The Hall Effect

◆ What is the Hall effect?

Consider a flat strip of material of width w carrying a current I. A uniform magnetic field B is established perpendicular to the plane of the strip. The build up of charge along the right side of the strip produces an electric field E across the strip. Equivalently, a potential difference U=E・w called the Hall potential difference, exists across the strip.

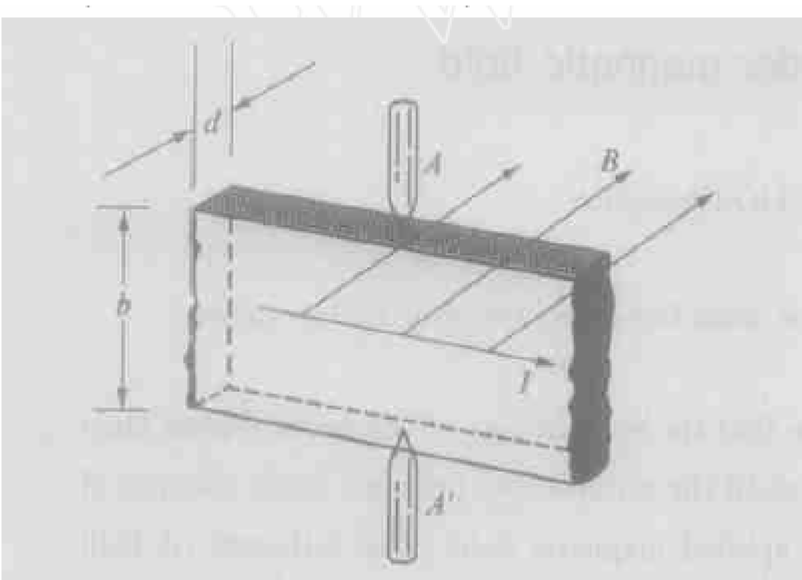


图 1　霍尔效应

Fig. 1　Hall effect

◆ History of the Hall effect

In 1879,Edwin Hall showed that the moving conduction electrons in a conductor could be deflected by a magnetic field.

Hall's work was down nearly 20 years before Thomson's discovery of electron. And the nature of electrical conduction in metals was not at all obvious at that time.

◆ Analysis to the theory:

According to experiment:

If the magnetic field B is not too strong. The Hall potential difference U is proportional to the current I and the uniform magnetic field B. And it is inversely proportional to the thickness of the strip t:

$$U=K\,I\,B/\,t \qquad \cdots(1)$$

(K is the Hall coefficient)

Let us assume that conduction in the material is due to charge carriers of a particular sign moving with drift velocity v. The charge carriers experience a magnetic deflecting force $F=q\,v\,B$ and they also experience a electric force $q\,E$. Equilibrium is quickly reached, and the Hall potential difference reaches its maximum. The sideways magnetic deflecting force then balances the sideways electric force.

The equation is:

$$qE + qv \times B = 0$$

(Since v and B are at right angels) $E = v \times B = vB$

We can write the drift speed as: $v = I/wtne$

(n is the density of charge carriers)

So we can write: $U = Ew = BI/tne$ ⋯(2)

From equation (1) and (2): $K = 1/ne$.

According to the equation. K is related to the density of charge carriers. So we can measure n via K.

As we known, semiconductors' density of charge carriers is much smaller than metals'. It effects heavily from temperature, mixed material and so on. So the Hall effect provides an important way to study the variance of the density of charge carriers. We can also know the sign of semiconductors according to the sign of K.

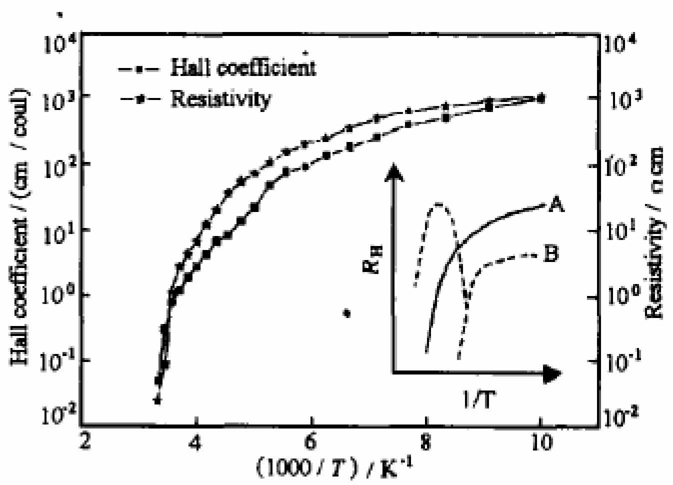


图 3　霍尔系数、霍尔电阻率随温度的倒数变化的关系曲线

Fig 3　Hall coefficient and resistivity as a function of $1/T$ of the copper nitride thin film. And the inserted shows the Hall coefficient changed with the temperature

