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Movement Of Robotic Arm Using Graphene Mixed Polymer Based Nanocomposite Film

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Abstract: This work reports the possibility of using graphene mixed polymer nano composite film as sensors for robotic arm movement. The working principle behind the movement of proposed robotic arm is piezo resistive film. Functionalized graphene mixed Poly (vinylidene fluoride) (PVDF) based nanocomposite films were prepared using solvent casting technique. It works by attaching graphene mixed Poly (vinylidene fluoride) (PVDF) based nanocomposite film to printed circuit board. The components in the circuit board include a microcontroller, analog to digital converter, timer, IC LM29, and a DC motor. The output is then connected to the arm of the robot. Resistance across the nanocomposite film varies for corresponding variation in the manual load applied. The resistance variation, which is obtained in analog form, is converted into digital form using analog to digital converter and stored using Data Acquisition unit (DAQ). The obtained value is compared with the previous resistance value, which is already stored in the Data Acquisition unit (DAQ). If the newly obtained value is greater than previous value then the movement of robotic arm will takes place in forward direction. If the value obtained is less than the previous value then movement of robotic arm will take place in reverse direction. By using graphene mixed Poly (vinylidene fluoride) (PVDF) film for controlling robotic arm movement one can achieve better sensitivity and selectivity. Graphene based nanocomposite film can also be used to develop a pick and place robot since the movement of the arm can be precisely measured.

Introduction

In the modern era the usage of nanotechnology and robotics in various fields of engineering and medicine has increased rapidly. Nanotechnology leads to the design, synthesis and application of particles in the range of 1-100 nm[1]. Robotics is a technology, which reduces the human intervention and is particularly useful to access hazardous materials or materials in sophisticated ambience[2]. This work signifies the combination of robotics with nanotechnology. The usage of nano material is because of its superior properties compared to the same material in its bulk form[3,4].

Graphene based nano material is used due to its extra-ordinary electrical, physical and mechanical properties[5]. Graphene can be synthesized by the methods of arc discharge, chemical vapour deposition, mechanical exfoliation, chemical exfoliation and reduction of graphite oxide[6,7]. Single layer graphene can be obtained from chemical vapour deposition method and through the reduction of graphite oxide. Multi- layer graphene can be obtained by the process of chemical exfoliation, mechanical exfoliation and by arc discharge method[8]. In this work graphene mixed polymer nanocomposite films were used to form a variable resistor which is used as controlling device in the movement of robotic arm. The achievement of better sensitivity, selectivity and flexibility can be obtained in the movement of the robotic arm by the usage of the graphene mixed polymer film.

Experimental

The process consists of preparation, characterization and applying it for robotic arm movement. Initially pure form of functionalized graphene and pure PVDF were purchased commercially.

Preparation of Nanocomposite films

The various steps involved in synthesis of 3wt % graphene-PVDF Nanocomposite films are given in the schematic diagram[9,10] which is shown in Figure 1.The parameters involved in the synthesis of nano composite films like sonication time, magnetic stirring duration, temperature level need to be optimized inorder to get better result.

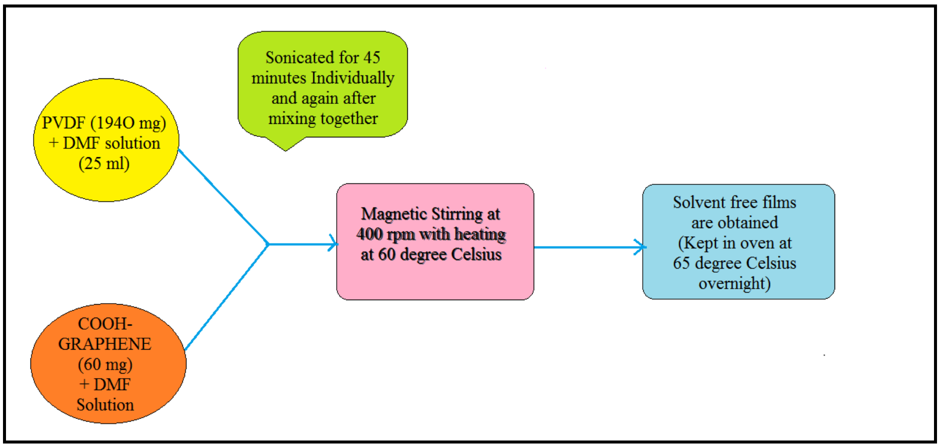

Figure 1: Steps involved in developing graphene-PVDF films.

Results and Discussions

SEM and EDX Analysis

Figure 2 shows a SEM micrograph of 3wt % graphene-PVDF films. Graphene were mixed uniformly over the PVDF matrix and a conductive network is being formed. SEM also reveals that microporosity and other defects are not found.

