Current Density - Mini Pencil Emergency Light

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ABSTRACT

This experiment was conducted to understand the fundamentals of electric fields in material space. The material involved in this study was graphite and the properties of graphite which made it a great current conductor. Graphite is a soft material made up of carbon. Graphite has incredible metallic properties including thermal conductivity and electrical conductivity. The materials involved in this experiment were pencils, LED, batteries and connecting wires. In this study, graphite in pencils were used to illustrate the current production. 2 pencils were combined and added with an LED in one end and a battery-power source at the other. When the power supply is turned on current starts to follow through the graphite element making the LED light up.

Keywords: Electric field in material space, conductor, current conduction, graphite

1. Introduction

As electric fields can occur in free space, they can also occur in material space. Materials are broadly classified in terms of their electrical properties as conductors and non-conductors. We know that conductors have a large number of free electrons that implement conduction current. However, another aspect to be considered is that in mediums and captive fields (Material fields), electrons experience constant collisions with the atomic lattice and drift from one atom to another. It is directly proportional to the conductivity of the material. The electrical properties of the material are the primary justification of the material behavior in electric fields. By understanding the mechanism by which materials influence an electric field, we can use them for our benefits in many electrical field-based applications. This report aims to discuss a newly discovered conductive material which is Graphene. Accordingly, An experiment using graphite-based material will be conducted for more understanding.

To begin with, it is important to know that the conduction current density in a material is directly proportional to its conductivity and the electric field intensity. Moreover, the conductivity of the material is the product of charge density and electron mobility. Therefore, we conclude that the conduction current density is directly proportional to the charge density and electron mobility. Despite that, Graphene is a two-dimensional material unlike other solid materials; it has some fantastic electrical properties such as very high electrical conductivity and thermal conductivity. The high electrical conductivity of Graphene is due to its high mobility of electrons compared to other metals. Additionally, Graphene has very low resistivity, lower than copper. Furthermore, Graphene has some other non-metallic properties such as high thermal resistance, and lubricity. Those promising features have put the Graphene into consideration by scientists and manufacturers for better electronic devices and new technology products. In the coming experiment, Graphene's high conductivity due to its high electrons mobility will be proven using a pencil, and a real-life problem will be solved.

2. Methodology

Figure 1 depicted the fabrication process of the mini pencil emergency light, in which describes the assembly of the essential components listed in Table 1.

