuy, J. of Alloys and Compounds **269** (1998) 17.

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