Kondo lattice – fluctuating valence transition in $Ce(Cu_{1-x}Ni_x)_4Al$ compounds

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Recent decades have abounded the research on the strongly correlated systems, mainly due to their fascinating basic physics, explanation of which is still a challenge in systems like heavy fermions (HF), superconductors with unconventional pairing mechanisms, Kondo lattices and materials exhibiting the fluctuating valence (FV), non-Fermi liquid (NFL) behavior, or the quantum critical point. Many of these effects can be stimulated by treating the starting material by external or internal (alloying) pressure or by application of the magnetic field. In the case of Ce-based compounds the parent composition is usually modified by substitution of Ce by the nonmagnetic La or Y. The effects of the dilution depend on the position of the parent Ce-based compound on the Doniach Diagram, which is determined by the competition between the RKKY interaction and the screening of the magnetic moments originating from the Kondo effect. A widely studied example of an HF system is $CeCu_4Al$, whereas the iso-structural $CeNi_4Al$ was identified as the FV compound. $CeCu_4Al$ does not order magnetically down to 150 mK and the electronic specific heat coefficient is equal to 2.3 JK^{-2} mol^{-1} at the lowest temperatures. Our inelastic neutron diffraction experiments have revealed only a single crystal electric field (CEF) excitation at about 8 meV (93 K), in agreement with previous studies. The Schottky anomaly extracted from the specific heat provided the energy level scheme of the type doublet–quartet (0–93 K) or three doublets with similar energies of the excited levels 0–64–93 K. The Kondo temperature has been estimated to fall in the range 3–10 K. The FV state of $CeNi_4Al$ has been concluded based on the X-ray photoemission studies and the Gunnarsson and Schönhammer model. The specific heat measurements yielded a value of 29 $mJK^{-2}mol^{-1}$ for the electronic specific heat coefficient. The crystal field scheme consists of three doublets with the scheme 0–109–174K. As the $CeNi_4Al$ compound is classified as the FV system, one can expect a high Kondo temperature, which can be comparable with the energy of the CEF levels. In this contribution the results obtained for the $Ce(Cu_{1-x}Ni_x)_4Al$ series of compounds will be presented. An interesting aspect of these studies is that the amount of cerium is not modified – the dilution and transition from the Kondo lattice to the FV state occurs by substituting the magnetic Ni for the nonmagnetic Cu. The properties of the diluted compounds are studied by the specific heat, magnetic susceptibility and electrical resistivity measurements and compared with the reference $CeCu_4Al$ and $CeNi_4Al$ compounds. For this purpose the crystalline compounds of the composition $Ce(Cu_{1-x}Ni_x)_4Al$ have been prepared by the induction melting of the constituent elements under an argon atmosphere at the Institute of Molecular Physics PAS in Poznań. The crystal structure was checked by the powder X-ray diffraction technique, using the Co-K radiation [1].

[1] T. Toliński et al., *Phys. Status Solidi B* 248 (2011), 2186–2191