# *Miscellaneous in Electricity*

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*2nd Oct, 2022*

## *Learning Outcome*

I highly recommend you to finish this checklist to determine whether you've achieved the learning objectives.

- ☐ understand that metals have *delocalised electrons* to be conductive
- ☐ explain why temeperature could change the resistance, and the phenomenon of *superconducitiviy*
- ☐ sketch and explain the *I–V* characteristics for *filament lamp*, *diodes*, *thermistor*
- ☐ sketch the temperature characteristic for an NTC thermistor
- ☐ sketch the light intensity characteristics for an light-dependent resistor(LDR)

## *Leadin*

Resistor is just the start in electronics, there are more components to be invented in a row, let's dig more.

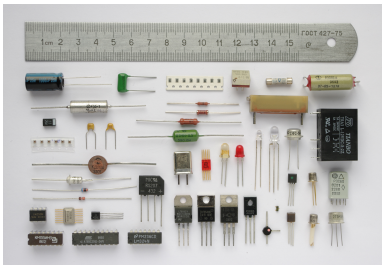


Figure 1: What are the names of the components above?

## *Essence of Conductivity*

In previous "Currents" chapter, the metals are conductive because a sea of electrons exsist in the cavity. and now such free electrons are called *delocalised electron*

### *Delocalised Electron*

The definition is as following

**Summary**

Delocalised Electron is

### *Effect of Temperature on Resistance*

The relationship between resistance in a metal and temperature is that: usually, if the temperature becomes _____, the resistance will also become _____.

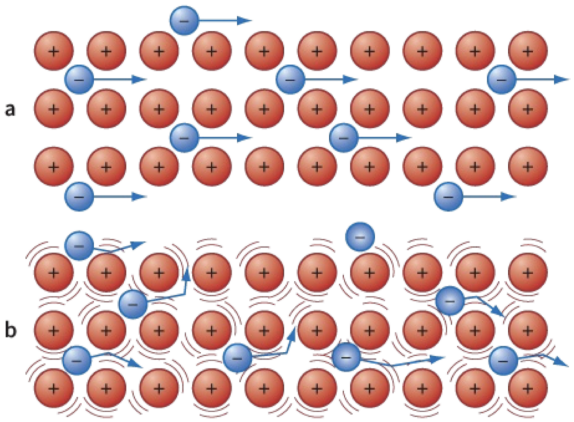



Figure 2: a model used to explain the resistance

From Fig.**??**

### *Superconductivity*

If the temperature is low enough, is there any possibility that the resistance suddenly disappear? The answer is quite obvious, it do happen, such phenomenon is called *superconductivity*[1].

Superconductivity was firstly discovered by Heike Kamerlingh Onnes, The critical temperature for mercury to be superconductive is 4.1 K. And usually the critical temperature, $T_c$, for metals is around 0 K to 10 K. So one

[1] exp:

of the cutting-edge field of research in superconductivity is high-temprature superconductivity or even room-temperature superconductivity.In Yuan CAO's publication "Unconventional superconductivity in magic-angle graphene superlattices", unconventional superconductivity might occur at the temperature of 1.7 K.

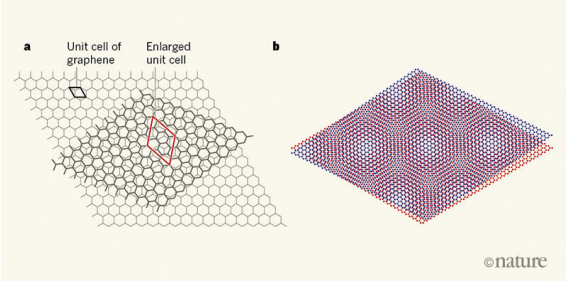



Figure 3: an angle of 1.1° is the magical angle

**Task**

List the field that superconductivity could be applied.

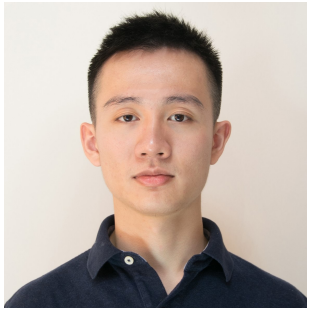


Figure 4: Yuan CAO,Forbes 30 under 30 Asia

### *Effect of Impurity on Resistance*

Alloys are the mixture of two or more metals, and ususally because the difference between the nuclei of different metal, the resistance might be raised as well.

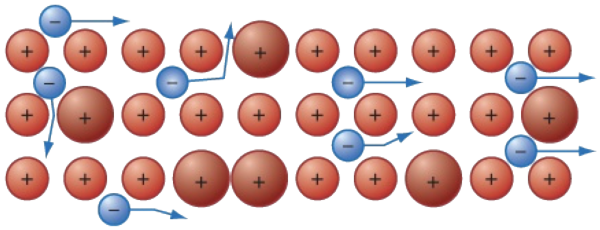


Figure 5: impurity might also influence the resistance

### *Filament Lamp*

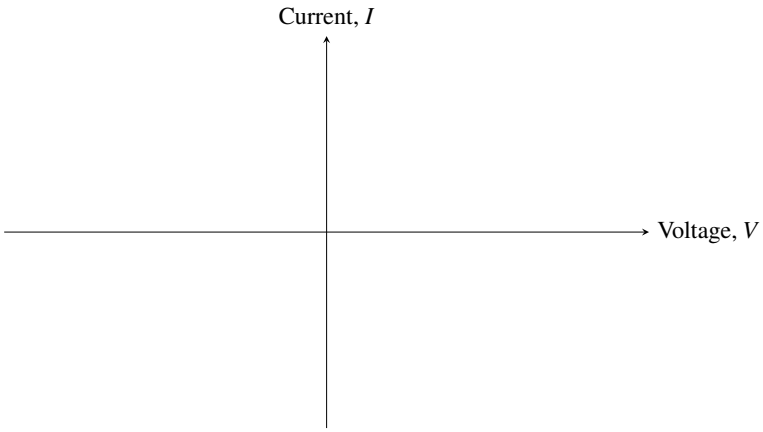
A conductor that does not obey Ohm's law is described as non-ohmic. An example is a filament lamp. Let's dig out the *I-V* characteristics.

