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Effects of Magnetic Field on 4H-SiC P-N Junctions

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Abstract : Silicon carbide is one of the promising materials with potential applications in electronic devices using high power, high frequency and high electric field. Currently, silicon carbide is used to manufacture high power and frequency diodes, transistors, radiation detectors, light emitting diodes (LEDs) and other functional devices. In this work, the effects of magnetic field on p-n junctions based on 4H-SiC were experimentally studied. As a research material, monocrystalline silicon carbide wafers (Cree Research, Inc., USA) with relatively few growth defects grown by physical vapor transport (PVT) method were used: Nd dislocations 104 cm^2, Nm micropipes ~ 10–10^2 cm^{-2}, thickness ~ 300-600 μm, surface ~ 0.25 cm^2, resistivity ~ 3.6–20 Ω□cm, the concentration of background impurities Nd − Na ~ (0.5–1.0)×1017cm^{-3}. The initial parameters of the samples were determined on a Hall Effect Measurement System HMS-7000 (Ecopia) measuring device. Diffusing Ni nickel atoms were covered to the silicon surface of silicon carbide in a Universal Vacuum Post device at a vacuum of 10^{-5} -10^{-6} Torr by thermal sputtering and kept at a temperature of 600-650°C for 30 minutes. Then Ni atoms were diffused into the silicon carbide 4H-SiC sample at a temperature of 1150-1300°C by low temperature diffusion method in an air atmosphere, and the effects of the magnetic field on the I-V characteristics of the samples were studied. I-V characteristics of silicon carbide 4H-SiC<Ni> p-n junction sample were measured in the magnetic field and in the absence of a magnetic field. The measurements were carried out under conditions where the magnitude of the magnetic field induction vector was 0.5 T. In the state, the direction of the current flowing through the diode is perpendicular to the direction of the magnetic field. From the obtained results, it can be seen that the magnetic field significantly affects the I-V characteristics of the p-n junction in the magnetic field when it is measured in the forward direction. Under the influence of the magnetic field, the change of the magnetic resistance of the sample of silicon carbide 4H-SiC<Ni> p-n junction was determined. It was found that changing the magnetic field poles increases the direct forward current of the p-n junction or decreases it when the field direction changes. These unique electrical properties of the 4H-SiC<Ni> p-n junction sample of silicon carbide, that is, the change of the sample's electrical properties in a magnetic field, makes it possible to fabricate magnetic field sensing devices based on silicon carbide to use at harsh environments in future. So far, the productions of silicon carbide magnetic detectors are not available in the industry.

Keywords : 4H-SiC, diffusion Ni, effects of magnetic field, I-V characteristics
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