EXPERIMENT 6

Tungsten Filament Bulb and Semiconductor Diode

Purpose:

- To investigate of the current-voltage characteristics of tungsten filament (bulb) and semiconductor diode and observe the difference between ohmic and non-ohmic devices.

Experimental Instruments:

- Power Supply
- 100Ω Resistor
- Tungsten Filament Bulb
- Semiconductor Diode
- Avometer
- Connection Cables

Theoretical Information:

Ohmic Devices:

Ohm’s law states that ‘*The current flowing through a conductor is directly proportional to the potential difference V across its ends.’* Thereby, the device which follows Ohm's Law for all voltages across is called as an **ohmic device**. (i.e. under constant physical conditions the resistance is constant for all currents that pass through it). Examples of ohmic devices can be given as a wire, or a resistor.

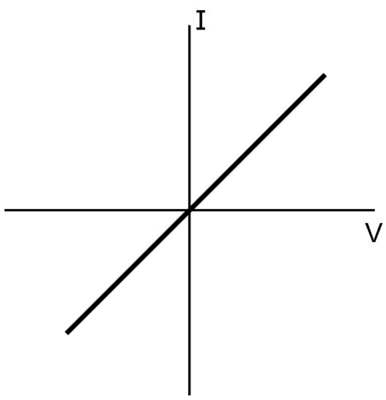

Figure 6.1 Current-voltage graph of ohmic devices

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Non-Ohmic Devices:

If a device behaves in a way that is **not** described by Ohm's Law, (i.e. the resistance is not constant, but changes in a way that depends on the voltage across it) the device is said to be non-ohmic. In this case, current-voltage graph is not a straight line, but has some curvy shape. Such devices do not have a constant value of resistance. Examples of such non-ohmic devices are tungsten filament (bulb), diode, LED, thermistor, etc.

Tungsten Filament Bulb:

- Metals must be heated to extreme temperatures before it will emit a useful amount of visible light. Most of the metals melt before reaching such extreme temperatures. The vibration breaks apart the rigid structural bonds between the atoms so that the material becomes a liquid. Light bulbs are manufactured with tungsten filaments because tungsten has an abnormally high melting temperature (Melting temperature of W: 3.695 K).
- An incandescent light bulb with a tungsten filament has a positive temperature coefficient, and therefore has a very low initial resistance when the power is first applied. As the temperature of the filament increases, the resistance of the filament increases also. The temperature of the resistor increases by increasing the applied voltage, since the power dissipated as heat is increased due to the relation **P = IV**, where I is the current passing through the tungsten filament and V is the voltage applied across it. For metals, the number of free electrons is fixed. As the temperature increases, the amplitude of vibration of atoms/ions increases and collisions of electrons with them become more effective and frequent. As a result, current-carrying electrons find more resistance in passing through and the resistance increases.

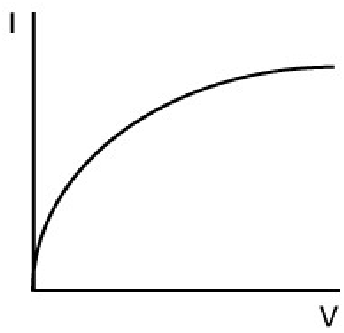

Figure 6.2 Current-voltage graph for tungsten filament bulb

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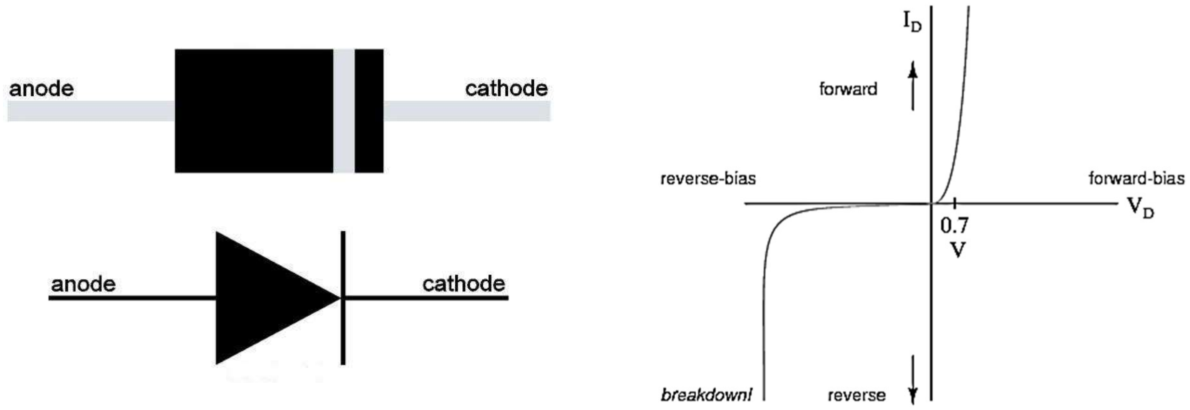
Semiconductor Diode:

- Semiconductors are a group of materials having conductivities between those of metals and insulators. At T= 0 K semiconductors behave as insulators. When the temperature starts to increase semiconductor starts to conduct.
- A diode is a specialized electronic component with two electrodes called the anode and the cathode. Most diodes are made with semiconductor materials such as silicon or germanium.
- The diode transmits the current when the p side (*anode*) is connected to the positive pole of the power supply and the n side (*cathode*) is connected to the negative pole and this is called **FORWARD BIAS.** When connected in the reverse direction, it does not transmit the current and this is called **REVERSE BIAS.**