The characteristics of filament lamp are summarized as below:

Figure 6: The material for the filament tungsten which can endure high temperature

**Summary**

- Current (can/can not) passes freely through either side of the lamp
- The filament lamp is (ohmic/non-ohmic)




- For very small currents and voltages, the graph is roughly a straight line.
- As the voltage increases, the resistance of the filament lamp will (increase/decrease)

**Task**

Sketch the $I$-$V$ characteristic of filament lamp;

Explain why the resistance of filament lamp change under different voltage (Hint: connect it with the effect of temperature on resistance)

## *Diodes*

Diodes are are made of *semi-conductors*, which is also a kind of non-ohmic components. Watch the video. The most important thing about diodes is that it can only allows currents to pass through in only one direction.

Thus the $I$-$V$ characteristic of diodes is as following:

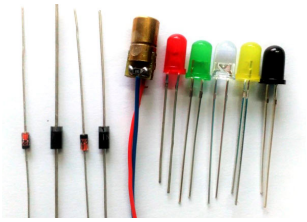
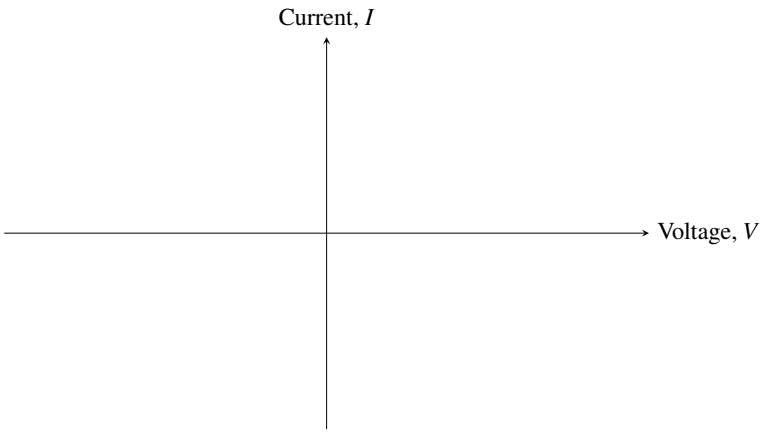


Figure 7: Different types of diodes, LED is also a kind of diodes



The characteristics are summarised below:

**Summary**

- If the p.d.(voltage) is not consistant with the direction the diode, no current flows in the diode
- When the p.d.(voltage) is consistant, if the p.d. does not exceed the *threshold voltage*, there is still no current flowing in the diodes
- After the voltage is big enough, the diodes behaves like a ohmic resistor

## *NTC Thermistors*

Thermistors (thermal resistors) are components that are designed to have a resistance that changes rapidly with temperature. There are two types of thermistors, NTC and PTC.

**Task**

Define NTC and PTC thermistors.

However, when talking about thermistors, we are actually referring to the NTC thermistors.


Figure 8: NTC is usally black packaged, PTC is usually blue packaged

The resistance characteristics are shown below:

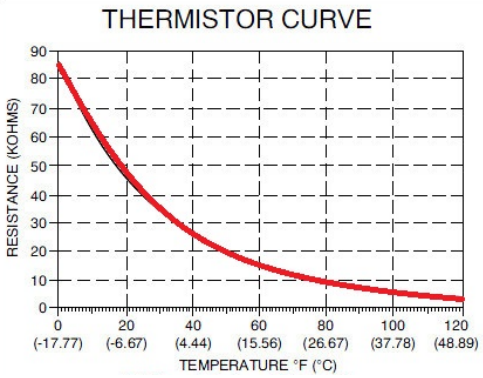



Figure 9: NTC's resistance is dependent of the temperature

### *LDR*

A light-dependent resistor (LDR) is made of a high-resistance semiconductor, the resistance of which can vary greatly according to the light intensity[2].

[2] The unit for light intensity is cd, which is also a base unit in SI system

**Summary**

Usually, if more light are cast on the LDR, the resistance will decrease.

The variation of the resistance of a typical LDR with light intensity is shown below:

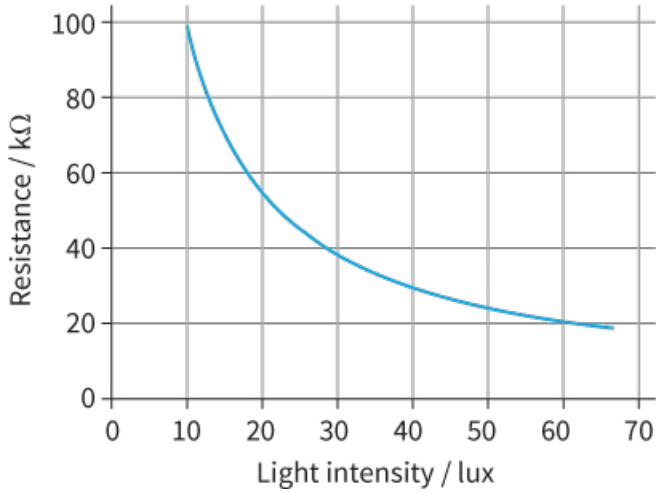



Figure 10: A typical LDR