ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 12, March 2017

DESIGN AND DEVELOPMENT OF KNOCK SENSOR FOR AUTOMOBILE APPLICATION

M.MARI ALIAS ESAKKI KUMAR[a], Dr.R.BALAJI[b], J.AJAY DEEPAK[c]
[a]Junior research fellow, Centre of Nanoscience and Technology, Sathyabama University, Chennai-600119.
[b] Associate Professor ,Department of physics, PSG college of Technology, Coimbatore
[C] Department of Electronics and Communication Engineering, PSG college of Technology, Coimbatore
E-mail:mariesakkikumar@gmail.com, contact number: - +91 8489535444.

ABSTRACT

Current scenario in automobiles largely circumferences around sensors for avoiding malfunction of the system. In particular, engine sensors are looked up as the heart of sensors network since engine is the key component of the system. Engine knock sensor senses the improper ignition and channelizes the problem to ECU. Mostly piezoelectric sensors are the most sought option for this type of applications. In this work we aim at developing a nano composite based piezo electric material ($PbZrTio_3$) with high sensitivity. Lead Zirconium Titanate nano particles were synthesized by the modified sol-gel method in aqueous PEG solution. The properties of PZT-NPs were studied as a function of different calcinations temperature. The synthesis and characterization of the nano composite are elaborated. The fabricated nano composite PZT sensor is checked for its sensitivity using piezo meter.

Key Words: Knock Sensor, PZT, Sensitivity

1. INTRODUCTION

Piezoelectric materials that transfer mechanical energy to electrical energy were widely used for electromechanical transducers. PZT-PVDF piezoelectric composites show many advantages over bulk piezoelectric ceramics: lower acoustic impedance (Z), higher coupling coefficient (Kt), lower mechanical quality factor (Q_m) and dielectric loss (tan δ) and better design flexibility. Structures using smart materials such as piezoelectric materials have potential applications in many areas, especially in controlling vibration, energy recovery on a vibrating structure and acoustic transducers. Piezoelectric ceramic and composite materials have been widely used in electromechanical actuators and sensors, given their high piezoelectric performances. However, piezoelectric ceramic demonstrates a brittle behavior and is very sensitive to cracking. The properties of piezo electric nano composites depend of numerous parameters such as fibre volume ratio, matrix properties and especially the PZT fibre/matrix interfaces. Consequently, the piezoelectric and mechanical properties can be tuned in relation to the desired application. Piezoelectric nano composites of a polymer matrix loaded with piezoelectric ceramic powder such as (PZT) and $PbTiO_3$, $PbZrO_3$. In this type of composite, the particles are not in contact with each other and the polymer phase as self connected in all three dimensions. One of the most attractive features of PZT-PVDF composites is their versatility in assuming a verity of forms, including thin sheets, extruded bars and fibers. This type of composite is also easy to fabricate and capable of mass production.

PZT nano powder was prepared by co-precipitation from an aqueous solution of lead acetate, titanium (IV) isopropoxide and zirconium Nitrate. The synthesized PZT nano powder will be characterized by using SEM & EDX. To prepare the composite, PZT powder was dispersed in a PVDF gel polymer and then mixed by using magnetic stirrer. The nano composite will be made into a pellet shape by using hydraulic pellet press. The fabricated pellet was convert into require design by using Nd-Yag laser micromachining. Then the pellet was sintering by using high temperature furnace. The fabricated pellet has been involved in poling process

The process of poling involves aligning of all these individual dipole moments, so that they all point in the same general direction. This is accomplished by putting the crystal in a constant electric field to force the dipoles to align. In the electric field each dipole will feel a torque if it is not parallel to the field lines produced, and so is turned to that direction. When the electric field is removed, the dipoles remain fairly aligned, although there will still be some element of random direction. Then

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 12, March 2017

piezoelectric coefficient and capacitance will be determined by using piezo meter.

The nano composite piezoelectric pellet was used in automobile sensing application. In automobile vehicles plenty of sensors are used, but we are focused on engine knock sensor. Engine knock occurs in engine cylinders because of improper ignition timing or faulty components. Modern cars incorporate knock-sensor systems for engines to minimize knocking, which can maximize engine lifetime, increase power, and improve fuel efficiency. Engine knock, or detonation, is uncontrolled ignition of pockets of air and fuel mixture in a cylinder in addition to the pocket initiated by the spark plug. Engine knock can greatly increase cylinder pressure, damage engine components, and cause a pinging sound. In normal combustion, an internal-combustion engine burns the air and fuel mixture in a controlled fashion. Combustion should start at a few crankshaft degrees prior to the piston passing the top dead center. This timing advance is necessary because it takes time for the air and fuel mixture to fully burn and it varies with engine speed and load. If timed correctly, maximum cylinder pressure occurs a few crankshaft degrees after the piston passes the top dead center The completely ignited air and fuel mixture then pushes the piston down with a great force, resulting in the maximum torque applied to the crankshaft for each cycle.

