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54	HALL-EFFECT SENSOR

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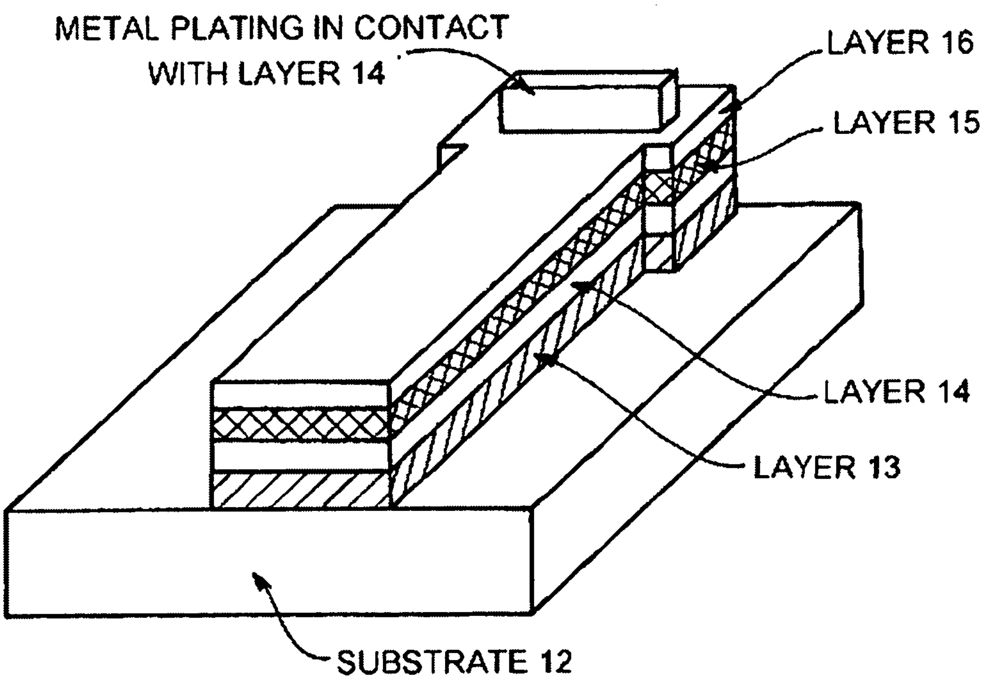
If no classification is finished, Form P.9 should accompany this form.
The figure of the drawing to which the abstract refers is attached.

Abstract

The invention concerns a Hall-effect sensor consisting of a multilayer structure comprising a thin semiconductor material layer deposited on a semiconductor substrate (12), the two layers being electrically insulated with an insulation. The invention is characterised in that the substrate (12) is a n+-type semiconductor material whereon is deposited an insulating material consisting of a p- type semiconductor layer (13), and the thin active layer (14) is of the n- type doped in exhaustion mode. Preferably, the active layer consists of a silicon carbide or a gallium nitride layer.



VIEW ALONG SECTION PLANE AA' OF SAID SENSOR

HALL EFFECT SENSOR

The present invention pertains to the field of Hall sensors intended for the quantitative measurement of magnetic fields.

The general principle of Hall effect sensors is well known. In particular, sensors are known which are constituted by a multilayer structure comprising a thin layer of a semiconductor material deposited on a substrate which is itself a semiconductor, with the two layers being electrically isolated from each other.

As an example, European patent EP 572,298 describes a "two-dimensional electron gas" Hall effect sensor comprising, on an isolating substrate, a quantum well structure, a carrier supply layer adjacent to the quantum well structure, of a thickness less than 250 angstroms and possessing a surface density of donors integrated over the entire surface of the supply layer of carriers lower than a threshold value, an isolating burial layer deposited on the carrier supply layer, possessing an energy conduction band greater than the fermi energy of the sensor and of a thickness greater than 200 angstroms.