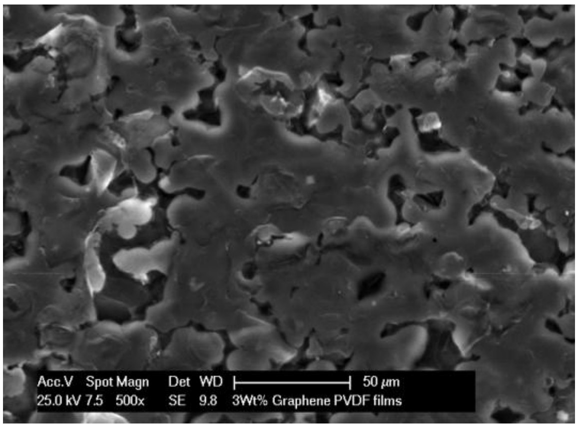

Figure 2: SEM micrograph of graphene mixed PVDF nanocomposite films

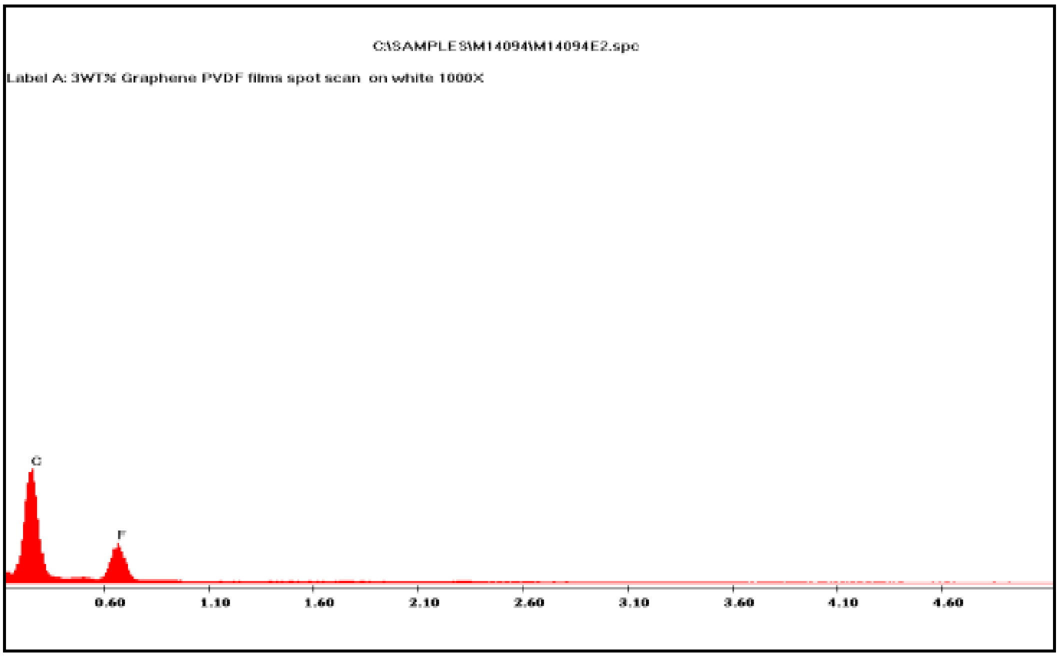

Figure 3: EDX micrograph of graphene mixed PVDF nanocomposite films

Figure 3 shows the EDX image of Graphene-PVDF films. EDX image pattern shows that carbon content is high in graphene-PVDF films. Fluorine concentration is also high next to carbon due to PVDF powder which contain fluorine in it.

