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## APPLICATION FOR ADMISSION TO Ph.D. PROGRAMMES

Date of Application:29-06-2020

Department	MECHANICAL ENGINEERING	Application No.	20200168
Area of Research	COMPOSITES AND SENSORS	Research Mode	FULL TIME

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M.E.	MECHANICAL	MAHENDRA ENGINEERING COLLEGE	2017	7.5	1ST CLASS	REGULAR

Experience				
Organization	Designation	Experience From	Experience TO	Work Nature

Payment Details				
Transaction ID	Reference	Date of transaction	Amount	Status
20200168_200630144222	SHMP8947387485	30-06-2020	600	SUCCESS

# **A method to design highly reliable Piezoelectric nanogenerator based on Graphene/PVDF ink with good energy harvesting performance**

## **1. Abstract**

The various composites materials with high flexibility and electrical conductivity have been widely employed as a functional material in a flexible nanogenerator. It can be mounted on to the human skin or mesh into the clothing or e-skin. In this work, Polymer material especially PVDF and their nanocomposites have attracted more attention due to their good flexibility, high durability, and high thermal stability properties. The flexible piezoelectric nanogenerator was developed by Graphene/PVDF ink while the graphene acts as a nucleating agent to increase the electroactive  $\beta$  phase. The Graphene/PVDF ink was filled in between the PDMS substrate to make a sandwich structure film. Consequently, this device is capable of producing energy from accessible biomedical and human motion such as hand folding, jogging, walking, etc., and machine vibration.

## **2. Introduction**

Nowadays, the limitations of fuel availability and energy concerns have encouraged the study and development of new eco-friendly technology for accumulating energy from our human motion [1]. Several approaches have been developed to harvest mechanical energy from different sources such as human motions (talking, breathing, walking, etc.,) vibrations and hydraulic forces (blood flow) to power up various portable electronic devices [2-5]. Thus, the energy harvesting technology based on human motion has great concern due to its emergent trends to power up small electronic devices [6]. Recently piezoelectric nanogenerator has attracted great consideration for producing mechanical energy under different small mechanical actions. Moreover, the polymeric materials have excellent flexibility, compatibility, withstand higher mechanical deformation, nanomaterial formability which is suitable for polymeric nanogenerator. Therefore, the use of piezoelectric polymeric material in the nanogenerator has been developed rapidly.

Polymer materials, especially PVDF is one of the most important polymers which generate piezoelectricity when a mechanical force or pressure applied to it. PVDF polymer can harvest mechanical energy and output voltage/current signals through the piezoelectric effect. Accordingly, PVDF based nanogenerator with high durability, excellent sensitivity in small force and high electrical output is desirable. Depending on the chain conformation structure PVDF has four crystalline phases such as  $\alpha$  (TGTG'),  $\beta$  (TTTT),  $\gamma$  (TTTG'TTTG') [7]. Among them  $\alpha$  induced non-polar phases.  $\beta$  and  $\gamma$  polar phases highly desirable phases due to their piezoelectric properties. Above all phases,  $\beta$  is the most important due to the polarization of excellent piezoelectric properties [8-9]. There are several methods to induce the electro-active  $\beta$  phases to achieve the piezoelectric properties. The electrical poling process was used to

stabilize the polar phases in PVDF which done through the alignment of CH<sub>2</sub>/CF<sub>2</sub> dipoles to achieve better output performance. The various applications reported in the literature suggest that the flexible and easy to implement material is required as a sensor substrate. PDMS is a silicone-based elastomer to improve the piezoelectric applications including flexibility, bio-compatibility, permeability to water and low electrical conductivity.

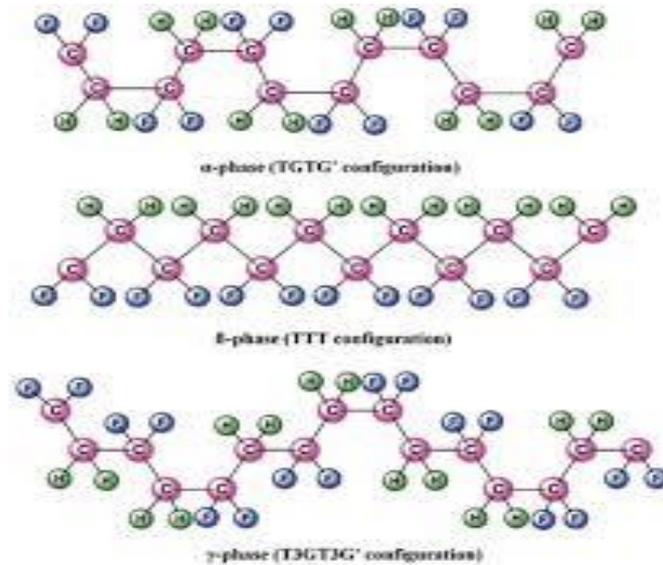


Fig 1.  $\alpha$ ,  $\beta$  and  $\gamma$  phase formation in PVDF material

### 3.OBJECTIVES

\* To design a Graphene/PVDF composite solution for improve the piezoelectric performance.

