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Use the LiquidCrystals and it as a heat sensor by using semiconductor laser beams

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ABSTRACT

In this research, a practical study was conducted to measure the temperature of objects remotely using a semiconductor laser and a heat-sensitive liquid crystals thermotropic material at different temperature values, starting from 30 °C to 70 °C, at each value of the temperature the temperature is known To the bodies by reflected laser beams loaded with a portion of the measured body heat.

The final results showed that the best measurement of body temperature can be obtained at large distances such as 1, 1.5, 2 meters, as this is due to the fact that the scattered laser beams have less impact on the detector, and this is what was observed in the study when taking distances 1, 1.5 And 2 meters, where the graphs at these distances show good stability of the reflected laser beam loaded with a part of the heat to that point which reflex of it and whose temperature is to be known, which radiates heat perhaps more or less than other parts of the body.

As for less distances, the results obtained from this study lack accuracy, and this is what was shown by the graphs at a distance of 0.5 meter, This is due to the interference caused by the reflection and scattering of the laser light falling on the polarized plates and returning it to the detector.

Introduction

LCD is known as an intermediate state and described as a fourth state of matter and it belongs to the solid and liquid states, but it has special features that are not present in the solid and liquid states, and the first to notice this state was the Austrian botanist Friedrich Reinitzer in **1888[1],** when he found that This substance melts at a temperature of 146 °C, but it does not melt at this temperature completely, and when it is at this temperature, the substance becomes in an intermediate state called liquid crystal, and when it reaches a temperature of **179** °C, it is an isotropic **[2]** , As in the following equation **[3]**

$$\text{Solid} \xrightleftharpoons{146^{0}\,C} \text{Liquid crystals} \xrightleftharpoons{179^{0}\,C} \text{Isotropic}$$

Liquid crystals are classified into two main classes: Lyotropic Liquid Crystals. This class of liquid crystals arises when specific volumes of a polar solvent such as water and alcohol are added to calculated amounts of amphiphilic organic compounds at room temperature or at higher temperatures. The second class is Thermotropic liquid crystals, and this type of crystal depends on the temperature and the amount of change in it, so it is called the Temperature Induced Mesophase **[4]** . And many scientists contributed to the diagnosis of a large number of compounds with thermotropic systems, including the scientist Sakman in 1966 and the scientist Demus 1973 **[5]** .Using a laser beam to know the temperature of objects using an LCD material, and that the word "laser" is derived from the first letters of the following words (Light Amplification by stimulated Emission of Radiation) and means light amplification by stimulated emission of radiation, which is a focused and regular beam with photons sharing its frequency and matching its waves so that the phenomenon of constructive interference occurs between its waves[**6**].The use of laser beams is common in many applications, we find it an essential element in many industrial, medical, commercial and military applications due to the advantages that the laser beam has from other light sources such as low diffraction, brightness, static and high directivity, as well as some other known physical characteristics such as reflection, refraction, diffraction, absorption and transmittance, all these qualities make laser an important and advanced technology in common use **[7].**

1- Previous studies :

1- In 2001, researcher Alaa Khudair Hashem Al-Rubaie studied the liquid crystal behavior and electrical properties of new classes of Schiff base twins and their complexes, and prepared ten compounds from Schiff bases derived from benzene. The study also found that the continuous electrical conductivity of Schiff base and its liquid metal complexes increases with increasing temperature **[8]**.

2- In 2005 The researcher Hadeel Kazem Muhammad studied the preparation and diagnosis of electrical properties in a new type of polymeric liquid crystals containing coronal ethers. Then the liquid crystalline phases and the isotropic state appear, and the increase in the thermal range of the nematic phases shown by the prepared polymers, which helps in using them for various industrial purposes, and through the properties that have been reached for the polymers, they can be considered as liquid crystals that can be used in the field of electronics, as photoelectric materials, as carriers and sensors **[9].**

3- In 2004, the researcher Sanaa Riad Musa Al-Khuzai studied the performance of the laser diode system to measure the distance of the body, where a semiconductor laser was used to measure the distance of a specific object from the laser with the help of light returned from the body to the laser. The distance between the laser, semiconductor and the body does not exceed tens of centimeters, The researcher relied on measuring the distance with the help of the computer, and by treating the changes that occur in the laser parameters with the program in (Matlab) called (Fast Fourier Trans for mation) and the symbol (FTT) because of the small distance that cannot be measured practically by calculating the super time behind the rule The laser can sense these variables **[10]** .