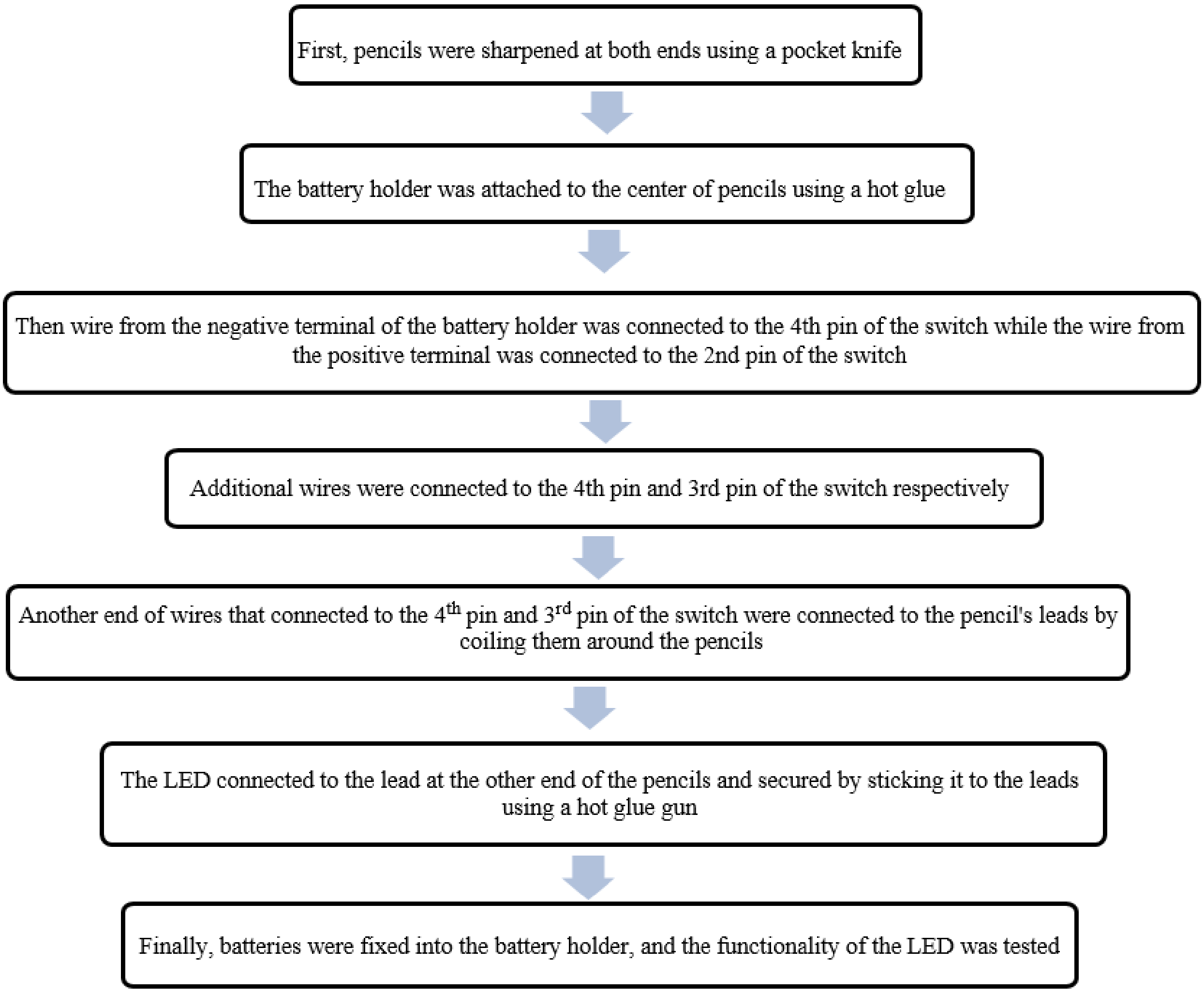

Figure 1. Fabrication process of the Mini Pencil Emergency Light

Table 1. Components for the mini pencil emergency light

No	Materials	Quantity
1	Battery holder	1
2	Light Emitting Diode (LED)	1
3	Toggle switch	1
4	Hot glue gun	1
5	Pocket knife	1
6	Wires	2
7	Pencils	2
8	Batteries (1.5V)	2