\* To design a Graphene/PVDF-PDMS nanogenerator sandwich structure for device application such as hand folding, jogging, walking, etc., and machine vibration

#### 3.1. Fabrication process of graphene/PVDF-PDMS nanogenerator sandwich structure

Initially, PDMS pre-polymer and its curing agent was mixed with the ratio of 10:1 and stirred well for 5mins. Then the resultant solution was kept at an oven for 15min to remove the air bubbles. The glass substrate was surrounded by the sticking tape, the dimensions of 50mmx30mmx2mm and the PDMS solution (layer 1) was casting on the substrate area and dried at 80°C for 4Hrs. Consequently, PDMS layer 2 was casted by following the same procedure before that the PLA Stamp was kept on the top of the PDMS layer 1. After fully cured, remove the PLA Stamp and fill the Graphene/PVDF ink then cure it for 30mins under 60°C for 1Hr. Moreover, the sticking tape was placed on the top of the already attached tape (2mm thick), then coated the PDMS solution (Layer 3) on the substrate area and kept 85°C for 4hrs. Finally, peeled

off the Graphene/PVDF-PDMS sandwich structure composite film from the glass substrate which was examined for the physicochemical properties and piezoelectric applications.

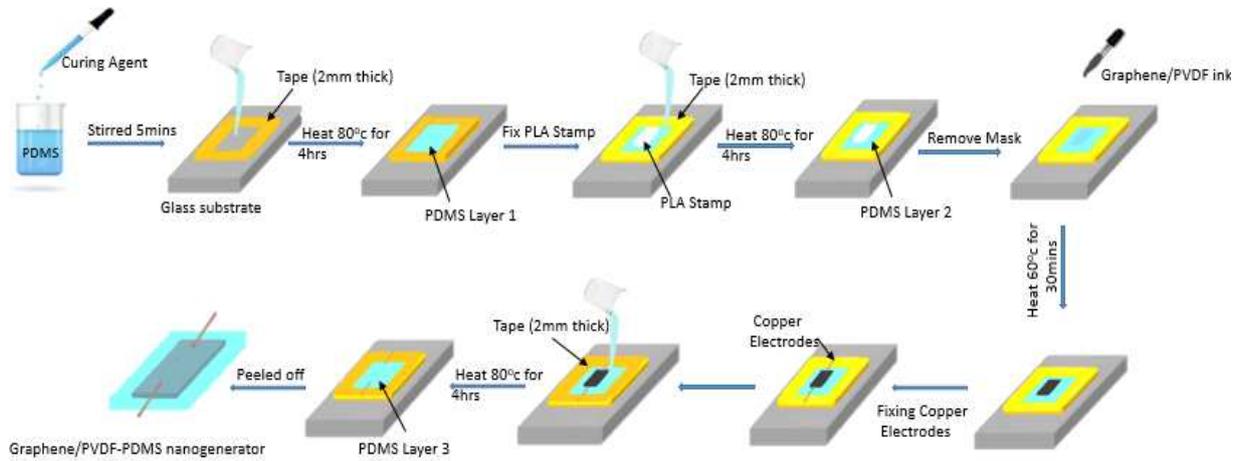


Fig.2. Fabrication process of graphene/PVDF-PDMS nanogenerator sandwich structure

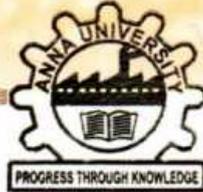
#### 4. Piezoelectric Measurement

The transmit pressure or load is an important factor for the generation of output voltage as the deformation of a sandwich structure depends on applied mechanical pressure. Therefore, we are measure the output signal generated from the Graphene/PVDF-PDMS nanogenerator by finger imparting and releasing conditions at different pressure and loading and unloading condition at a different frequency. Furthermore, different types of body movements are available in our daily life such as jogging, finger typing, running, walking, arm movements, eye blinking, blood flow, and heartbeats, The Graphene/PVDF-PDMS composite film exhibits the biomechanical energy for developing human-based self-powered devices. The prepared piezoelectric nanogenerator was placed below the foot and analyzed the electrical output for various movements including foot pressing, jogging and walking. Meanwhile, the device was attached above the throat to measure the electrical signal of swelling behavior and also to detect human breathing. The Graphene/PVDF-PDMS composite film was also employed to detect the signals of the masticatory movement and record the electric output under continuous chewing activities. The prepared device was fixed on the wrist to distinguish different kinds of wrist movements, including upward bending, downward bending, and torsion and analysis of the output voltage response. Finally, the stability and durability of the nanogenerator were tested under cyclic pressing and releasing with imparting frequency. The excellent stability of the devices is applicability as effective and robust energy harvester that might be very much appropriate for energy harvesting applications.