4- In 2019, the researcher (Soo suh young) studied laser sensors to measure distance, displacement and position, which in turn depend on many different types of optical technologies such as time of flight, confocal sensors, triangulation sensors, and laser interferometry. Fields including biomedical fields, monitoring, autonomous driving and robotics, in confocal sensors the laser light falls on the target and the light is reflected from the target and is detected through the aperture when the target is on the focal plane, and the intensity of the reflected light becomes large, using this property can measure the distance To the target with extreme accuracy, for example, an accuracy of 0.01μm at a target distance of 6mm for the sensor used **[11] .**

This study differs from previous studies by using liquid crystals as a temperature sensor by the origin of the laser rays reflected from the body whose temperature and the limits of the safe point are measured.

2- Equipment and method of work:

2-1 Semiconductor laser: The semiconductor laser or diode laser is a semiconductor material that converts current into monochromatic electromagnetic radiation.The semiconductor laser is one of the best types of lasers in terms of conversion efficiency, which is estimated in the range of 40% -30 % of pumping capacity **[12].**

The probability of the electrons being in an energy level (E) in the equilibrium state is expressed in terms of the Fermi-Dirac distribution and according to the following equation**[13]**:

$E(f) = \frac{1}{1+E^{(E-F)/KT}}$ absolute temperature...... (1) T whereas absolute temperature .

Whereas, F is the Fermi level that falls within the energy gap of the Fermi level. Also, this level is characterized by the following considerations at absolute zero, T= 0 and for the values of F < E, that is, for the conduction band to be F= 0, F > E is F=1 meaning that this level represents one Between completely empty energy levels and completely filled levels at the absolute zero degree, that is, the conduction levels are completely empty and the valence levels will be filled. At this stage, the semiconductor is an electrical insulator, at a temperature above absolute zero (T > 0) some of the electrons are in the range The conduction leaves behind electronic gaps (minutes with a positive charge) in the valence band and thus an electric current flows between the two bands **[14].**The reverse rehabilitation process in semiconductor laser requires that both layers are P-N insoluble and the dissolution takes place in both levels if the rate of doping is very high. In semiconductor the change in energy levels is given by the following relationship**[15]:**

$\Delta f = eV_b$ 2

As e is the electron charge Vb the barrier potential, and as a result the rendezvous region will contain a high concentration of electrons in the conduction beam and a high concentration of holes in the valence beam. Thus, the inverse rehabilitation is achieved, that the electrons and holes recombine and emit energy in the form of a photon whose energy is given by the following equation **[16] :**

$\Delta f = E_g$ 3

Since the wavelength equation is :

Thus, the wavelength of the photon resulting from the process of combining electrons and holes, measured in micrometers, is equal to **[17]:**

$\lambda = hc / E_g$ 4

The principle of semiconductor laser work depends on the projection of an electric potential through the laser diode, it works to move each of the electrons and holes to enter the junction region, and this process is called the injection of carriers **[18] .** that the electric force required for this process is about the size of the energy gap, i.e. approximately 1.5V**[19],** and it is known When electrons combine with holes, the total energy is released as a photon whose frequency is given according to the following Planck equation **[20] .**

$h\upsilon = E_2 - E_1$ 5

2-2 Using Thermotropic Liquid Crystals :

This type of liquid crystals depends on the temperature and the amount of change in it, so it is called the heat-catalyzed intermediate phases. Compounds are called polyphasic intermediates, and the reflection of the formation system of these intermediate phases occurs upon cooling, and such type of liquid crystalline phases that appear during heating and cooling are called enantiotropic, As for the crystalline phases that appear in one state upon cooling or heating, they are called monotropic **[5].** And the regularity scale of molecules depends on the temperature, and the regularity scale of molecules can be expressed by the regularity coefficient and can be represented by the following equation **[21]:**

$$Ś = \frac{1}{2}\ (3cos^2\theta - 1)$$

Since θ represents the angle between the arrangement of the molecule and the vertical symmetry axis, And the value of the regularity coefficient Ś is equal to 1 right in the crystalline state and equal to zero in the liquid state, as for the value of the regularity coefficient for liquid crystals, it ranges between 1 and zero, because when the molecules fuse, they arrange less Regularity in the crystalline state, and the irregular state increases with increasing temperature.