In their work involves three major areas such as Preparation of Nano composite Sensing Element, Fabrication of Fixture of sensor ,Microcontroller based Signal Conditioning Circuit for detect knocks in engine . Then the Fabricated sensor will be tested with the corresponding setup.

2. SYNTHESIS AND CHARACTERIZATION OF PZT NANO POWDER

This work involves three major areas such as Preparation of Nano composite Sensing Element, Microcontroller based Signal Conditioning Circuit, Design of Fixture of sensor. The PZT-NPs will be prepared by sol-gel synthesis process. The ratio of material will be taken as Pb: Zr: Ti, 1:0.52:0.48 respectively. Lead(II) acetate , $Pb(CH_3COO)_2$ (Aldrich, >99%), titanium isopropoxide, $Ti(OCH(CH_3)_2)_4$ (Aldrich, >97%), zirconium nitrate($Zr(NO_3)_4$), (LOBA, 70 wt.% in 1-propanol) and PEG (Aldrich, MW=600) used as starting materials. The lead solution will prepared by dissolving lead acetate in a minimum amount of citric acid and stirred for 30 min. 5% additional lead will added, in order to compensate for the loss of Pb in the subsequent thermal treatment.. The solution was stirred for 15 min to acquire a homogenous solution. Then, Zirconium Nitrate will be added to the solution and stirred at 70 °C for 30 min. The lead solution will be added to an equal volume of PEG. The mixture will then be cooled till ambient temperature and titanium isopropoxide will be added following the same procedure, and stirring will be continued until a milky colored solution was obtained. The sol will be placed in a closed flask for 24 hrs and then stirred at 90 °C for 1 h. Finally, the temperature of the solution was increased to 130 °C to achieve a clear yellow gel. As the process will be continued, the gel color gradually changed to dark brown. The temperature will be increased to 300 °C for 2 hours to produce a xerogel. This. In order to prepare the PZT-NPs, the nano powder will be calcinated at different temperatures of 600 °C for 2 hrs. The PZT-NPs will obtain from the different calcinations temperatures will characterize by using EDX and SEM.

To prepare the composite, PZT powder was dispersed in a PVDF gel polymer and then mixed by using magnetic stirrer. The nano composite will be made into a pellet shape by using hydraulic pellet press. The fabricated pellet was convert into require design by using Nd-Yag laser micromachining. Then the pellet was sintering by using high temperature furnace on 1200 °C. The fabricated pellet has been involved in poling process

The process of poling involves aligning of all these individual dipole moments, so that they all point in the same general direction. This is accomplished by putting the crystal in a constant electric field to force the dipoles to align. In the electric field each dipole will feel a torque if it is not parallel to the field lines produced, and so is turned to that direction. When the electric field is removed, the dipoles remain fairly aligned, although there will still be some element of random direction. Then piezoelectric coefficient and capacitance will be determined by using piezo meter. In Piezometer Study the output electric charge depends on the mechanical vibration frequency.if the frequency be not charge,the electrical output will be constant.otherwise the electrical charge will be changed.The sensitivity of the PZT/PVDF sensor obtained 8 PC/N.The figure Shows the Result of EDX. The Result of EDX tell about the presence of PZT in the form of nano level and its purity. The nano composite piezoelectric pellet was used in

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 12, March 2017

automobile sensing application. [8] proposed a principle in which another NN yield input control law was created for an under incited quad rotor UAV which uses the regular limitations of the under incited framework to create virtual control contributions to ensure the UAV tracks a craved direction. Utilizing the versatile back venturing method, every one of the six DOF are effectively followed utilizing just four control inputs while within the sight of un demonstrated flow and limited unsettling influences.

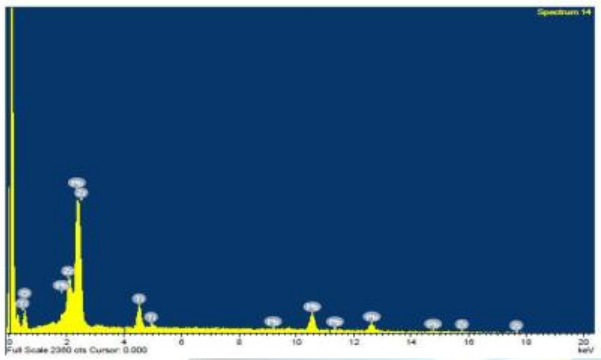

Fig.EDX Analysis

3. DESIGN OF FIXTURE OF SENSOR

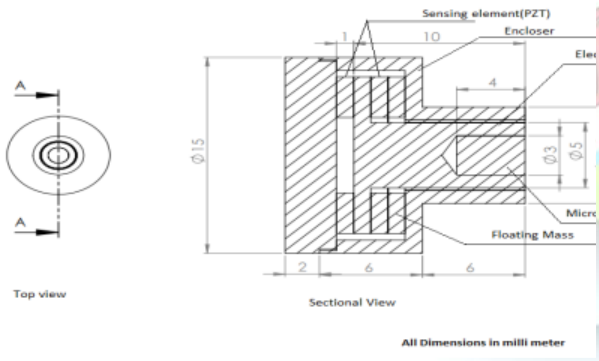

Fig. Design of Fixture of sensor

The design of fixture of sensor is done by using the tool autocad.The design can be tested in comsol multiphysics for high frequency application and it stable at maximum temperature of sensor outer casing material. The sensing element made be a ceramic,so it stand with higher temperature upto the limit of 1700 ^{O}C.

