Development of a GaAs Hall sensor

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The Hall device is a magnetic field sensor exploiting the Hall effect practically in the same way as Hall has discovered it [1]. This sensor is a transducer: it is a device that converts a magnetic field \( B \), in an electric signal, that is, the Hall voltage \( \Delta V_H \) [2]. The Hall device is used to measure magnetic field strength, angular dislocations, current, power and for characterization of semiconductor materials. The GaAs Hall sensors offer higher sensitivity and thermal stability when compared with silicon Hall devices, due to the higher band-gap and electron mobility.

The Hall device is a thin, usually rectangular plate of a relatively high resistivity semiconductor material, provided with four ohmic contacts (see Fig.1) and dimensions \((l, w, t, s)\). A bias current \( I \) is supplied to the device via two of the contacts (\( C_1 \) e \( C_2 \) - called the current contacts). The other two contacts (\( C_3 \) e \( C_4 \) – sense contacts) are placed equipotential points at the plate boundary. If a perpendicular magnetic field is applied to the device, a voltage appears between the sense contacts. This voltage is called the Hall voltage \( \Delta V_H \) and is approximately proportional to the product of the magnetic field \( B \) and the bias current \( I \) [3].

\[
\Delta V_H = (r_n / qnt) G BI.
\]  

(1)

where \( r_n \) is Hall coefficient factor\(^1\), \( q \) is electron charge, \( n \) is electron concentration in active area, and \( G \) is the geometry factor of Hall device.

The Hall devices have been designed with three different shapes (rectangular, cross-shaped, van der Paw) to exhibit high values for Hall voltage, sensitivity and linearity respectively. The layout of the sensors (see Fig. 2) was designed with the LASI software.

\(^1\) The Hall coefficient factor \( r_n \) depends on the scattering mechanism, the kind of energy surfaces, the strength of magnetic field, and temperature (\( r_n \approx 1.2 \) for GaAs at room temperature).

Fig. 1. Rectangular Hall device.

The active layers were fabricated by \(^{29}\)Si\(^+\) ion implantation (\( E=180 \) keV, \( \phi = 7 \times 10^{12} / \text{cm}^2 \)). After the annealing at \( 900 \) °C, the samples presented the following characteristics: \( n_s = 3.79 \times 10^{12} / \text{cm}^2 \), \( R_s = 500 \Omega / \), \( \mu_s = 2640 \text{cm}^2/\text{V.s} \), \( t \approx 0.25 \mu \text{m} \) (simulation by TRIM), for the first run.

The Hall voltage vs. Magnetic field curves for the cross-shaped device \#10 are shown in Fig 3. The measurements were done with bias current ranging between 1-7 mA, magnetic induction (0-600 mT) and room temperature.

Fig. 3. Hall voltage vs. Magnetic Induction (Sensor 10).

The GaAs Hall sensors, fabricated by ion implantation, demonstrated high sensitivity (= 140 V/A.T), linearity (< 0.2 %) and low offset voltage (= 11 mV).

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References