alignment of the tools in the practical part **:**

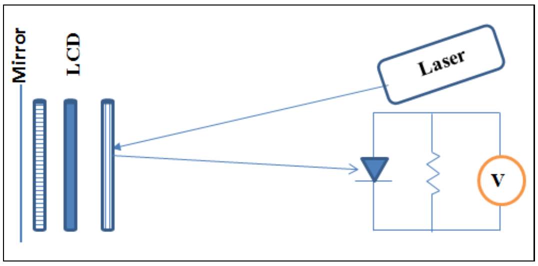

Fig. 1: shows the alignment of the tools in the practical part

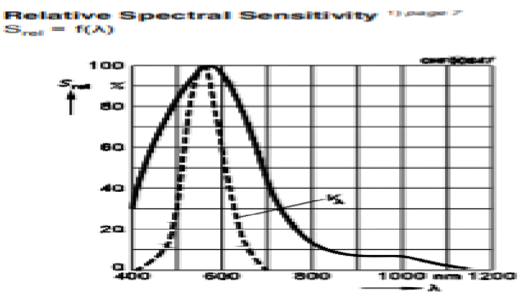

Fig. 2: shows the relationship between wavelength and sensitivity of the detector

3- The method of work:

Green and blue semiconductor lasers with power ranging from <200mw±10, <50mw±10, respectively, was used. The laser and the detector were placed at a distance of half a meter (0.5m) from the screen that contains two polarizing plates. The method of installation was on a plastic table, and the detector was connected to a voltage reader to take a reading. Voltage via connecting wires and the reading was taken at (2000mV) , Take the aluminum piece of flat circular shape and install the electronic piece (TEC1-12715) on it, which contains a positive electrode on one side and a negative electrode on the other, and the hot end of it is fixed inward and the cold end outward using EPOXY, so we have a hot end and a cold end For a circular piece of aluminum And then the other rectangular piece of aluminum was installed on the hot end of the electronic piece (TEC1-12715)) as well as using (EPOXY), and finally the screen was fixed on the rectangular aluminum piece by (EPOXY), and the screen was connected to a thermocouple (temperature reader device). It was connected to a power supply device via connecting wires, then the power supply was connected to an electrical source and the voltage was gradually raised until the sample was heated (the screen containing LC).

The amount of voltage supplied to the sample (screen) ranged from (0.5-5V), after a period of time this sample begins to heat up and the blackness begins clear to the screen (sample) when the thermocouple temperature reaches 57C° and upwards, a small circular black spot appears and the size of this circuit begins to increase as the The temperature increased and the entire sample (screen) prevailed when the temperature reached 70C.

A semiconductor laser beam was shed at a distance of half a meter (0.5m) from the screen after disconnecting a device equipped with power (voltage from the source). In the form of electrical energy represented by the voltage shown by the voltage-reading device, and the amount of this heat can be calculated by extracting the lighting current of the detector using Ohm's law $R = \frac{V}{I}$, Where the amount of resistance used is 10K Ω, which was connected to the detector through connecting wires and connected to a voltage reader device, then the readings were taken gradually to the temperature and in a descending manner from 70 – 30 ℃, and at each reading of two degrees descending, the sensitivity of the detector to the reflected laser radiation loaded with a part of the The temperature, after decreasing the temperature to 50 ℃ after which the reading was made for each 5 ℃ descending to 30 ℃, I repeated the same previous steps for a distance of one meter and one and a half meters and two meters and took all the readings for these distances.

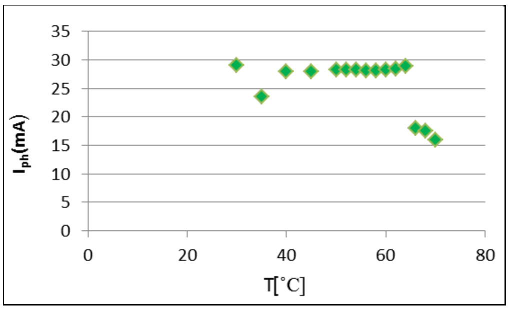

Fig. 1: shows the relationship between light current and temprerature by using agreen laser for adistance of half ameter

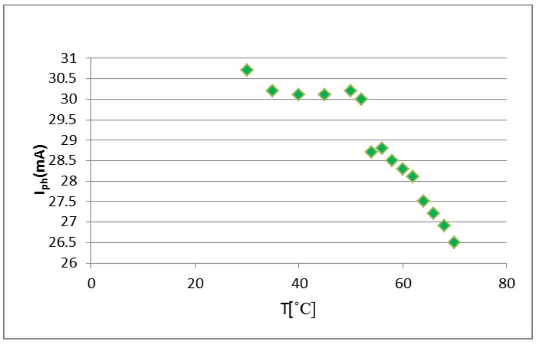

Fig. 2: shows the relationship between light current and temprerature by using agreen laser for adistance of one ameter

It can be seen from Figure 2 that the light current coming from the detector No. BPW21 took the value 30**.7** mA at a temperature of 30°C to 26.5 mA at a temperature of **70**°C, which produces the following equation:

Y = 34.463 – 0.1051X

R^2 = 0.86

As for R^2 it represents the ratio of the effect of temperature T [°C] on the photocurrent I_{ph} and for all the graphs below .

