Magnetometric MEMS manufacture based on magnetoresistive nanostructures

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The development of contemporary MEMS-sensors, magnetic sensors in particular, aims to improve their sensitivity, thermal stability and compactness. The range of use of magnetoresistive sensors in the technique is extremely wide therefore requirements to sensitivity value are extremely broad. The sensitivity to the magnetic field is determined by the ratio of the signal amplitude imbalance in a magnetoresistive bridge, caused the by influence of the magnetic field, to the value of that field in the linear region of the transfer characteristics of the sensor. It is the most important parameter [1-3], because it determines the use of sensors to address various problems. The sensitivity value is influenced by a number of factors, among which first and foremost design and technology. To ensure a high level of output characteristics of AMR sensors it is needed to improve the magnetic properties of the magnetoresistive material. In particular, it is needed to maximize the AMR effect, which determines the output signal amplitude, and to prevent the strong growth of the coercive force and anisotropy field for maximum sensitivity and minimum hysteresis achievement. However, the magnetoresistive material parameters are determined not only by its internal characteristics, but by the composition and parameters of the film growth, particularly, average grain size.

Experimental samples of permalloy films (80%Ni20%Fe) on the silicon wafer with an insulating layer of Si_3N_4 were manufactured. The value of AMR effect was 2.2%. Then a layer of conductive material (Al) with a thickness of 0.6 μm was formed. Samples with magnetic and non-magnetic layers of a given shape were formed by using photolithography operations. Based on the obtained magnetoresistive nanostructures, magnetometric microsystems (sensors) with even and odd transfer characteristics are developed.

The sensor with an even transfer characteristic consists of four magnetoresistors in the form of a strip of thin magnetic film 0.03 μm thick with contact platforms made from aluminum of ~0.6 μm thick. The magnetoresistors on different shoulders of the bridge are turned 90° from each other, as a result of which a variation in the resistance of all resistors is provided under the action of a planar magnetic field. A prominent feature of this sensor consists in the almost total absence of linear portions. The sensors have a high output signal (~20 mV/V); however, their characteristic is nonlinear, which provides serious difficulties when measuring magnetic fields and prevents determining the magnetic-field polarity.

Sensors with an odd transfer characteristic have wider possibilities. The structure represents a strip of magnetic film 0.03 μm thick on which thin strips of high-conductivity material (aluminum) are located at an angle of 45° to the magnetic-film axis. It enables us to linearize the characteristic and to make it odd. By virtue of these circumstances, sensors with an odd transfer characteristic have received greater circulation in comparison with conventional Hall sensors.

Based on magnetometric MEMS it is possible to develop various sensors of physical quantities.

The work was performed on the equipment of MIET Core facilities center «Microsystem technique and the bases of electronic components», supported by the Ministry of Education and Science of the Russian Federation (state contract No. 14.594.21.0012, unique identifier of the project RFMEFI59417X0012).

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