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The Influence of the Texture on Properties of IrMn Spin Valve Magnetic Tunnel Junctions with MgO Barrier and CoFeB Electrodes

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In this work the influence of seed-buffer layers on the texture and tunnelling parameters was investigated. The spin valve magnetic tunnel junctions (SV-MTJs) were deposited onto thermally oxidized Si wafers by magnetron sputtering in the following sequence of layers: substrate Si(100)/SiO_2 47 nm/buffer layers/$Ir_{17}Mn_{83}$ 10 nm/CoFeB 3 nm/MgO 1.5 nm/CoFeB 4 nm/top layers. Following buffer systems have been used in order to induce different degree of the texture: (a) Cu 25 nm, (b) Ta 5 nm/Cu 25 nm and (c) Ta 10 nm/Cu 30 nm/Ta 10 nm/Cu 5 nm. The type of buffer layers strongly influences texture of IrMn antiferromagnetlayer and induces roughness of magnetic layers and MgO barrier. The highest TMR value ~140 % was obtained for sample with small roughness annealed in vacuum at 350 °C. A strong influence of the roughness, due to barrier thickness fluctuations, on the resistance area product (R×A) of the junctions was observed. The Néel coupling field increase in case of strong textured and rough layers and becomes small for smooth interfaces. The proper design of the composition of the buffer layers allows to improve the magnetic and tunneling properties of MTJs.

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Tunnel magnetoresistance of ferromagnetic semiconductor junctions

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Spintronics is an expanding field in the solid state physics aiming at developing novel devices which utilize the two fundamental degrees of freedom of electrons, charge and spin. Magnetic tunnel junction (MTJ) is one of the spintronic devices and is applicable to the magnetic random access memory, the read head of hard disc drive, etc. A high MR ratio as much as 70% in the pessimistic definition has been observed at room temperature in single-crystalline Fe/MgO/Fe junctions [1]. However, semiconductor-based MTJ is highly desired because of the integrability with existing semiconductor devicesand the controllability of band structures. In semiconductor-based MTJ (Ga-Mn)As/AlAs/(Ga-Mn)As, 40% of MR ratio at 8K and a non-monotonic dependence of the MR ratio on the AlAs thickness have been observed [2]. Such thickness dependence is not explained by free electron model nor simple tight-binding model. In this work, we clarify how the MR ratio depends on the barrier thickness in (Ga-Mn)As/AlAs/(Ga-Mn)As junctions by microscopic calculations using a realistic band model.

We consider a tunnel junctions consisting of two semi-infinite (Ga-Mn)As electrodes separated by an AlAs barrier. In order to treat realistic band structures of (Ga-Mn)As and AlAs, we use a sp-orbital tight-binding model [3]. We assume that there is no disorder in the system and concentrate ourselves on the ballistic transport. The conductance is calculated by using the linear response theory (Kubo-Landauer formalism) and the recursive Green's function method [4]. The MR ratio is given by $(G_P-G_{AP})/G_P$ where G_P and G_{AP} are conductances for parallel and anti-parallel alignments of (Ga-Mn)As magnetizations.

Calculated results of the MR ratio are shown in Fig. 1 as a function of the AlAs thickness. The MR ratio decreases almost monotonically with increasing AlAs thickness. In addition, the decrease is much slower than experimental one. These discrepancies might originate from the existence of GaAs layer at the interfaces in the experiments. The effect of interfacial GaAs layer on the MR ratio will be discussed.

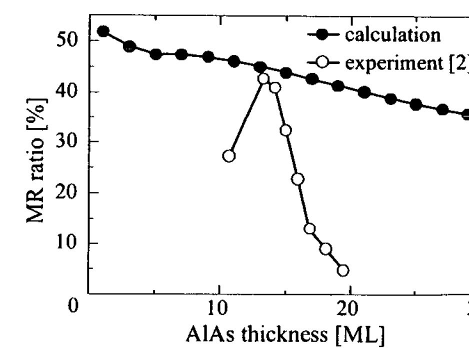

Fig.1. MR ratio of (Ga-Mn)As/AlAs/(Ga-Mn)As junctions.

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