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The influence of order-disorder transition on the electronic structure and magnetic properties of FeAl alloy films

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INTRODUCTION

The main purpose of this study is an investigation of the influence of the structural order-disorder phase transition in FeAl alloy films on their electronic structures and magnetic properties. It is well known that the optical spectroscopy is a rather sensitive tool for study of the energy structures (EES) of solids. The practical use of this experimental technique is complicated because of the difficulties in interpretation of the experimental spectra. To reveal the main features in the optical spectra of interband absorption, first-principle self-consistent calculations of the EES have been performed by using the scalar-relativistic extended LAPW method, including a so-called combined correlation term. Optical conductivity (OC) spectra for the ordered FeAl alloy were also calculated based on a CsCl structure with a lattice parameter of 2.908 Å.

EXPERIMENTAL

Experimental study of the optical properties of the ordered and disordered FeAl alloy was carried out on the films of 150 nm thickness, which were prepared by means of "flash evaporation" technique. The structures of the films were examined by transmission electron microscopy and x-ray diffraction. The optical properties (real and imaginary parts of the dielectric function, ε_1 and ε_2, respectively) of the ordered and disordered FeAl films were investigated at room temperature in a spectral range

of 250 - 2500 nm (5.0 - 0.5 eV) at a fixed incidence angle of 73 degrees by the polarimetric Beattie technique. Such a combination of the experimental and theoretical approaches provide us with a new way in studying the EES of disordered solids. Field dependence of magnetization was measured by a vibrating sample magnetometer (VSM) at room temperature. Magnetoresistance (MR) of the FeAl samples was evaluated along and transverse to current in a magnetic field up to 1.5 T. Surface morphology and magnetic domain structures were also examined by scanning probe microscopy in air.

RESULTS AND DISCUSSION

It was shown that the overall shape of the OC spectrum of the ordered FeAl alloy is in good agreement with the results of the theoretical calculations, however the experimental one is slightly shifted to the lower energies by 0.8 eV. The reason for this shift is discussed. The loss of the translation invariance in the disordered state leads to noticeable changes in the optical properties of the FeAl alloy : a shift of the main absorption band to the lower energy side, and considerable changes in the ε_1 spectrum at $h\nu < 2$ eV. It was observed that the order-disorder structural transition in FeAl alloy films leads to significant changes in the effective magnetic moment and the MR values. The obtained results are discussed in terms of the changes in atomic structures and peculiarities in the EES.