2.1 Steps of experimental set up

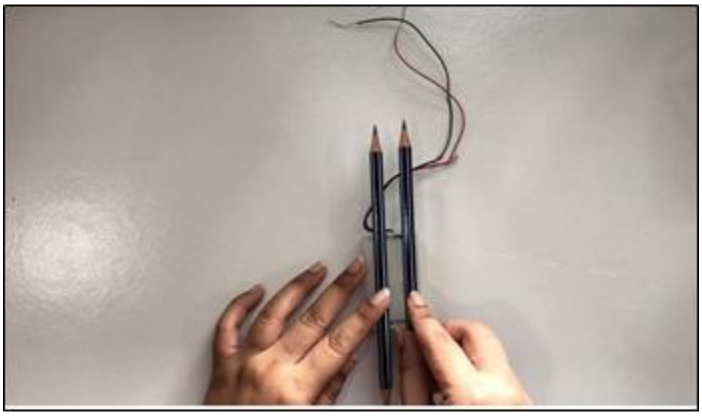

Figure 2. Attaching battery holder to the pencils

Figure 3. Connecting wires to the switch

Figure 4. Coiling wires around the pencils

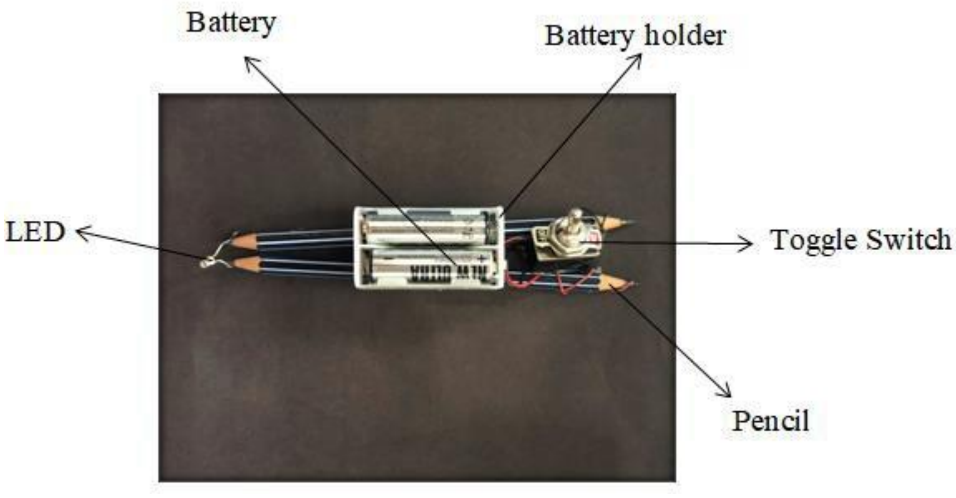

Figure 5. Final product

At first, pencils must be sharpened at both ends to expose the leads. The length of the lead must be at least 0.8 cm long. This is to ensure that the end of the wire that coiled around the pencils is attached to the lead rather than touching the pencil's surface which will not promote electricity conduction. Before attaching the battery holder to pencils, the LED is placed on the pencil's lead to get the sample measurement of the distance between the pencils. This is done because the legs of LED are shorter; if we placed pencils far away from each other it will be difficult when attaching the LED to pencils leads at the end of the experiment.

A wiring diagram of 4 pin switch is used as a reference when connecting the wires to the toggle switch. It is important to know the function of each pin of the switch before connecting. According to a wiring diagram of 4 pin toggle switch, 2nd pin of the switch is connected to the positive terminal of the battery holder, 4th pin connected to the negative terminal, 3rd pin connected to pencil lead and 1st pin remained unconnected. This diagram enables the correct connection of wires to the switch. Connecting wires to an incorrect pin can either prevent current flow or allow the current flow even though the switch is off. Finally, LED connected to the pencil leads according to the terminals. The longest leg of LED known as an anode is connected to the positive terminal while the shortest leg known as cathode is connected to the negative terminal of lead.

3. Result

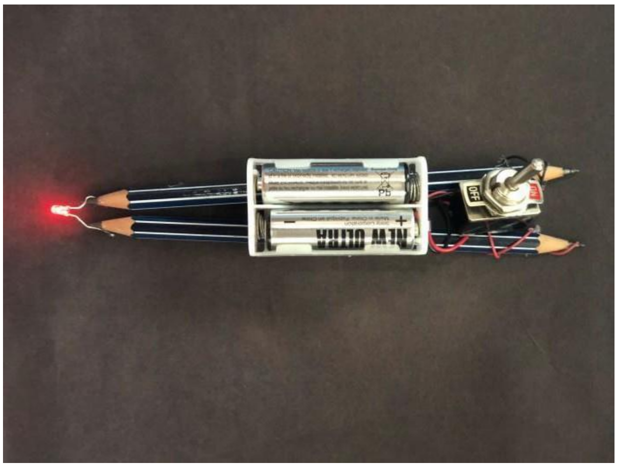

Figure 4.1. Result obtained from the experiment when the switch is ON.

When the switch is on, the electricity flows from one battery terminal to the other through the wires that connect to the one end of the pencil's lead. As the current flows, it meets a lot of resistance within the lead which is made up of graphite. This resistance causes the graphite filament to heat up. Once the graphite filament heats up enough, the free electron of graphite is excited to higher energy states and starts to move. The movement of this electron conducts electricity throughout the graphite filament and causes the LED at the other end of the pencil to emit light.

4. Conclusion

This experiment was conducted to understand the fundamentals of electric fields in material space. The material involved in this study was graphite and the properties of graphite, which made it a great current conductor. In this study, graphite in pencils was used to illustrate the current production. When the graphite element is connected to a power supply, it will heat up due to the electrons. When electrons gain energy, the electrons move around faster, producing higher current. Graphite has great metallic properties compared to other metals, including thermal conductivity and electrical conductivity. Graphite is also known for its non- metallic properties, including lubricity and thermal resistance. Graphite is commonly used in pencils, steel manufacturing, and electronics. Graphite is also the source of graphene. Graphene is thin, tough, and electrically and thermally conductive. Applications of graphene include not just electronics but also biosensing, battery technology, membrane technology. Graphene technologies are in early stages of innovation and soon will become renowned material in the future.

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