4. FABRICATION OF FIXTURE OF SENSOR

Fig. Enclosure

Fig .Inner Structure

Figure 1 show that the enclosure of knock sensor. The bottom part be connected to the enclosure of the engine. The inner structure, floating mass (seismic mass), connecting part shows in the above figure. Piezoelectric property says the mechanical energy is converted into the electrical property. knock, or detonation, is uncontrolled ignition of pockets of air and fuel mixture in a cylinder in addition to the pocket initiated by the spark plug. Engine knock can greatly increase cylinder pressure, damage engine components, and cause a pinging sound. In normal combustion, an internal-combustion engine burns the air and fuel mixture in a controlled fashion. Combustion should start at a few crankshaft degrees prior to the piston passing the top dead center. This timing advance is necessary because it takes time for the air and fuel mixture to fully burn

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 12, March 2017

and it varies with engine speed and load. If timed correctly, maximum cylinder pressure occurs a few crankshaft degrees after the piston passes the top dead center The completely ignited air and fuel mixture then pushes the piston down with a great force, resulting in the maximum torque applied to the crankshaft for each cycle. The output electrical signal denotes the knocks present or not present in the engine.

5. RESULT

The fabricated sensing element embedded with the fabricated fixture of sensor part. the overall tested in piezometer.In the piezometer changes in vibration (frequency) and the piezoelectric coefficient was changed.the figure indicates the piezometer and table indicates about changes of piezoelectric coefficient.

Fig.Piezometer

The piezometer vibration changes in the form of frequency and it may vary above the 50 Hz ,the piezoelectric coefficient will be changed in numerical.The piezoelectric voltage depends upon the piezoelectric coefficient and the developed voltage its manily depend on the vibration. So the changes of vibration also the corresponding voltage may changed.

S.no	Vibration(Hz)	Piezoelectric coefficient
1	100	35
2	150	36
3	200	37
4	250	38
5	300	39

Table:Piezometer Characteristics

6. CONCLUSION

In this study PZT nanopowder were successfully synthesized by sol-gel method. The EDX result proves the high amount of purity. Piezometer denotes the sensitivity of sensor. The overall conclusion this sensor is used to find the knocks present in the engine.

REFERENCES

[1]. Sangsubun, Chontira, et al. "Preparation of PZT nanopowders via sol gel processing." *CMU J. Special Issue on Nanotechnology* 4.1 (2005): 53-58.

[2]. Huang, Hsien-Lin, G. Z. Cao, and I. Y. Shen. "Hydrothermal synthesis of lead zirconate titanate (PZT or Pb (Zr 0.52 Ti 0.48) O 3) nano-particles using controlled ramping and cooling rates." *Sensors and Actuators A: Physical* 214 (2014): 111-119.

[3]. Zak, A. Khorsand, WHABD MAJID, and M. Darroudi. "Synthesis and characterization of sol-gel derived single-phase PZT nanoparticles in aqueous polyol solution." *Journal of Optoelectronics and Advanced Materials* 12.8 (2010): 1714-1719.

[4]. Fleming, William J. "Overview of automotive sensors." *Sensors Journal, IEEE* 1.4 (2001): 296-308.

[5]. Deutsch, Robert W., and David O. Potter. "System for monitoring and/or controlling multiple cylinder engine performance." U.S. Patent No. 4,936,277. 26 Jun. 1990.

[6]. Hammami, H., et al. "Experimental study of relaxations in unidirectional piezoelectric composites." *Composites Part A: Applied Science and Manufacturing* 37.1 (2006): 1-8.

[7]. Ahmad, Zeeshan, Ashutosh Prasad, and K. Prasad. "A comparative approach to predicting effective dielectric, piezoelectric and elastic properties of PZT/PVDF composites." *Physica B: Condensed Matter* 404.20 (2009): 3637-3644.

[8]. Christo Ananth,"A NOVEL NN OUTPUT FEEDBACK CONTROL LAW FOR QUAD ROTOR UAV",International Journal of Advanced Research in Innovative Discoveries in Engineering

and Applications[IJARIDEA],Volume 2,Issue 1,February 2017,pp:18-26.

[9]. Seema. A., K. R. Dayas, and Justin M. Varghese. "PVDF-PZT-5H composites prepared by hot press and tape casting techniques", *Journal of applied polymer science* 106.1 (2007): 146-151.

[10]. Choi, Jong-Jin, et al. "Preparation and characterization of piezoelectric ceramic–polymer composite thick films by aerosol deposition for sensor application." *Sensors and Actuators A: Physical* 153.1 (2009): 89-95.