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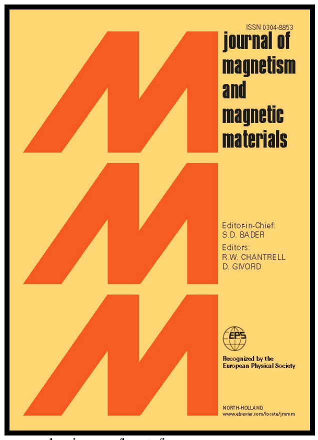


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# Magnetic-field-driven electron transport in ferromagnetic/ insulator/semiconductor hybrid structures

N.V. Volkov[1], A.S. Tarasov[1*], M.V. Rautskii[1], A.V. Lukyanenko[1,2], S.N. Varnakov[1], S.G. Ovchinnikov[1,2]

[1]*Kirensky Institute of Physics, Federal Research Center KSC SB RAS, Krasnoyarsk, 660036 Russia*

[2]*Institute of Engineering Physics and Radio Electronics, Siberian Federal University, Krasnoyarsk, 660041 Russia*

[*]e-mail: taras@iph.krasn.ru

**Abstract.** Extremely large magnetotransport phenomena were found in the simple devices fabricated on base of the Me/$SiO_2$/p-Si hybrid structures (where Me are Mn and Fe). These effects include gigantic magnetoimpedance (MI), dc magnetoresistance (MR) and the lateral magneto-photo-voltaic effect (LMPE). The MI and MR values exceed $10^6$ % in magnetic field about 0.2 T for Mn/$SiO_2$/p-Si Schottky diode. LMPE observed in Fe/$SiO_2$/p-Si lateral device reaches the value of $10^4$ % in a field of 1 T. We believe that in case with the Schottky diode MR and MI effects are originate from magnetic field influence on impact ionization process by two different ways. First, the trajectory of the electron is deflected by a magnetic field, which suppresses acquisition of kinetic energy and therefore impact ionization. Second, the magnetic field gives rise to shift of the acceptor energy levels in silicon to a higher energy. As a result, the activation energy for impact ionization significantly increases and consequently threshold voltage rises. Moreover, the second mechanism (acceptor level energy shifting in magnetic field) can be responsible for giant LMPE.

keywords: hybrid structures, magnetoresistance, magnetoimpedance; photovoltage

## 1. Introduction

Magnetotransport phenomena in hybrid structures, which are compatible with CMOS technology, are an attractive field of investigation because of the interesting physical phenomena and promising application in memory devices, sensors, magnetic field-controlled logic, etc[1,2,3,4]. Semiconductor structures and devices are of special interest for fundamental research[5], because any developed magnetoelectronic or spintronic devices need to be compatible with modern semiconductor electronics. Semiconductor-based MR elements and devices can be easily integrated in semiconductor chips. In this way, semiconductor electronics acquires new functional possibilities.

At the present time, in hybrid structures the authors of [6,7,8] demonstrated spin injection, spin detection, and carrier transport manipulation via electron spin states in semiconductor structures with ferromagnetic electrodes of special topology; i.e., the transport properties of such structures can be controlled by a magnetic field. Moreover, it was established that semiconductor structures without ferromagnetic elements and simply bulk semiconductor can also exhibit the giant MR effect. Such effects are related to the occurrence of inhomogeneous states in semiconductors. In particular, the MR effect in the bulk of silicon can be caused by space charge inhomogeneity[9]. The other group of MR effects in semiconductors and semiconductor devices is related to the autocatalytic process of impact ionization, which can be suppress by magnetic field[10,11].

The giant ac and dc MR effects were observed in the on metal/insulator/semiconductor(MIS) diodes with the Schottky barrier[12,13]. Unfortunately, it remains unanswered whether the MR effect originates from the bulk of silicon or from interface. Our studies on lateral devices and Schottky diodes based on the Fe/$SiO_2$/*p*(*n*)-Si hybrid structures showed that interface states localized near the $SiO_2$/*p*(*n*)-Si boundary significantly contribute to magnetotransport[14,15,16,17].These surface states are involved in recharging processes and their energy structure is rearranged by a magnetic field. However, this is apparently not the only possible mechanism and it cannot explain the variety of MR effects observed in the MIS-structure-based devices.

Another one transport effect that was observed in the superlattices[18], heterostructures[19], two-dimensional electron systems[20], Schottky barrier structures[21] is the lateral photovoltaic effect (LPE). LPE discovered by Walter Schottky in 1930[22] continues attracting the considerable interest due to its application potential as small displacements sensor. However LPE's sensitivity to magnetic field was found only last decade in some systems[23,24] which can provide an enhancement of the functionality for the LPE-based devices. Until today, in fact, nobody has discussed the LMPE origin and carried out detailed fundamental investigation.

Thus in this paper we present results of systematically study of Mn/$SiO_2$/*p*-Si structure magnetotransport properties and LPE in external magnetic field for the hybrid metal-insulator-semiconductor (MIS) structure with Schottky barrier Fe/$SiO_2$/p-Si.