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Scanning MOKE investigation of ion-beam-synthesized silicide films

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ABSTRACT

Fe ions with an energy of 40 keV were implanted into Si plates with the fluence varying in the range of (1.6–3.0) $\times 10^{17}$ ion/cm^2 in the external magnetic field. Scanning magnetooptical Kerr effect (MOKE) studies have shown that all samples possess uniaxial anisotropy. Both the coercive field and the anisotropy field increase with fluence. It was suggested that induced anisotropy is caused by inverse magnetostriction.

1. Introduction

The modification of magnetic properties of thin films by ion implantation has gained an increased attention recently [1]. This technique is especially useful as it can be used to locally alter various magnetic properties of thin magnetic films. Recently [2], a large magnetic moment of the ferromagnetic CoPt phase was found in samples obtained by ion-beam mixing in the external magnetic field. Ion implantation in the external magnetic field was also used for local setting of magnetic anisotropy in amorphous films [3]. In these works a relatively low fluence ion implantation was used. Switching the direction of the anisotropy axis occurs at a Co fluence near 5×10^{13} cm^{-2}. So no structural changes occur and the adjustment of anisotropy is reversible.

Ion beam synthesis in the external magnetic field was used to produce thin anisotropic iron silicide films [4]. The ferromagnetic silicide Fe_3Si is attractive for Si-based spin transistor applications and there is progress in synthesis of this silicide on Si and Ge using molecular beam epitaxy [5,6]. Recently [7], the investigations of local magnetic characteristics of samples obtained by high-dose Fe^+ implantation into single-crystal silicon at applied magnetic field were carried out. It was shown that all samples implanted in the external magnetic field possess uniaxial anisotropy. In some regions of the samples the deviations of an easy magnetization axis (EMA) from the direction of the applied magnetic field were revealed by using a scanning magnetooptical Kerr polarimeter. It was supposed that these local changes can be caused by various reasons: by the presence of mechanical stresses in a silicon substrate during the ion bombardment, the appearance of temperature gradients, inhomogeneous sputtering, etc. Additionally, the mechanism of the anisotropy formation was not clearly established.

The goal of the present work is to investigate local magnetic properties of thin silicide films ion-beam-synthesized in the external magnetic field in monocrystalline Si substrate at various fluences. An effect of an implantation fluence on the coercive and anisotropy fields is investigated.

2. Experimental

About 40 keV Fe^+ and Co^+ ions were implanted into (1 1 1) single-crystal silicon wafers at room temperature. The implantation fluence was varied from 1.6×10^{17} to 3×10^{17} cm^{-2}, the ion current density being about 4 μA/cm^2. The external magnetic field H_i of 4×10^4 A/m was applied parallel to the sample surface during implantation.

Reflection high-energy electron diffraction (RHEED) was used for investigation of the phase composition and the texture of the synthesized films. The phase composition was also investigated by X-ray diffraction using a diffractometer DRON-3M with the Cu Kα radiation at grazing incidence geometry.

The local magnetic properties of the samples were investigated by scanning Kerr polarimeter in the longitudinal mode. For investigation of local magnetic characteristics the polarimeter was equipped with an automated system for the sample movement relative to the probing laser beam and with a focusing system. Within the frames of the present research, a laser spot on the sample surface with a diameter of about 100 μm at the beam incidence angle of 45° was used. To obtain the topograms of azimuthal dependences of the

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