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THE PROSPECTS OF USING OF InSe TYPE MAGNETORESISTIVE SEMICONDUCTOR MATERIALS AIMED AT THE CREATION OF MAGNETIC FIELD SENSORS

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Анотація

Об’єктом даного дослідження є магніторезистивні структури на основі шаруватих напівпровідників InSe, інтеркальовані нікелем, призначені для виявлення важкої бронетехніки. Досліджений імпеданс даних структур при температурах від рідкого азоту до кімнатної

Ключові слова: Магнітний сенсор, шаруваті напівпровідники, інтеркаляція, імпеданс, діаграми Боде

Abstract

The object of this study is magnetoresistive structures such as InSe semiconductors intercalated by nickel to be used for reconnaissance purposes. Impedance for temperatures ranging from room temperature down to liquid nitrogen is studied

Keywords: Magnetic sensor, layered semiconductor, intercalation, impedance, Bode diagrams

The magnetic field is difficult to shield from because of its high penetrating power that enables detection of disturbances of magnetic field lines through technology based on the latest magnetosensitive and magnetoresistive structures [1, 2]. Military armored vehicles consist of dozens of tons of ferromagnetic material which is affected by the Earth's magnetic field creating its own magnetic moment. That leads to the distortion of the magnetic field, which can be detected using magnetoresistive structures. Nowadays sensitive magnetic sensors are used in many technical systems, including modern anti-tank missiles to identify the center of the target area and a minimal armor region. Moreover compounds based on magnetoresistive structures are resistant to temperature extremes, and ionizing radiation, so they are promising for use in guidance systems of modern microprocessor warheads [1].

Sensors based on magnetoresistive structures are highly sensitive to the magnetic field fluctuations (10^{-15}T at temperatures of liquid helium, and 10^{-13}T at room temperature). This property is used in a wide range of military technologies, such as: navigation, detection of submarines, missile guidance to the target, and more.

One of these structures is magnetoresistive layered crystal of InSe or In_4Se_3, intercalated by Ni. These layered structures can be treated as low dimensional (two-dimensional), so that all processes can be described within the InSe layers and processes taking place perpendicular to the planes of the layers can be considered a disturbance, substantially simplifying the mathematical approach for description of these structures.

Low dimensionality of the mentioned structures leads to anisotropy, i.e. electrical, magnetic and optical properties are different along the layers and perpendicular to them. Therefore, if such a sensor is fixed on the axis and set for rotation with some frequency (likewise radar station) then this system may allow tracking down the motion of the heavy armoured vehicles.

The presence of giant magnetoresistance in nanostructures of alternating semiconductor and metal layers provides prospects of elaborating sensitive magnetic field sensors. Structures with alternating layers of semiconductor and metal provide the fundamental possibility to control the magnetic properties.

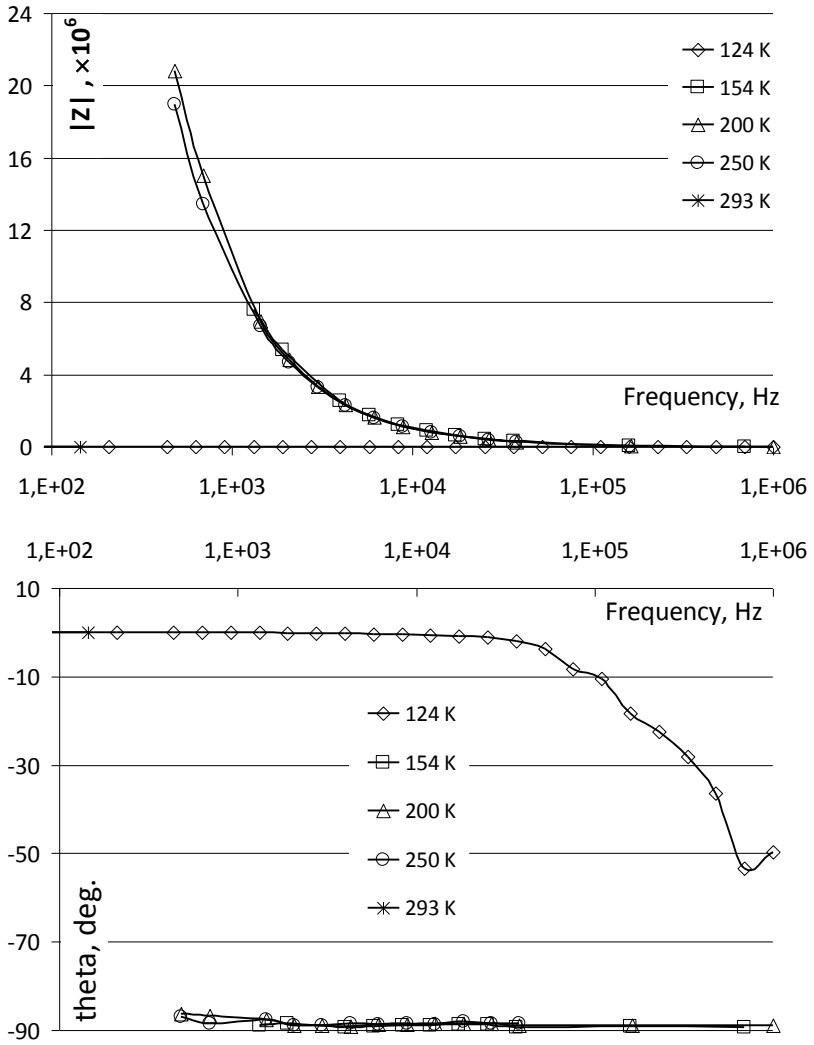

Figure 1 – Bode diagrams for pure InSe for various temperatures

Semiconductor structures are characterized by sensitivity of their electrical parameters to temperature differences, which in turn affects their magnetic properties. In order to identify specific properties of InSe and In_4Se_3 layered crystals, their impedance ranging from room temperature down to liquid nitrogen has been experimentally studied. For the sample of pure InSe a non-typical dependence of real impedance component (ReZ) on the temperature was observed including a significant similarity of ReZ for both 124 K and 293 K temperatures (Fig. 1). This deviation from the typical temperature dependencies should be taken into account when calculating the properties of the devices incorporating InSe (including magnetic field sensors), which operate under liquid nitrogen cooling.

Propertied of InSe based materials under liquid nitrogen cooling can also be simulated using the experimental data outlined here.

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