European patent EP 458,466 describes a Hall effect device comprising a substrate, an active layer formed by a diamond semiconductor deposited on the substrate, a pair of electrodes deposited on the opposite sides of the active layer, for introducing a current in the active layer in one direction and another pair of electrodes deposited on the other opposite sides of the active layer for detecting a tension or a tension component which is induced in a direction which is generally orthogonal to the direction of the current.

US patent 5,536,953 describes a broad-band semiconductor comprising multiple dopants at low concentrations.

The problem that characterizes the sensors according to the state of the art is that of the operating domain. In fact, the metrological performances of the sensors according to the state of the art degrade (decrease in sensitivity, nonlinearity, etc.) at temperatures higher than 200°C.

This degradation is linked to the performance of the structure (deficiencies in the electric isolation of the active/substrate layer) and/or the active layer (change in the conduction mechanisms, etc.).

The goal of the present invention is to propose a Hall effect sensor exhibiting a low sensitivity to temperature, typically of less than 250 ppm/°C for operating temperatures greater than 200°C, and presenting a high Hall KH coefficient on the order of several hundreds of volt/ampere/tesla. KH is inversely proportional to the surface carrier density and the electron charge.

For this purpose, the invention in its most general sense pertains to a Hall effect sensor constituted by a multilayer structure comprising a thin active layer made of a semiconductor material deposited on an isolating, semi-isolating or semiconductor substrate but of a type different from that of the thin semiconductor layer. In all cases, the active layer is electrically isolated from the substrate.

The active layer is preferably covered by an insulator (for example, silicon oxide or nitride) or by a passivation insulator. The doping level of the active layer is selected such that the sensor operates in exhaustion regime (total ionization of the dopants) over the entire temperature range corresponding to use.

According to a first mode of implementation, the active layer and/or the insulating layer and/or the substrate are constituted by a hexagonal silicon carbide layer. The doping level of the n^- active layer is advantageously lower than $5 \cdot 10^{15}$ per cm^3.

According to a variant, the active layer is a cubic silicon carbide layer. According to a variant, the active layer is a layer of nitrides based on GaN and/or its alloys.

According to a variant, the active layer is made from a material with a weaker forbidden band than that of the above materials (the case, e.g., of silicon).

The temperature range corresponding to the exhaustion regime is, in this case, shifted toward low temperatures (below 200°C) and is limited toward high temperatures (> 200°C). The sensitivity to temperature can be higher than in the preceding cases and not constant over the entire temperature interval corresponding to the exhaustion regime and to use.

The materials forming the substrate and the active layer are preferably of the same substance with different dopings.

According to a variant, the active layer can be transferred onto a substrate of a different substance. It can be adhered by molecular adhesion.

According to a particular variant, the invention pertains to a Hall effect sensor constituted by a multilayer structure comprising a thin active layer of a semiconductor material deposited on a semiconductor substrate, the two layers being isolated electrically by an insulating layer. The overall structure is characterized in that the substrate is a type n^+ semiconductor material on which is deposited an insulating material constituted by a type p^- semiconductor material and in that the thin active layer is of type n^-.

According to a particular mode of implementation, the sensor according to the invention is constituted by a bar presenting a body extended by two pairs of lateral arms, with the body presenting at each of its ends an electrode for electric power, two opposed lateral arms comprising electrodes for acquisition of the Hall signal and two adjacent arms presenting electrodes for measuring the resistance.

Better comprehension of the invention will be obtained from the description below of a nonlimitative example of implementation which refers to the attached drawings in which:

– figure 1 represents a top view of a sensor according to the invention,

– figure 2 represents a view along a cross-sectional plane of said sensor.

The Hall sensor according to the example of implementation described as an example presents a general shape of a "cross of Lorraine" with a body (1), a first pair of lateral arms (2, 3) and a second pair of lateral arms (4, 5) with the unit being designed to measure a magnetic field perpendicular to the plane formed by the median axis of the body (1) and by the median axis of at least one pair of arms (e.g., 2, 3).