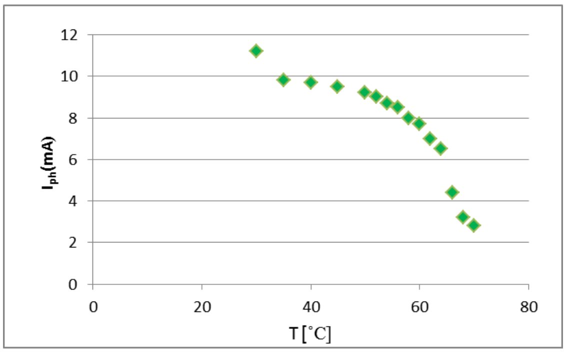

Fig. 3: shows the relationship between light current and tempreprature by using agreen laser for adistance of one ameter and a half

It can be seen from Figure 3 that the light current coming from the detector numbered BPW21 took the value 11.2 mA at a temperature of 30 °C to 2.8 mA at a temperature of 70 °C, which produces the following equation

Y = 17.492 – 0.1817 X

R^2 = 0.78

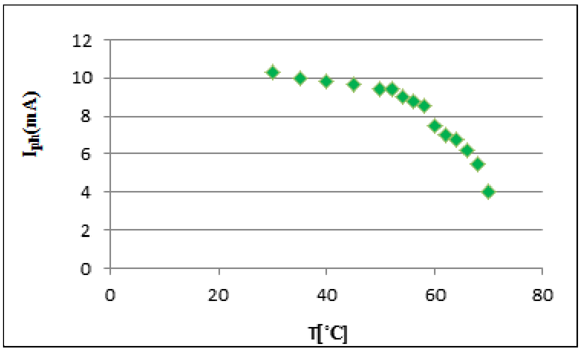

Fig. 4: shows the relationship between light current and tempreprature by using agreen laser for adistance of two ameter

It can be seen from Figure 4 that the light current coming from the detector numbered BPW21 took the value 10.3 mA at a temperature of 30 °C to 4 mA at a temperature of 70 °C, which produces the following equation

Y= 15.558 – 0.1376 X

R^2 = 0.78

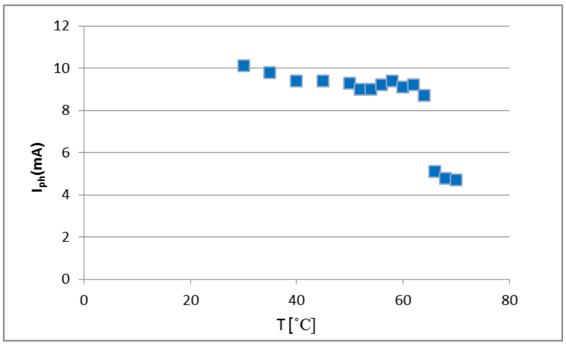

Fig. 5: shows the relationship between light current and tempreprature by using agreen laser for adistance of half ameter

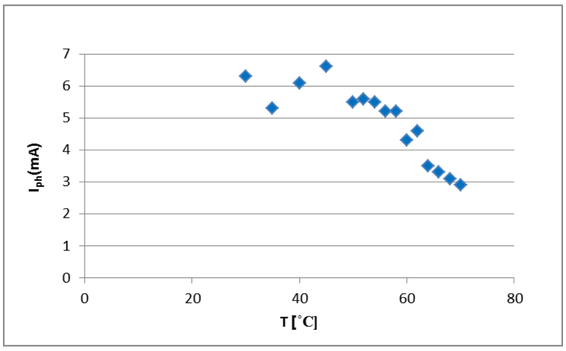

Fig. 6: shows relationship between light current and temperature by using ablue laser for adistance of one ameter

It can be seen from Figure 6 that the light current from the detector numbered BPW21 took the value 6.3mA at a temperature of 30 °C to 2.9 mA at a temperature of 70 °C, which produces the following equation:

Y= 9.3895 – 0.0838 X

R^2 = 0.72

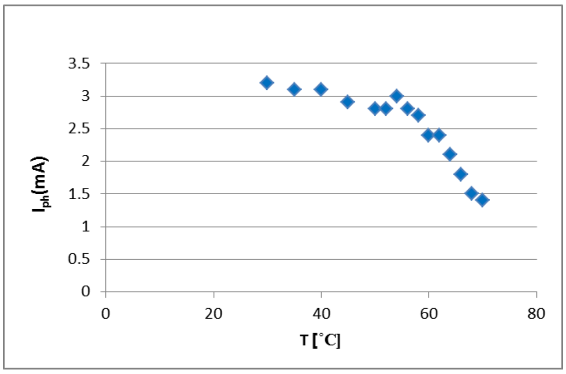

Fig. 7: shows relationship between light current and temperature by using ablue laser for adistance of one ameter and a half

