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Low-Temperature Electrical Resistivity of ThAsSe and Thermo-chemical Properties of Its Non-Actinide Derivatives

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UAsSe and NpAsSe display quite unusual transport properties. This concern, in particular, the disorder-dependent low-temperature upturn in the electrical resistivity deep in the ferromagnetic state. Importantly, this anomaly is independent of an external magnetic field as high as 45 T. Additionally, a structural disorder in the As-Se substructure of UAsSe was indicated by X-ray diffraction and scanning-electron-microscopy measurements. Since these findings suggest an anomalous electron scattering mechanism of non-magnetic origin caused by structural disorder, we extended our studies to their PbFCl-type diamagnetic counterparts.

Large single crystals of Th-, Zr- and Hf-based arsenide selenides were grown via chemical transport reaction. Both in the *ab* plane and along the *c* axis, their electrical resistivity increases as $-AT^{1/2}$ upon cooling to below 16 K [1,2]. Similarly to their ferromagnetic counterparts, this low-T increase of the resistivity is unaffected by the application of a magnetic field. Furthermore, for ThAsSe we were able to detect glass-type temperature dependencies of both the thermal conductivity and the heat capacity in the millikelvin temperature range. Whereas the latter findings constitute the proof on the presence of tunneling states, the field-independent $-AT^{1/2}$ term is considered as evidence for a two-channel Kondo effect derived from structural two-level systems [1].

Very recently it was conclusively pointed out that the microscopic nature of the two-level systems is the key parameter for a structural two-channel Kondo problem [3]. Therefore, we have performed thermo-chemical investigations of PbFCl-type arsenide selenides [4]. We chose non-actinide systems because their form factor and scattering length relations are advantageous in comparison with the uranium and thorium systems. From X-ray, neutron and electron diffraction as well as transmission-electron-microscopy experiments we can unambiguously assign that the PbFCl-type phase in the system $ZrAs_{x-y}Se_{2-x}$ exists in the range of $1.42(1) \leq x \leq 1.70(1)$ and exhibits significant As deficiency $0.03(1) \leq y \leq 0.10(1)$ down to composition $ZrAs_{1.40(1)}Se_{0.50(1)}$. Additionally, the crystallographic 2*a* non-metal site are occupied exclusively by As, although with a tendency to a significant concentration of vacancies, and the 2*c* non-metal site to be mixed but fully occupied with As and Se. Finally, there are no indications for an occupation of interstitial sites or for deviations of the occupancy of the Zr-site from unity [4]. Thus, at this stage of research, low-energy excitations of the electron gas appear to be triggered by defects in the As-layers.

References

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