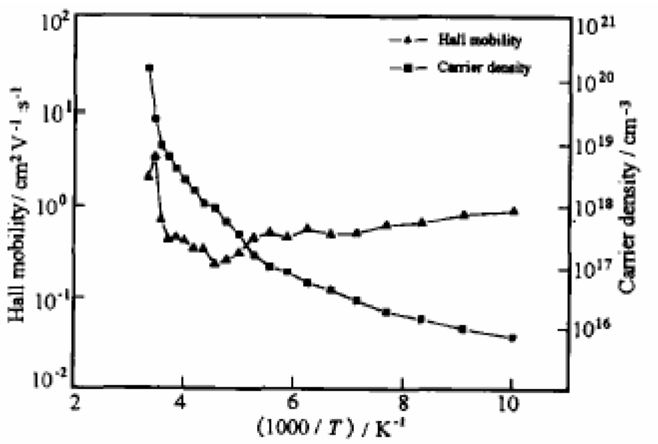


图 4　霍尔迁移率、载流子浓度随温度倒数变化的曲线

Fig. 4　Hall mobility and carrier density as a function of $1/T$ of the copper nitride thin film

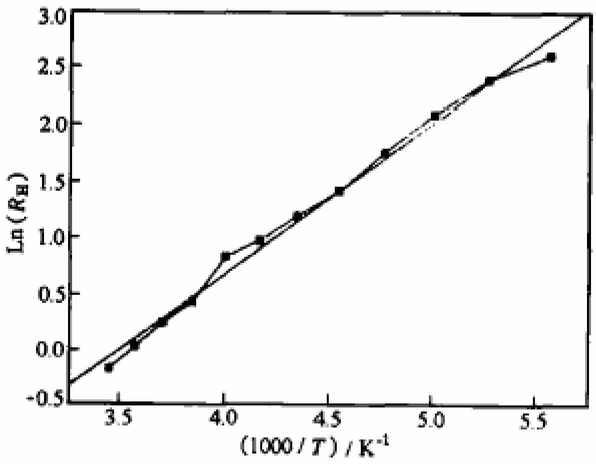


图 5 ln(R_H)同温度倒数的函数关系曲线

Fig. 5 Logarithmic plot of the Hall coefficient against $1/T$

◆ **Application**:

1. Measuring the magnetic field B. B=U・n・e・t/I

2. Measuring current and power in D.C and A.C circuit.

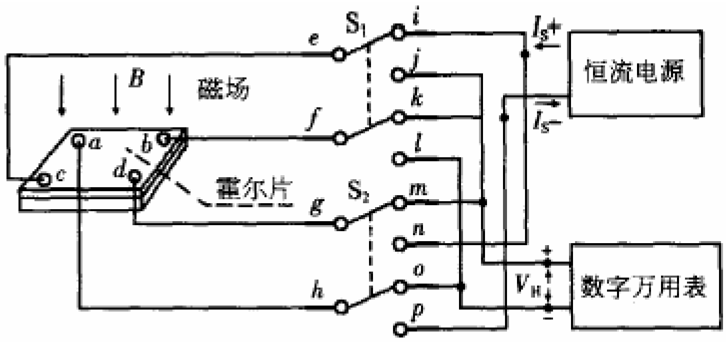


图 1　霍尔片测试电路图

Fig 1　Circuit diagram of Hall slice test

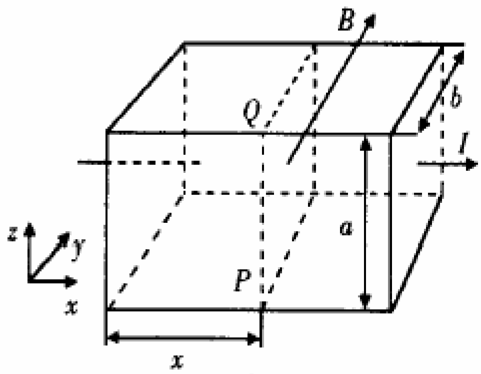


图 1　霍尔元件模型

Fig 1　Hall component model

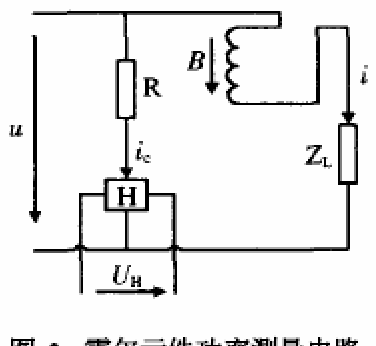


图 2　霍尔元件功率测量电路

Fig 2　Power measurement circuit of Hall component

3. The application of Hall Effect transducer in triaxial experiment

(霍尔效应传感器在土工试验中的应用)

