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TITLE: Magnetoresistive sensor with high sensitivity: self-aligned magnetic structures

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ABSTRACT BODY:

Digest Body: Magnetic materials provide a solution of many technical and technological problems in the world today. The effect of a variation in the resistance of metals, in particular, iron and nickel, in a magnetic field was discovered quite long ago; however, this phenomenon was barely used in engineering for a rather long time. The development of technology for the deposition of thin metal films and the discovery of the effect of magnetoresistance in films of iron-nickel and nickel-cobalt alloys opened up the possibility for the fabrication of efficient devices (based on these films) for measuring magnetic fields. The sensitivity to the magnetic field, which is determined by the ratio of the signal amplitude imbalance in 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 [1-2] is the most important parameter, because it determines the use of sensors to address various problems. The range of use of magnetoresistive sensors in the technique is extremely wide therefore requirements to sensitivity value are extremely broad. The sensitivity value is influenced by a number of factors, among which first and foremost design and technology. Sensors based on magnetoresistive structures usually consist of a thin strip of magnetic material with thickness 0.03 μm, mainly iron-nickel alloy on which strips of high conductivity material (aluminum) are applied at an angle of 45^0[1]. However, in real structures, this condition is not valid over the entire length of conducting stripes because there is strong bending at their ends. Since the magnetization of a magnetic stripe is characterized by quite homogeneous spatial distribution, the regions of curved current lines exhibit the corresponding misorientation of local magnetization and electric current vectors, which leads to a decrease in the magnetic sensitivity. Therefore, the main way to increasing sensitivity consists in decreasing the influence of these regions. To accomplish this task, we propose the magnetoresistive structure in which the magnetic layer occurs under the sloped conductors and repeats their shape (Fig.1). This structure may be called «self-aligned» [3].

Mathematical simulation shown that with using a self-aligned structure the sensitivity of AMR converter increases without changing other geometric dimensions. There is an optimum size of the protrusion height (3 μm), which allows to maximize the sensitivity and prevent the occurrence of hysteresis (6 μm). To confirm the results of the simulation a test batch AMR converters with self-combined structure was made [4-5]. The measurement results have confirmed an increase in sensitivity while maintaining the geometric dimensions (Fig.2). AMR effect in permalloy film in the produced batch was 2.5 %. The coercive force and anisotropy field reached 1.8 Oe and 5 Oe, respectively.

It should be mentioned that this effect is lower for structures with wider magnetic stripe. This proves the assumption that the use of self-combined structure changes the magnetization on the edge of the magnetic stripe so that the reduced edge effects. Developed self-aligned structure showed a significant, more than 2.5 times increase in sensitivity to the structure with a width of the magnetic strip 10 μm. This suggests that it is possible to reduce drastically the geometric size of the sensor, first of all its area, without changing its resistance. The sensitivity was determined as the ratio of the magnitude of the output signal (imbalance voltage of the bridge under the action of magnetic field) to the magnetic field magnitude on the linear range of transfer characteristic. The investigated structures had a wide range of sensitivity values from 3.0 (mV/V)/(kA/m) to 9.4 (mV/V)/(kA/m), in the bias field value of 1 kA/m. It is established what the main influence on the sensitivity of the sensor has a width of permalloy strips. The distance between the barber pole has a substantially smaller effect.

