MAGNETIC PROPERTIES OF LAYER CRYSTALS INTERCALATED BY NICKEL

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ABSTRACT

Obtaining of new scientific materials with magnetic impurities is complicated and an actual problem from the perspective of material science. Intercalation of layer crystal by 3d-atoms just allows the solution of such a problem. In this case the sets of mono-atomic layers bonded by ion-covalent coupling are in consequence with magnetic active atomic layers, isolating them from one another thus avoiding their coagulation. At the same time intercalation allows obtaining information from the metallic nanolayers. The structures with alternating semiconducting and magneto-active layers can serve as materials on the base of those one can create the spintronic elements, particularly, as the medium structures or spin-gated transistors. That is why complex studies of such structures provide additional opportunities to modify their magnetic properties in a wide range. Besides quasi two dimensional magnetic with a super-paramagnetic state can be created. At the same time such objects can provide Coulomb blockade of the electric current and optically or electrically control an electron tunneling process. Giant magneto-resistive effect in nanostructures with alternating semiconductor and metallic nano-layers is promising for the material technology.

Using a self-purification phenomenon of the semiconductor materials for the intercalation of InSe single crystal allowed to receive intercalates by thermo diffusion method by nickel concentration up to 10 atomic percent. X-ray analysis showed that the obtained material was completely homogeneous without any phase of substitution of Se-Ni compounds and free nickel. The lattice parameter along c-anisotropy axis is non-monotonous function of nickel concentration.

Results of the theoretical studies of the electron density of states of the layer crystals intercalated by 3d impurities are represented. The peculiarities of chemical bonding of layer crystals are introduced through the model in the non-parabolic dispersion law of free carriers. Such law describes crystal structure with intermediate dimension in the best way. Microscopic description of the electron subsystem of intercalated layer crystals such as: distortion of the van der Waals gap, caused by the change of electron hopping between the nearest layers (structure factor), intercalant energy state (localized or resonance) and intercalant-lattice electron mixing V_0 is carried out. The total density of electron states is obtained as a sum of lattice and intercalant state densities distorted by these reasons. Non monotonic shift of the peak of intercalant density of states depending on the structure factor and influence of electron hybridization on the topology of Lifshitz transition is found.

A significant increase of conductivity in Ni_xInSe polycrystals is caused by the increase of carrier's mobility as well as their concentration. Such behavior is described within the framework of the multiple impurity problem of a virtual crystal model. The effect of intercalant concentration, its energy state and anisotropy of electron mixing $V(\vec{k})$ on the behavior of the bands' change and topology of Lifshitz transition is revealed. Theoretical studies of real and implicit components of dielectric function for layer crystals with anisotropic non-parabolic dispersion law were carried out in the random phase approxiation. It was found that real component of dielectric function as a function of frequency is characterized by the oscillating behavior.