It can be seen from Figure 7 that the light current coming from the detector numbered BPW21 took the value 3.2 mA at a temperature of 30 ℃ to 1.4 mA at a temperature of 70 ℃, which produces the following equation:

$Y= 4.7987 – 0.042 X$

$R^2 = 0.75$

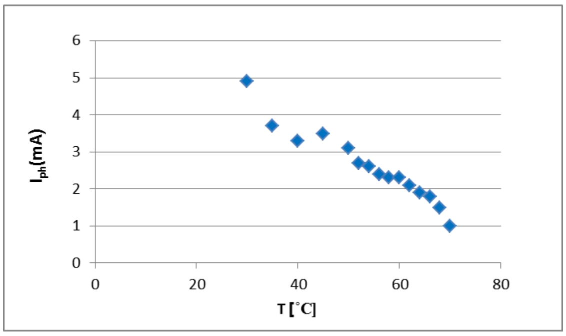

Fig. 8: shows relationship between light current and temperature by using ablue laser for adistance of two ameter

It can be seen from Figure 8 that the light current coming from the detector numbered BPW21 took the value of 4.9 mA at a temperature of 30 ℃ to 1 mA at a temperature of 70 ℃, which produces the following equation:

$Y= 6.8529 – 0.0786 X$

$R^2 = 0.94$

Results and discussion

For the purpose of knowing the temperature of the bodies, it was necessary we show the relationship between the temperature that can be possessed by many bodies in the range between 30-70 ℃, and the light current, which is part of the total heat of the body carried by the reflected laser beam and which is sensed by the detector in the form of a current phI photometric.

The results, using semiconductor lasers for different distances, showed that the relationship is inverse between temperature and photo current, as for a distance of 0.5 a meter we get a straight line, and then at a certain value the straight line takes a decreasingly curved shape and the relationship is not clear between temperature and light current, either The rest of the distances are for one meter and one and a half and two meters, The study showed that the change between current and temperature is more obvious.

Conclusions

From studying the tables and graphs obtained, we can conclude the following

1- The instability of the readings for a distance of half a meter is caused by the interference caused by the reflection and scattering of the laser light falling on the polarized plates and returning it to the detector.

2- As for larger distances represented by a meter, a meter and a half, two meters, it turns out that the change between the light current and temperature is more clear because the distance is far and the laser rays reflected from the polarizing plate to the detector have less impact on the detector .

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استخدام البلورات السائلة كمتحسس للحرارة بواسطة اشعة الليزر

هند صابر محمد ، ولاء محفوظ محمد

قسم الفيزياء ، كلية التربية للعلوم الصرفة ، جامعة تكريت ، تكريت ، العراق

الملخص

في هذا البحث تم اجراء دراسه عملية لقياس درجة الحراره للاجسام عن بعد باستخدام ليزر اشباه الموصلات Semiconductor laser، ومادة Thermotropic Liquid Crystals المتحسسه للحراره وذلك عند قيم مختلفة لدرجة الحرارة ابتدائا من 30°C الى 70°C ، عند كل قيمة من قيم درجة الحرارة يتم معرفة درجة الحرارة للاجسام عن طريق اشعة الليزر المنعكسة المحملة بجزء من حرارة ذلك الجسم المقاس .

بينت النتائج النهائية ان افضل قياس لدرجة حرارة الاجسام يمكن الحصول عليها وذلك عند المسافات الكبيرة مثل 1، 1.5، 2 متر حيث يعود ذلك الى ان اشعة الليزر المشتت اقل تاثيرا على الكاشف ، وهذا ما تم ملاحظته في الدراسة عند اخذ المسافات 1، 1,5 و 2 متر ، حيث تظهر الرسوم البيانية عند هذه المسافات استقرارية جيدة لشعاع الليزر المنعكس والمحمل بجزء من الحرارة للنقطة المنعكس منها والذي يراد معرفة درجة حرارتها والتي تشع حرارة ربما أكثر أو أقل من اجزاء الجسم الأخرى.

اما لمسافات اقل فتكون النتائج التي تم الحصول عليها من هذة الدراسة تفتقد الى الدقة وهذا ما اظهرتة الرسوم البيانية عند مسافة 0.5 متر وهذا يعود الى التشويش الناتج عن انعكاس وتشتت ضوء الليزر الساقط على الالواح المستقطبة وعودتها الى الكاشف .