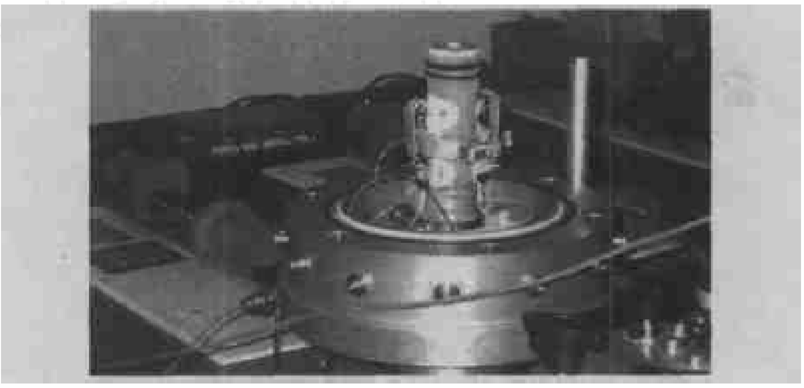
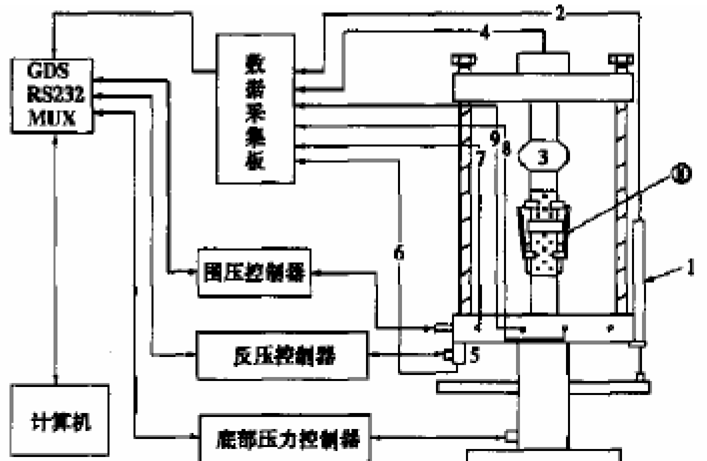


图 4　安装就位的霍尔效应传感器

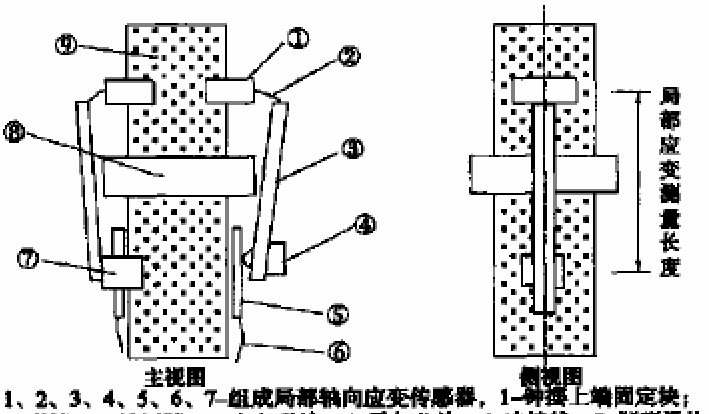
Fig. 4　The installed Hall effect sensor



1、2–（外部）竖向位移传感器及其连接线，3、4–轴向（潜水）荷载传感器及其连接线，5、6–孔压传感器及其连接线，7、8、9–霍尔传感器连接线，10–霍尔效应传感器

图 2　GDS 数据采集系统

Fig. 2　The data collection system



1、2、3、4、5、6、7–组成局部轴向应变传感器，1–钟摆上端固定块；2–弹簧；3–钟摆臂；4–永久磁铁；5–霍尔芯片；6–连接线；7–凹型滑块；8–局部径向应变传感器；9–试样

图 3　霍尔效应传感器

Fig. 3　Hall effect sensor