One of the pairs of arms (2, 3) presents electrodes (6, 7) for acquisition of the Hall signal.

The body also presents two electrodes (8, 9) positioned at opposite ends for powering with an excitation tension or a current feed. Moreover, two adjacent arms (2, 4) present electrodes (6, 10) for measuring the resistance of the structure, a measurement which allows deduction of the temperature of the Hall sensor.

Figure 2 represents a view along a cross-sectional plane. The Hall sensor according to a first mode of implementation of the invention is designed to present an impedance of several kilo-ohms, typically on the order of 10 kilo-ohms, a thermal sensitivity on the order of 200 ppm/°C and a KH factor on the order of multiple hundreds of volt/ampere/tesla.

In order to attain these performance levels, the Hall sensor according to the invention is constituted by a substrate (12) made of an n^+ doped semiconductor. The semiconductor is monocrystalline of the silicon carbide (SiC) type, preferably of the 4H-SiC type.

An insulating layer (13) is deposited on this substrate, e.g., by epitaxial growth. This layer is constituted by a semiconductor material identical to that of the p^+ doped substrate.

On this insulating layer (13) is deposited a thin active layer (14) constituted by an n^- doped semiconductor. The semiconductor is monocrystalline of the silicon carbide SiC type, of type 4H-SiC.

The active layer is itself optionally covered by an insulating layer (15) and a passivation layer (16), e.g., of silicon oxide (SiO_2).

The sensor according to the invention employs large-gap semiconductors working in exhaustion regime.

According to a variant, the active layer can be deposited in the form of nitrides (GaN and/or alloys). The substrate can be sapphire on which is deposited a buffer layer, or silicon carbide with a buffer layer, or a nitride or any other substrate.

CLAIMS

1. A metrological Hall effect sensor with sensitivity to temperature less than 250 ppm/°C and with high Hall effect coefficient for temperatures greater than 200°C formed in a multilayer structure comprising: a thin active layer deposited on a substrate, wherein said substrate is made of a monocrystalline silicon carbide (SiC), wherein said thin active layer is made of a weakly type n^- doped silicon carbide (SiC) semiconductor in the exhaustion regime.

2. The metrological Hall effect sensor according to claim 1, wherein said substrate is p- doped in order to electrically isolate said thin active layer from said substrate.

3. The metrological Hall effect sensor according to claim 1, wherein in case said substrate is n+ type, an intermediate thin p- type layer is deposited between said substrate and said thin active layer in order to electrically isolate said thin active layer from said substrate.

4. The metrological Hall effect sensor according to any of claims 1 to 3, characterized in that the n- type active layer is covered by a thermal oxide and by a passivation insulator.

5. The metrological Hall effect sensor according to any one of the preceding claims, characterized in that the doping level of the n^- active layer is lower than 5.10^{15} per cm^3.

6. The metrological Hall effect sensor according to any one of the preceding claims, characterized in that the active layer is made of hexagonal silicon carbide.

7. The metrological Hall effect sensor according to any one of the preceding claims, characterized in that the substrate is made of hexagonal silicon carbide.

8. The metrological Hall effect sensor according to any one of the preceding claims, characterized in that the active layer is made of cubic silicon carbide.

9. The metrological Hall effect sensor according to claim 2, characterized in that the semiconductor materials forming the substrate and the active layer are made of the same substance.

Amended 31 March 2004

10. The metrological Hall effect sensor according to claim 3, characterized in that the semiconductor materials forming the substrate, the deposited insulating layer and the active layer are made of the same substance.

11. The metrological Hall effect sensor according to any one of claims 1 to 10, wherein the active layer is transferred onto a substrate of a different substance

12. The metrological Hall effect sensor according to any one of the preceding claims, characterized in that it is constituted by a bar presenting a body extended by two pairs of lateral arms, with the body presenting at each of its ends an electrode for electric power, two opposed lateral arms comprising electrodes for acquisition of the Hall signal and two adjacent arms presenting electrodes for measuring the resistance.