KINETIC AND THERMODYNAMIC PROPERTIES of InSe INTERCALATED BY NICKEL

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ABSTRACT

A comprehensive study of the $A^{III}B^{VI}$ type crystal intercalated by magnetic impurities, materials - "hosts" of complex molecular structures has been carried out. Studies of these structures open up additional opportunities to detect interesting phenomena and effects that could lead to new areas of practical application such as: spin capacitors, magnetic electrets, analysis and signal processing. In the longer term quantum coherent spintronics is of much interest. This work will touch base on the above mentioned issues. X-ray phase analysis of the intercalation compounds of Ni_xInSe (x = 0; 0,25; 0,5; 0,75; 1,0; 1,25, ..., 10 at. %) [1,2] showed that the resulting materials are homogeneous. Neither phase replacement of nickel selenides compounds nor free unbound nickel were found. Concentration dependence of the lattice parameter c is a non monotonous function of the concentration of intercalant, whereas the parameters a, b remain unchanged. Frequency dependences of the real component of the complex impedance ρ (ω) of the studied structures show that for all values of x except x = 1,25, ρ(ω) is the inverse function of lattice parameter along the crystallographic C axis, which may be due to the formation of quasimolecules by creating links between Se-In-In-Se blocks [2]. In order to describe the mechanisms of electric current flow in synthesized intercalats Nyquist diagram – dependences of the imaginary component of the complex impedance on its real component are constructed. For the original matrix this dependence has one loop, proving capacitive feedback of the localized states, pointing to the contribution of the carriers hopping to the overall conductivity or localized states excitations into their tails or into delocalized bands. After intercalation Nyquist diagram depending on the distribution and the ratio of relaxation times has either the form of a single loop type with synthetic structure or the form of a pronounced two or three character arc. This suggests a modification of energy shape of the indium selenide output matrix by the barriers caused by nickel guest. But the fact that low frequency branches ρ(ω) for x = 0,25 and x = 0,75 are deformed is of most interest. For these values of x the function ρ(ω) reaches absolute maxima that may be associated with the crystal's inductive feedback. The most peculiar is that with strong deformations of ρ(ω) for x = 0,75 low-frequency branch of Nyquist diagrams enters quadrant IV of the complex plane of the inductive impedance. Debye temperature obtained from heat capacity measurements is assumed to correlate with the rigidity of the lattice. However experimental studies of Ni_xInSe [3] throughout the whole range of x ($x \leq 10$ at.%) proved that temperature dependence of the capacity is independent on x. To explain the experimental data heat capacity is described quasi-phenomenologicaly as suggested by a modified Debye approach [3]. The reason for deviation of C from Debye Ω_D is explained by the input of the localized states caused by damping of the acoustic phonons at the frequency of the first van Hove peculiarity $\omega^* \approx \omega_D/2$.

References

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