XRD Analysis

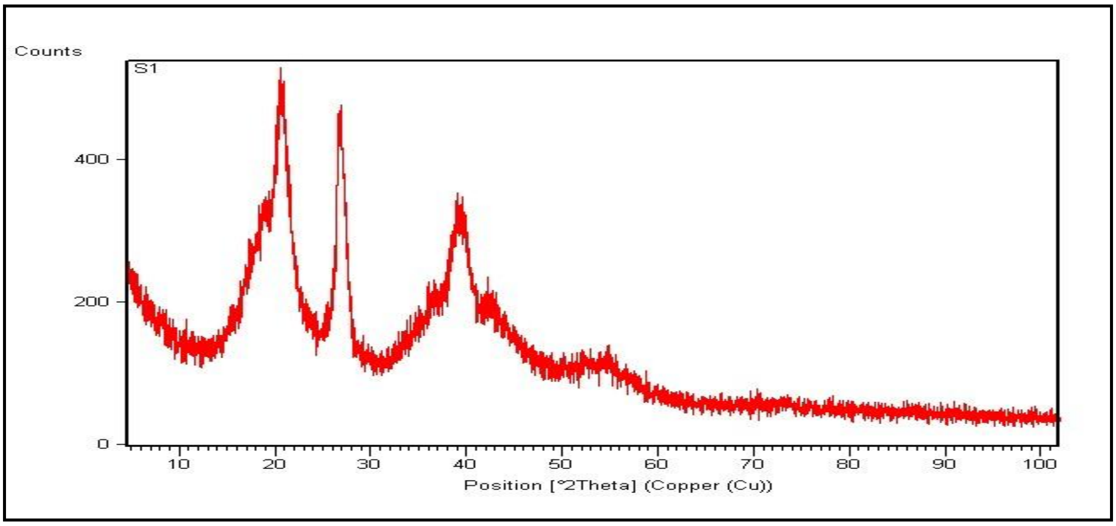

Figure 4: XRD image of graphene-PVDF films.

Figure 4 shows a XRD image which shows the presence of three peaks. The peak at 20.2 degree and 40.5 degree corresponds to PVDF (Poly (vinylidene fluoride)) and the peak at 20.6 degree represents graphene peak.

Robotic Arm Movement

The robotic arm movement takes place by interfacing graphene-PVDF based films with 8051 micro controller and components like analog to digital converter, 555 timer, IC LM29, and a DC motor. Graphene-PVDF film based sensor, 8051 microcontroller and all other interfacing component together constitute DAQ (Data Acquisition) unit.

Preparation of resistor using Nanocomposite film

The prepared nanocomposite film is taken in required dimension and two wire contacts are attached to the film by using silver epoxy. The method provides two wire contacts on the both sides of the film. Here silver epoxy is used in order to have better electrical contact between the wire and the film. The developed resistors will be piezo resistive in nature. Piezo resistivity is the property in which there exists a change in the electrical resistivity of the materials when some mechanical strain is applied.

Flow chart for robotic arm movement

Figure 5 explains the flow chart of movement of the robotic arm .The critical value of resistance should be stored in the DAQ unit[11]. Manual load is applied on the steel scale. It induces strain in the film, which leads to the change in the resistance of the film. The varied resistance is taken as the output and is passed through the DAQ unit. The output is then compared with the critical value. If the output value from the resistor is less than the critical value then the robotic arm movement takes place in the forward direction. If the output value from the resistor is greater than the critical value then the robotic arm movement takes place in the reverse direction.

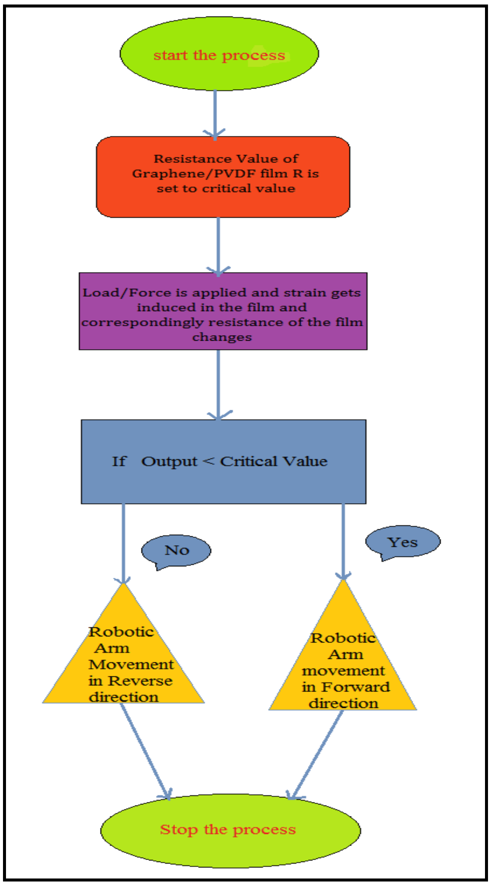

Figure 5: Steps involved in robotic arm movement

Construction of robotic arm with nanocomposite film

The circuit required to drive robotic arm movement is shown in Figure 6. The supply of 12V is obtained from the step down transformer. 12V AC supply is then converted to DC and then passed through a capacitor. Now this 12V DC is converted to 5V by using the voltage regulator[12]. This 5V is given as a supply for microcontroller[13]. The usage of capacitors in the circuit is to remove the external noise signals[14]. The film is attached to a steel scale and two wire contacts are provided on the film by using silver epoxy. The ends of the film are then connected to the 8051 microcontroller and to its peripheral[15] components such as LCD, IC 555, IC LM 29, analog to digital convertor. Since microcontroller is digital device and hence analog to digital converter is used to convert the analog data from the film to the digital data which is used as a trigger. IC 555 timer is used for timing the signals[16]. The voltage variations are displayed in the LCD. IC LM29 is used as a switching device and dc motor is connected to it. The direction of the motor rotation initiates the direction of movement of the robotic arm.