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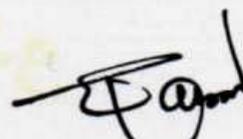
*The Syndicate of the Anna University hereby makes known that*  
**SATHISHKUMAR S** *has been admitted to the* **DEGREE OF MASTER OF ENGINEERING** *in* **COMPUTER AIDED DESIGN** *under the*  
*Faculty of Mechanical Engineering, having completed the prescribed*  
*programme of study through* **MAHENDRA ENGINEERING COLLEGE,**  
**NAMAKKAL** *an autonomous college affiliated to this University and having*  
*been certified by the duly appointed examiners to be qualified to receive the same,*  
*and has been placed in* **FIRST CLASS** *at the Examination held in* **MAY 2017.**

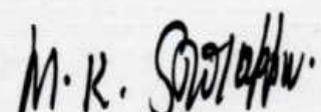
*Given under the Seal of the University*



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India  
June 2018  
CP/24/00002

  
Controller of Examinations

  
Registrar

  
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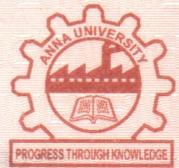
# MAHENDRA ENGINEERING COLLEGE

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## CONSOLIDATED STATEMENT OF GRADES

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 Branch : M.E - COMPUTER AIDED DESIGN  
 Regulations : 2015 MONTH AND YEAR OF COMPLETION : APR/MAY - 2017



Semester Number	Course Code	Course Title	Credits	Letter Grade	Grade Point	Month & Year of Passing
01	15CAD11101	APPLIED MATHEMATICS FOR ENGINEERING DESIGN	4	B	6	NOV-2015
01	15CAD12101	COMPUTER APPLICATIONS IN DESIGN	3	A	8	NOV-2015
01	15CAD12102	COMPUTER INTEGRATED MANUFACTURING	3	A	8	NOV-2015
01	15CAD12103	FINITE ELEMENT ANALYSIS	3	B	6	NOV-2015
01	15CAD13101	RAPID PROTOTYPING AND TOOLING	3	A	8	NOV-2015
01	15CAD13102	COMPOSITE MATERIALS AND MECHANICS	3	B+	7	NOV-2015
01	15CAD22101	CAD LABORATORY	2	A+	9	NOV-2016
02	15CAD12201	VIBRATION ANALYSIS AND CONTROL	4	B	6	APR-2016
02	15CAD12202	PROACTIVE CONCEPTS IN DESIGN	3	B+	7	APR-2016
02	15CAD12203	PRODUCT DESIGN AND DEVELOPMENT	4	A	8	APR-2016
02	15CAD12204	MECHANISMS DESIGN AND SIMULATION	4	B	6	APR-2016
02	15CAD13004	DESIGN FOR MANUFACTURE ASSEMBLY AND ENVIRONMENTS	3	A+	9	APR-2016
02	15CAD13007	DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS	3	A	8	APR-2016
02	15CAD22201	ANALYSIS AND SIMULATION LABORATORY	2	A+	9	NOV-2016
03	15CAD13010	ENTERPRISE RESOURCE PLANNING	3	A	8	NOV-2016
03	15CAD13011	INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS	3	A	8	NOV-2016
03	15CAD13018	PRODUCTIVITY MANAGEMENT AND RE-ENGINEERING	3	A	8	NOV-2016
03	15CAD34301	PROJECT WORK -PHASE-I	6	A+	9	NOV-2016
04	15CAD14401	PROJECT ELECTIVE	3	A	8	APR-2017
04	15CAD34401	PROJECT WORK -PHASE -II	12	A+	9	APR-2017

CUMULATIVE GRADE POINT AVERAGE (CGPA) : 7.85

-- END OF STATEMENT --

CLASSIFICATION : FIRST CLASS

Medium of Instruction : English



Mallasamudram - 637503

Date : 14 - Jul. - 17

SIGNATURE OF THE CANDIDATE

CONTROLLER OF EXAMINATIONS



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(AUTONOMOUS)



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ISO 9001 : 2008

## TRANSFER CERTIFICATE

S.No. : 0976 / 17

Admission No. : 151210

1. Name of the Student : SATHISHKUMAR S
2. Name of the Parent / Guardian : SUBBURAJ R
3. Nationality / Religion : INDIAN, HINDU
4. Caste / Community : VADUGAN, BC
5. Sex : MALE
6. Date of Birth as entered in the Admission Register (in figures & words) : 09/05/1992  
NINETH MAY NINETEEN HUNDRED AND NINETYTWO
7. Date of Admission : 29/08/2015
8. Class in which student was studying at the time of leaving : FINAL YEAR M.E. COMPUTER AIDED DESIGN
9. Whether Qualified for Promotion to Higher Class : REFER THE STATEMENT OF MARKS
10. Date on which the student actually left the college : 24/05/2017
11. Date of Application for Transfer Certificate : 25/05/2017
12. Date of Transfer Certificate : 25/05/2017
13. Conduct and Character : GOOD



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Note : Erasures and unauthenticated or fraudulent alteration in the certificate will lead to its cancellation.  
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GOVT. OF INDIA

SATHISHKUMAR

SUBBURASU

09/05/1992

Permanent Account Number

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Signature



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இந்திய அரசாங்கம்

Government of India



சதிஷ்குமார் சுப்புராஜ்

Sathishkumar Subburaj

தந்தை : சுப்புராஜ் ராமசாமி நாயக்கர்

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பிறந்தவருடம் / Year of Birth : 1992

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