Referee's report of the doctoral Thesis

U in metastable systems: structure, magnetism, superconductivity

by Volodymyr Buturlim

The submitted doctoral Thesis is devoted to the study of alloys and hydrides U-Nb and U-Ti synthesized using various technologies. Changes in the microstructure in dependence on Ti or Nb concentrations enable to look for optimal parameters for preparation of the metastable bcc allotropic phase of uranium. Application of a fast cooling technology accompanied by alloying leads to the stabilization of materials with a high degree of atomic disorder. The disorder should be proofed by measurements of transport properties. The samples of the alloys exhibit weakly paramagnetic ground states and low-temperature superconductivity.

The introductory part of this work gives information on basic knowledge on formation and ordering of magnetic moments, electron and heat transport in matter and strong electron correlations in the U-based compounds. Information on materials which studies are subjects is given in following chapters on metastable alloys based on uranium, basic principles of the hydride formation an uranium hydrides. The next part of the Thesis reports on interactions of the alloys with hydrogen. The author succeeded to stabilize β-UH3 (ferromagnetic with transition temperatures exceeding 170 K) and UTi2Hx (cubic Laves phase AB2) which does not exists without hydrogen and which forms magnetic UTi2H6 and non-magnetic UTi2H5.

The methods of sample preparation, i.e. basic alloys and their hydrogenations, and the methods sample characterization are described in the experimental part of the Thesis. There is information on determination of the crystal structure of the U-(Ti, Nb) alloys and hydrides, investigation of the microstructure and grain orientation distribution, description of the SEM, surface preparation and study, studies of the physical properties, heat capacity, magnetic properties, transport properties, studies of ac susceptibility under pressure.

I very appreciate thorough investigations of the sample microstructure using advanced scanning electron microscopy tools in backscattered electrons and secondary electrons. For information on homogeneity of distribution of elements a surface energy dispersive spectroscopy was applied. These complex studies give detailed data on the sample surfaces. There is also an excellent section devoted to XRD experiments, their interpretation and detailed discussion.

The results achieved in this work and further perspectives of a research in the field are clearly summarized in the Chapter 8 "Conclusions and future outlook".

Comments and questions.

- In the Thesis, very detailed and precise analyses of the XRD data are shown. However measurements at low and/or high temperatures would support some conclusions on Debye temperatures and phase composition.
- What is the accuracy of the determination of Debye temperatures from the experimental data of the heat capacity measurements?
- An increase in electrical conductivity of the fast quenched samples was ascribed to the atomic disorder. Could be also there an influence by a higher density of grain boundaries (finer grain size) and probably a higher density of lattice defects at least in the surrounding of the grain boundaries?
- How did you check hydrogen content in samples? What method was used to determine the hydrogen content of the samples?
- Are the hydride samples stable by application of high magnetic fields? Did you check their structure after the magnetic measurements?
- Could you indicate directions of the temperature changes during the ZFC- FC measurements?
- Was it possible to repeat the measurement of the field dependence of magnetization of (UH3)0.83Nb0.17 at 2 K shown in the figure 7.30 ?
- Were the dependencies shown in Fig. 30 measured after ZFC? Namely those at 2K?

Final opinion.

Many of the results derived in this Thesis improve upon previous results by other authors or they solve problems left open by them. The experiments used are mostly quite clever and technically involved, showing that Volodymyr Buturlim has achieved a deep understanding of the problems considered and the techniques that have been applied for studying them. This is also documented by participation in publication of 17 papers in refereed journals and 10 contributions to conference proceedings. The Thesis is presented in a good form, the discussions and proofs are given in details. In my opinion this Thesis is of high quality, both with respect to the results obtained and the way in which they are presented. This clearly shows his ability for creative scientific work and independent research. Therefore, I recommend accepting this doctoral Thesis as a basis for awarding the PhD. degree.

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