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Supervisor's report on the Ph.D. thesis: "Study of microstructure and real structure of nanoparticles prepared by gas aggregation cluster source"

by

RNDr. Tereza Košutová

RNDr. Tereza Košutová started her Ph.D. studies at the Department of Condensed Matter Physics in October 2018. However we met before during her undergraduate studies and later on we closely cooperated when Mrs. T. Košutová worked on her master thesis "Modification of nanoparticles by means of tubular sputtering systems", done at the Department of Macromolecular Physics. One particular task of the thesis was the investigation of prepared nanoparticles using the x-ray scattering methods, which she did under my supervision. Although it was not a main part of her master thesis she demonstrated outstanding capabilities to promptly learn and deeply understand new things.

In her Ph.D. thesis entitled "Study of microstructure and real structure of nanoparticles prepared by gas aggregation cluster source", Mrs. T. Košutová studies the growth, microstructure, real structure and functional properties of various types of homogeneous and heterogeneous nanoparticles (metallic, dielectric, polymers and their combinations). This study has both, an extensive importance from the point of view of basic research, as well as a significant technological relevance, since these nanoparticles can be used in biology and biomedicine, catalyzers and solar cells, as chemical sensors, and in many other emerging high added value applications.

Several gas aggregation deposition systems were used for the preparation of studied nanoparticles. Within this Ph.D. thesis the single-metal nanoparticles: gold, silver, copper and niobium were studied. The development of phase composition, morphology, microstructure and the real structure of these systems with temperature was described in details. The thermal treatment influences the crystal structure defects, coalescence and size distributions variously for individual types of nanoparticles. In niobium nanoparticles complete amorphization occurred, followed by the formation of a substoichiometric niobium pentoxide phase, which crystal structure was fully refined for the first time and is presented in the thesis.

The results observed on pure silver nanoparticles were correlated with two core@shell silver based nanoparticles systems: Ag@ppHMDSO and Ag@TiO_x. It was shown that the thermal stability of silver nanoparticles is significantly enhanced by covering them with the shell composed from another material. Additionally, within the thesis the nanofluids composing of vacuum-compatible liquid – polyethylene glycol and different single-metal nanoparticles, prepared by direct deposition, were studied with focus on the time stability and nanoparticles size evolution, sedimentation and separation. Finally, particular results for Ni@Ti, Fe-C:H, Ta₃N_yO_x and V_xO_y nanoparticles systems are discussed in the thesis.

The characterization of nanoparticle systems studied within this thesis was mainly done with focus on x-ray scattering methods (x-ray diffraction and small angle x-ray scattering) supplemented by other complementary methods as electron microscopy, x-ray photoelectron spectroscopy and optical measurements.

The Ph.D. thesis is written in good English with a minimum of mistakes or typos. Graphics, language and formal level of the thesis is excellent. The work consists of seven chapters, has 130 pages and 91 figures. The design of the figures is brilliant as well.

The author critically in details discuss possible errors of measured results. The obtained original results are censoriously discussed, argued and compared with relevant published literature sources. The author rigorously cites 248 papers published in international journals.

Outstanding scientific quality of this thesis is manifested by 15 original papers published in international journals with impact factor where Mrs. T. Košutová is an author or a co-author and which contains results published in this thesis.

During her Ph.D. work Mrs. T. Košutová definitely demonstrated an excellent will and capability to perform independent top level research and broad expertise in crystallography and solid state physics. Besides of her exceptional experimental laboratory abilities she revealed as well deep and outstanding theoretical knowledges in theory of x-ray scattering and profound experiences in work with numerous dedicated scientific software.

Although that the scientific carrier of Mrs. T. Košutová is at the beginning she is already an author or co-author of 27 original scientific papers published in international journals with impact factor, which were 135 cited, up today. She achieved the H-index = 7. The outstanding quality of her research work is, without any doubt, as well demonstrated by 15 presentations, which she held at international conferences (from all of them lets name here the keynote lecture at the 17th European Powder Diffraction Conference (EPDIC 17), 2022, Šibenik, Croatia) and by two awards, 1st place in student competition in the category Physics and materials at conference Struktura 2020, and 2nd place at the student talks during Czech-Bavarian school on large-scale facilities 2020, which she was awarded. Last but not least the quality of her research was confirmed by supporting her research by grant funded by the Charles University Grant Agency (GAUK no. 1546119 – “Study of thermal stability and real structure of heterogeneous nanoparticles prepared by gas phase condensation method”, successfully solved 2019-2021). Additionally, during her scientific carrier Mrs. Tereza Košutová completed 3 research visits at the international institutions and was a member of research

teams in 6 grant projects. Finally her scientific qualities were recognized by the Fulbright foundation and she spent 6 months Fulbright scholarship at the Brookhaven National Laboratory (USA) in a group of prof. Ian Robinson.

As a Ph.D. supervisor of Mrs. T. Košutová I would like to mention that besides the top level science, which she is doing, Tereza is young, noble, clever person and she immediately become, because of her expertise, communication skills together with her nice personality, extremely valuable member of our research group and laboratory. She is any time ready to help and support other colleagues and students and in a good sense she is definitely the “team - player” and favourite person. Additionally, based on her knowledges, expertise and personality traits she clearly demonstrated outstanding capabilities to lead, educate and train younger students.

By writing and submitting of this thesis RNDr. Tereza Košutová clearly demonstrated her diligence and abilities of independent, creative research work and critical thinking. The thesis fulfilled set goals, is of very high standard and after its successful defence I recommend to award RNDr. Tereza Košutová by Ph.D. doctoral degree.

RNDr. Milan Dopita, Ph.D.
supervisor