Preface

In 1998, a monograph “Nanocrystalline Materials: Methods of Production and Properties” by Gusev [1] was published in Ekaterinburg. The monograph became the first Russian and one of the first world’s generalizations of experimental results and theoretical concepts about the structure and properties not only of dispersed, but also of compact solid state with nanometer dimensions of particles, grains, crystallites or other microstructure elements.

The monograph “Nanocrystalline Materials” (Cambridge International Science Publishing) by Gusev and Rempel [2] was published in 2004 in Cambridge. This monograph was devoted to one of the most topical problems lying at the interface of material science, physics and solid state chemistry – nanocrystalline state of matter. The objects described in the monograph are metals, alloys, intermetallic compounds, oxides, carbides, nitrides, borides, carbon nanostructures, nanoporous materials and nanocomposites.

Extensive research over the two latest decades revealed that the greatest effect of particle (grain, crystallite) size reduction down to tens of nanometers and less is observed for semiconducting compounds. This is due to the commensurability of the size of semiconducting particles with such physical parameter having a dimensionality of length as the exciton diameter.

The new monograph offered to the readers is focused on simultaneous analysis of structure, nonstoichiometry and properties of semiconducting lead, cadmium and silver sulfides in the form of nanocrystalline powders, colloidal solutions, quantum dots, isolated nanoparticles and heteronanostructures. These nanostructured sulfides, along with other chalcogenides, attract the greatest attention owing to their potential application in electronics, biology and medicine.

The synthesis and properties of nanostructured chalcogenides were described in a number of books [3–6]. However, too broad range of objects inevitably made the discussion too brief. Nanostructured lead, cadmium, and silver sulfides are not mentioned almost in this book. Nonstoichiometry of discussed nanostructured semiconductors not considered at all.

Nonstoichiometry, i.e. deviation from stoichiometric composition, is a fundamental characteristic of inorganic substances, which affects the structure and properties of compounds, on the one hand, and depends on the size of structural elements (particles, crystallites, domains) of substances, on the other hand. Until recently, the relation and interdependence between nonstoichiometry and particle size in the nanometer scale has been scarcely examined or discussed only on the example of strongly nonstoichiometric compounds (carbides, oxides, nitrides of transition metals). And certainly the nonstoichiometry in nanostructured sulfides, which in the conventional state are traditionally considered as stoichiometric compounds, has never been discussed. Indeed, at present the number of studies devoted to nonstoichiometry of sulfide nanopartricles is extremely limited. The investigation of the relationship between the size of nanoparticles and their nonstoichiometry is a topical research area since nonstoichiometry affects the properties of nanoparticles and can be used for additional control over the functional properties of nanoparticles and nanomaterials.

Modern solid state physics, physical material science and electronics are inconceivable without semiconducting heterostructures. Semiconducting heterostructures, especially quantum wells, quantum wires and quantum dots, allow to control such fundamental parameters of semiconducting crystals as forbidden band width, effective mass and mobility of charge carriers and electronic energy spectrum.

Heteronanostructures combining the properties of semiconductors in nanocrystalline state, on the one hand, and nonstoichiometry, on the other hand, are the next step in the development of quantum electronics.

The production (preparation, synthesis) of nanostructured sulfides is immediately connected with the development and application of nanotechnologies. The essence of nanotechnology consists in the possibility to work at the atomic and molecular level, in the length scale between 1 and 100 nm in order to produce and use materials and devices having new properties and functions. Therefore much attention in the monograph is devoted to different methods of synthesis of nanostructured sulfides with allowance for their structure and composition.

The authors of this monograph tried to take into account both the purely scientific, fundamental interest in the problem of nanosized sulfides and some applied aspects of this problem that are of considerable importance for practical application of these substances.

The monograph includes much essential information about nanostructured lead, cadmium and silver sulfides in the form of nanocrystalline powders and isolated nanoparticles with different morphology, colloidal solutions, quantum dots and heteronanostructures. Writing it, the authors used a large number of original studies beginning with 1828 and up to 2017 inclusive. More than 80% of all references are given to the works performed after 2000. Thus, the monograph reflects the state of the art in the research of nanostructured lead, cadmium and silver sulfides. It will be useful and interesting for a wide range of specialists dealing with condensed matter physics, solid stare chemistry, physical chemistry and material science, as well as for engineers involved in the production and application of nanocrystalline semiconducting materials.

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References

[1] Gusev, A.I.: Nanocrystalline materials: Methods of production and properties, 200 pp. Ural Branch of the Russian Academy of Sciences, Ekaterinburg (1998) (in Russian)
[2] Gusev A.I., Rempel A.A.: Nanocrysnalline materials, 351 pp. Cambridge Intern. Science Publication, Cambridge (2004)
[3] Bimberg, D. (ed.): Semiconductor nanostructures, 357 pp. Springer, Berlin, Heidelberg (2008)
[4] Reithmaier, J.P., Petkov, P., Kulisch, W., Popov, C. (eds.): Nanostructured Materials for Advanced Technological Applications, 547 pp. Springer, Netherlands (2009)
[5] Granitzer, P. Rumpf, K. (eds.): Nanostructured Semiconductors: From Basic Research to Applications, 700 pp. CRC Press, New York (2014)
[6] Qurashi, A. (ed.): Metal chalcogenide nanostructures for renewable energy applications, 320 pp. Wiley, New York (2015)

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