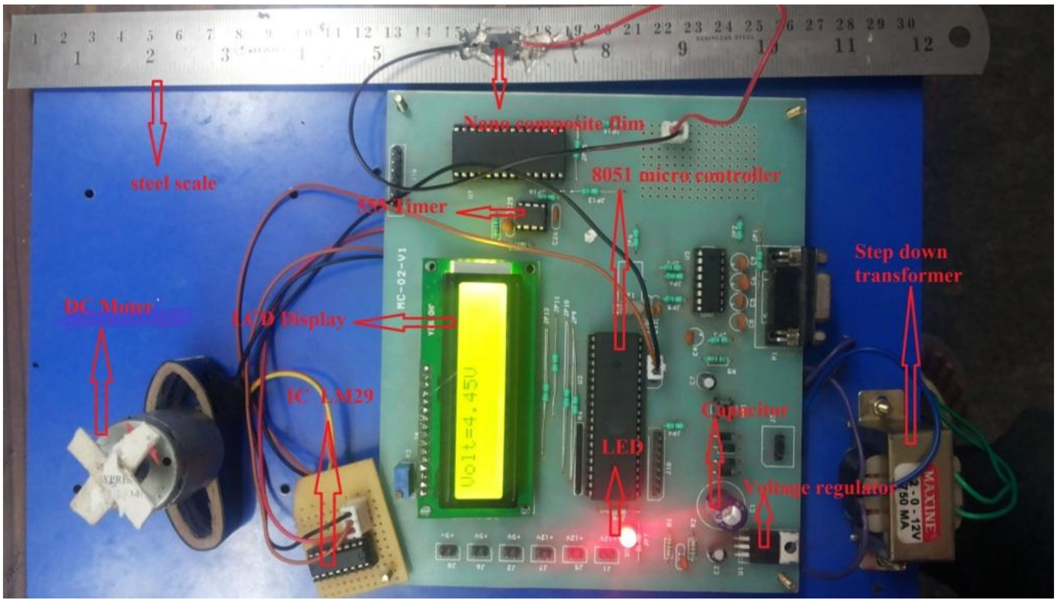

Figure 6: Circuit diagram showing Motor connected to nano composite based resistor

Working of robotic arm movement

The initial value of output voltage is stored in the DAQ unit. DAQ unit consist of sensors, signal conditioning and analog to digital converter. DAQ are controlled by software program, in this work embedded 'c' is used. There exists no variation in the output voltage when load is not applied on the film. When manual force is applied by bending the steel scale then there exits strain in the film and the resistance of the film gets decreased and the voltage drop reduces and the output voltage gets increased. Now the output voltage obtained is compared with the initial output voltage of the film. If the output voltage obtained is greater than the initial output voltage the rotation of motor takes place in forward direction which leads to the forward movement of the robotic arm. When the force applied is reduced then the strain obtained on the film gets reduced and the resistance value increases which increases the voltage drop and in turn decreases the output voltage. Now the output voltage is compared with the previous value. Here the output voltage is lesser than the previous value, the rotation of the motor takes place in reverse direction which leads to reverse movement of the robotic arm. The movement of the robotic arm mainly depends upon the microcontroller and its peripheral device IC LM29. The coding value responsible for the movement of robotic arm is embedded into the microcontroller with the help of embedded C fuzzy logics[17].

IC LM 29 as Switching Device

IC LM 29 is a pin that consists of 14 pins in which it is composed of four (Field Effect Transistors) FET[18]. It is comprised of two p-type FET and two n-type FET. The operation of the robot depends upon the set and the reset function of the FET. A motor is attached with the IC LM 29 which is responsible for the movement of the robotic arm. When the FET is given binary input 1 0 then the movement of the robotic arm takes place in the forward direction. When the FET is given binary input 0 1 then the movement of the robotic arm takes place in the reverse direction.

Conclusion

Graphene-PVDF films are shown to exhibit good piezo resistive properties, showing sensitive influence of applied strain on output voltage. This effect is made to good use for precise control for robotic arm movement as illustrated and discussed elaborately in the discussion. The robotic arm movement practised using nanocomposite based resistor has better sensitivity, selectivity, durability and portability. The film is also more flexible and hence can be used in the manufacturing of flexible electronic components. It can withstand high stress and its durability is high. The sensors can also find good use as touch sensors for robotics application.

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