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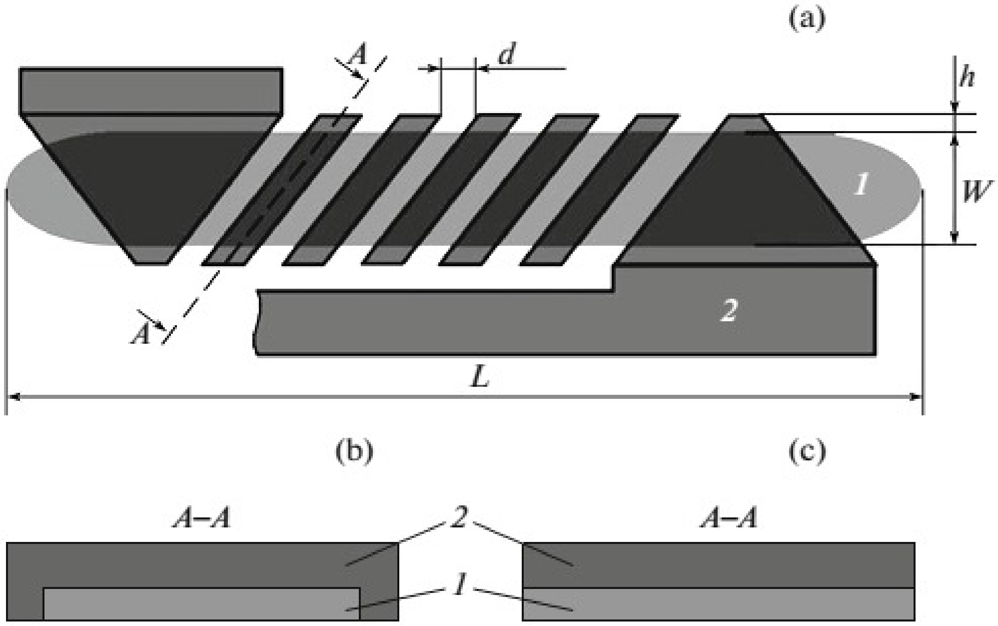

Fig. 1 – Schematic diagrams of (a) magnetic sensor and comparison of the topology of (b) a classical barber-pole and (a) a self-aligned magnetic sensor structure: (*1*) permalloy; (*2*) aluminum.

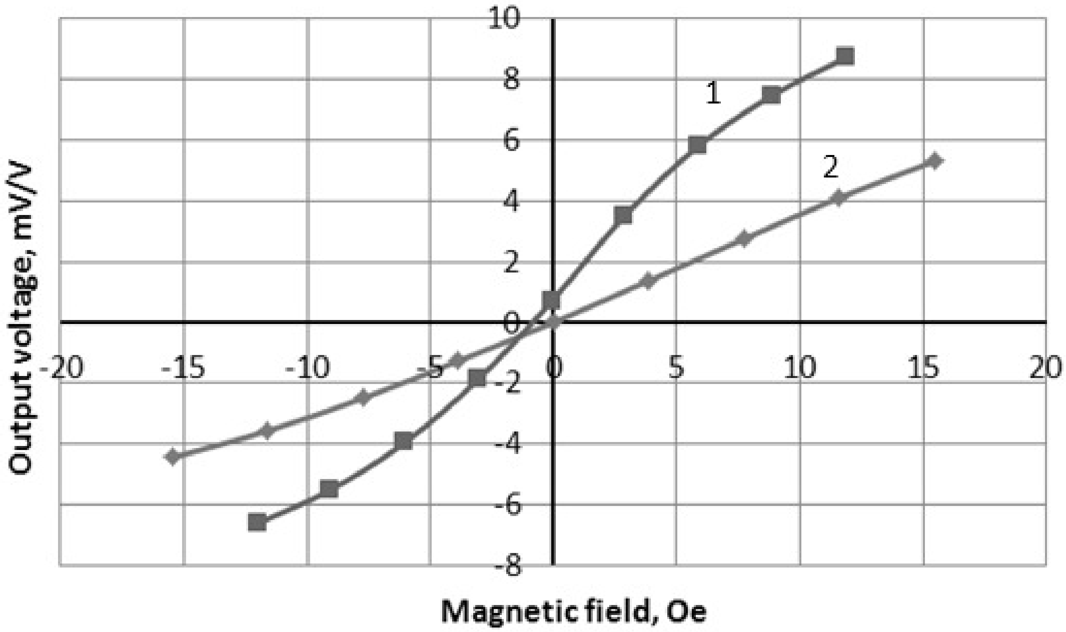

Fig. 2 – The transfer characteristic of self-aligned (1) and classical (2) structures with the magnetizing field 1 kA / m

IMAGE CAPTION: Fig. 1 – Schematic diagrams of (a) magnetic sensor and comparison of the topology of (b) a classical barber-pole and (a) a self-aligned magnetic sensor structure: (*1*) permalloy; (*2*) aluminum. Fig. 2 – The transfer characteristic of self-aligned (1) and classical (2) structures with the magnetizing field 1 kA / m

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AWARDS: