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X-RAY PHOTOELECTRON SPECTROSCOPY STUDY OF MBE GROWN Gd/EuTe MULTILAYERS

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X-ray photoelectron spectroscopy was used to study the Gd/EuTe multilayers structure with cover layer of Al (100 Å). The study of the main Eu, Gd, Te, Al core level and valence band photoemission spectra showed that there is no interaction between Gd and EuTe layers and Gd is in pure metallic state. The ion of Eu was found divalent in the Gd/EuTe multilayers structure. Ar ion sputtering of the sample surface leads to a change of stoichiometry in the near surface region of the EuTe layers and to the appearance of Eu^{3+} species (after complete sputtering of 100 Å protective top layer of Al) in the EuTe uppermost layers.

Keywords: Photoelectron spectroscopy, gadolinium, europium telluride

Introduction

The europium mono-chalcogenides as EuO and EuS are ferromagnetic, as EuSe they are ferrimagnetic and as EuTe antiferromagnetic semiconductors. The compounds properties (magnetic, magneto-optic and semiconducting) are resulted of the exchange interaction between the localized moments of the half-filled 4*f* shell of the Eu^{2+} ions and free electrons of the conduction band. The strength of the exchange interaction strongly depends on the concentration of free carriers and may be driven by doping with suitable impurities as Gd^{3+} [1]. The rare earth metal and semiconductor interface formation [2] is a most important issue in the practical aspect.

In this paper we present the results of X-ray photoelectron spectroscopy study on MBE grown Gd/EuTe multilayers structure.

Experimental

The Gd/EuTe multilayers were grown in a molecular beam epitaxy (MBE) system with the vacuum level in the range of 10^{-10} torr. The wafers of KCl with orientation (100) buffered with a PbTe layer as substrates were used. The samples had the following configuration: KCl/PbTe 2 μm/[EuTe 1.8 Å/Gd 13.25 Å]×41 with 100 Å of Al top layer. Gd was evaporated from electron gun and EuTe from effusion cell at the rates lower than 0.4 Å/s. All deposition process was performed at 300˚C. Aluminum was used as a cover layer to protect from oxidation.

The XPS spectra were recorded using a KRATOS Analytical XSAM800 spectrometer. The X-ray source with AlK_α ($h\nu$ = 1486.6 eV) anode was used. The normalization of the spectrometer was determined according to the Au4*f* 7/2 peak. The analyzer works in the constant pass energy equal 20 eV. The main core level photoemission spectra of Eu, Gd, Te, Al, O, C as well as valence band spectra were determined after sequential Ar ion sputtering of a cover layer of Al. The ion etching was performed at the ion energy 3 keV and ion current density 17 μA/cm^{-2}.

Results and discussion

The high sensitivity of the surface stoichiometry to the surface treatment (oxidation, Ar ion sputtering, sample annealing) was noticed in some europium chalcogenides compounds [3-5]. Therefore all photoelectron spectra of the Gd/EuTe multilayers structure in this study were taken through a cover layer of Al. This allowed keeping undamaged the EuTe surface, while moderate Ar ion sputtering was used to reach different stages of the analyzed Gd/EuTe multilayers structure. The XPS spectra of the Gd and Eu 3*d* region after Ar ion sputtering for Gd/EuTe multilayers are presented in Fig. 1 (bottom curve). The europium is in the divalent state in EuTe layer. It is confirmed by the XPS spectra of Eu 4*d* and valence band region. The analysis of Gd 3*d* and 4*d* core level and valence band structure spectra shows that Gd is metallic in the Gd/EuTe multilayers. The literature data [6-7] confirm this conclusion.

The spectra measured after complete sputtering of the protective top layer of Al indicate the creation of Eu^{3+} ions in the EuTe uppermost layer (Figure 1, top curve). This conclusion is in good agreement with results of the high-energy photoemission spectra study done for MBE grown PbS/EuS layers [5].

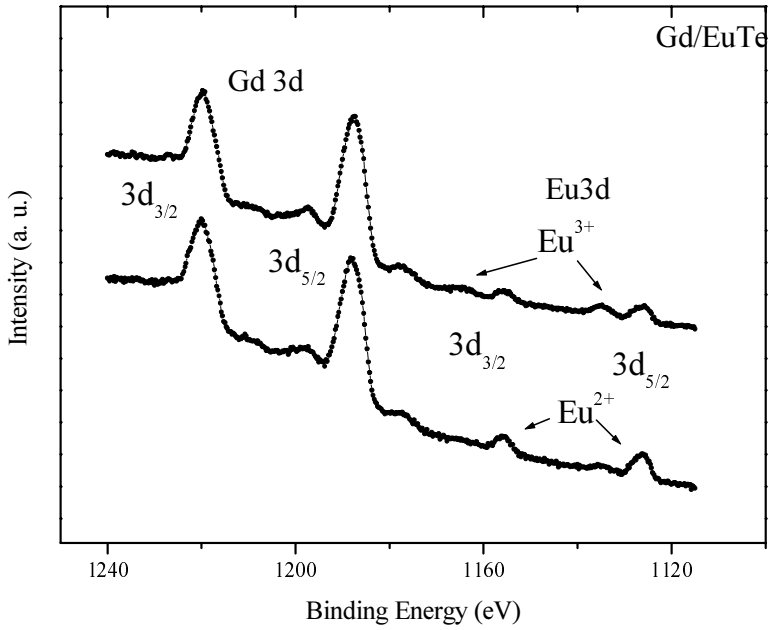

Figure 1. Gd and Eu 3*d* core level spectra of the Gd/EuTe multilayers: bottom – measured after ordinary Ar ion sputtering with Al cover layer and top - measured immediately after complete sputtering of 100 Å protective top layer of Al.

Summary

The Gd/EuTe multilayers were grown in MBE system, where EuTe layers were developed by evaporation EuTe powder from effusion cell. The electronic structure of Gd/EuTe multilayers was investigated by X-ray electron spectroscopy. The analysis of data obtained from the main core level photoemission spectra of elements as well as valence band spectra indicate that Gd is in pure metallic state and Eu is divalent in the EuTe layers. The sputtering by Ar ions leads to the appearance of Eu^{3+} species in the EuTe uppermost layers in the MBE grown Gd/EuTe.

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