(a) **(b)**

Figure 6.3 (a) *pn* junction diode device package and its schematic symbol, **(b)** current-voltage graph for pn junction diode

Experimental Procedure:

Section 1 (Tungsten Filament Bulb):

1. Set up the circuit shown as in Figure 6.4.
2. Switch on the power supply.
3. By setting the voltage from 1V to 10V, record the data read from the voltmeter in **Table 6.1. (WARNING: The voltage value on the voltmeter must not exceed 8 volts. The filament may burn out.**)

Section 2 (Semiconductor Diode):

1. Set up the circuit shown as in Figure 6.5.
2. Switch on the power supply.
3. By setting the voltage from 1V to 10V, record the data you have read from the voltmeter in the *Forward Bias* column in Table 6.2.
4. By reversing the poles of the power supply, write the V_1 and V_2 voltage values that you measured for the same voltage values in the *Reverse Bias* column in Table 6.2.

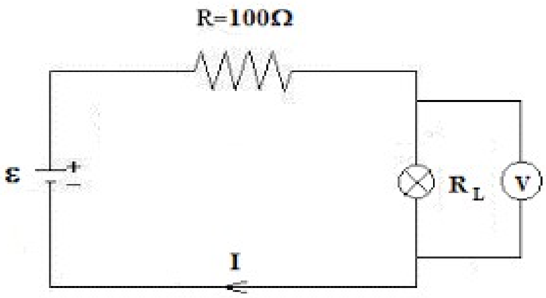


Figure 6.4 Tungsten filament bulb circuit

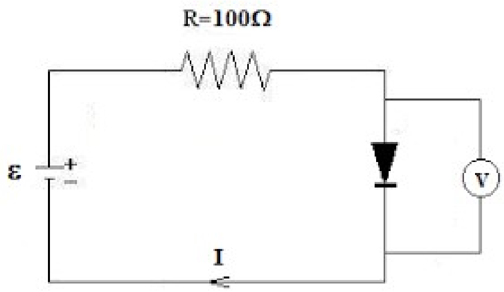


Figure 6.5 Semiconductor diode circuit

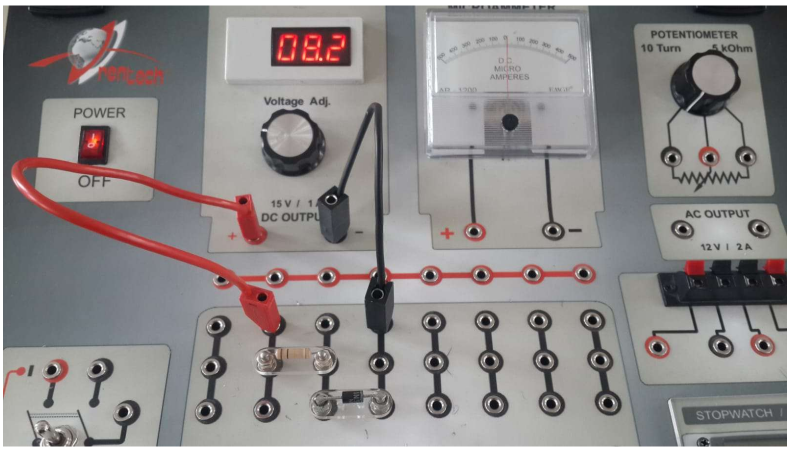


Figure 6.6 Semiconductor diode experimental setup

EXPERIMENT 6

Tungsten Filament Bulb and Semiconductor Diode

DATE :

GROUP ID :

Student ID	Name Surname	Signature

Experiment Expectation	

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CALCULATIONS AND RESULTS:

Section 1

Table 6.1. Tungsten filament bulb

ε (V)	**Power supply output voltage** V_1 (V)	**Voltage on the bulb** V_2 (V)	$\mathbf{I_L}$ (mA)	$\mathbf{R_L}$ (Ω)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

- Using the measured voltage values, calculate the main current of the circuit ($\mathbf{I_L}$) and the resistance of the lamp ($\mathbf{R_L}$) for 10 different output voltages and record the data to Table 6.1.

There are two equations to obtain the main current and tungsten resistance.

$$I_L = \frac{V_2 - V_1}{R} \tag{6.1}$$

$$R_L = \frac{V_2}{I} \tag{6.2}$$

Section 2

Table 6.2. Semiconductor diode

		Forward Bias			Reverse Bias		
ε (V)	**Power supply output voltage** V_1 (V)	**Voltage on the Diode** V_2 (V)	**I_D** (mA)	**R_D** (Ω)	V_2 (V)	**I_D** (mA)	**R_D** (Ω)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

- Using the measured voltage values, calculate the main current of the circuit (**I_D**) and the resistance of the diode (**R_D**) for 10 different output voltages and record the data to Table 6.2.

$$I_D = \frac{V_2 - V_1}{R} \tag{6.3}$$

$$R_D = \frac{V_2}{I} \tag{6.4}$$

DISCUSSION AND COMMENTS:

1) ***For Section 1,*** Plot the I-V_2 and evaluate whether the tungsten filament bulb is an ohmic circuit device or a non-ohmic circuit device.

2) ***For Section 2,*** Plot the I-V_2 and evaluate whether the diode is an ohmic circuit device or a non-ohmic circuit device.

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