Ga-ZnO/PVDF NANOGENERATOR

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Abstract-In this paper, we report piezoelectric Ga doped ZnO/PVDF nanogenerator for energy harvesting and sensing applications. Ga doped ZnO NPs are incorporated into PVDF polymer. Ga-ZnO NPs have been successfully synthesized by Solvent casting method. The fabricated film was characterized using XRD, SEM, EDAX, and FTIR. The fabricated nanogenerator is of size 3cm x 4cm. From energy harvesting point of view, the response of the nanogenerator due to fingertip impacts ranges from 60mV to 100mV

Keywords: Ga doped ZnO Nanoparticles (NPs) Polyvinylidene fluoride (PVDF), piezoelectricity

I. INTRODUCTION

Powering nano scale devices is the main challenge in the present day nanotechnology world. The potential power sources for nano devices are vibrational energy, mechanical energy, solar energy, hydraulic energy [1]. The miniaturization of portable electronic devices is very difficult without batteries. The problems associated with the use of batteries include limitation in the size of the device and frequent recharging process. However in place of batteries, if we adopt nanogenerators, mechanical energy is always available in and around us for powering these nano devices. Nanogenerator is a device which converts random mechanical energy into electrical energy to drive nano scale level devices Zinc Oxide (ZnO) is one of the promising potential materials for energy harvesting and sensing applications. ZnO is a semiconducting piezoelectric material having energy band gap of 3.37 eV and large excitation binding energy of 60 meV at room temperature [2]. It is a prominent material because of its structural, semiconducting, mechanical and piezoelectric properties. The advantages of ZnO are: it exhibits both semiconducting and piezoelectric properties, environmental friendly, biocompatible, growth occurs on large variety of substrate materials [1, 3].

ZnO is co doped with Galium which is p type dopant. Ga and ZnO have similar atomic radius, Ga is chosen to dope with ZnO because Ga is stable, results less distortion and improves the conductivity of ZnO material by release of free electrons from oxygen. PVDF (Polyvinylidene fluoride) is piezoelectric polymer and nontoxic, it has advantages of of mechanical flexibility, lower fabrication cost and faster processing compared to other polymers. It improves the piezoelectricity property when Ga doped ZnO NPs are incorporated into PVDF polymer and PVDF contributes the formation of thin film.

Various techniques are used for the synthesis of ZnO nanostructures such as physical vapour deposition (PVD), chemical methods, molecular beam epitaxy (MBE), pulsed laser deposition (PLD). Among these techniques, solution based chemical methods are more advantageous because they are simple, convenient, low cost, less hazardous, compatible, capable of large scaling up and growth occurs at relatively low temperatures [2].

The use of these nanogenerators for sensing applications further eliminate the requirement of batteries and make them single independent system. Hence, in the present work, we have reported piezoelectric Ga doped ZnO nanoparticles synthesized then incorporated into PVDF polymer which acts as substrate.

II. EXPERIMENTAL

A. Synthesis of Ga doped ZnO NPs by solvent casting method.

Stoichiometric amounts of respective Gallium and Zn nitrites are weighed (0.2:0.8) and transferred to clean conical flask and dissolved by using 25ml of distilled water. Zn and Gallium nitrites are stirred for 2 hr on magnetic stirrer at 50°C, a viscous liquid is obtained to which the fuel solution urea is added at 10 pH. Then, the above solution is mixed by using magnetic stirrer and heated at 100°C for 1 hr to get gel like material. So obtained gel material is calcinated around 500°C for 1 hr to get Gallium doped ZnO nano particles.

B. Synthesis of Ga-ZnO/PVDF film

Two weighed(0.4gm) percentage of PVDF solution is prepared by using Dimethyl formaldehyde (DMF) at 60°C and the solution is poured into petri dish(8cm diameter) and Ga-Zn0 Nano particles are added and ultra-sonicated using probe ultra sonicator and poured on petri dish followed by drying at 60°C for 12 hrs.

$$Zn(NO_3)_2{\bullet}6H_2O + CH_3OH \longrightarrow Zn(OCH_3)_2 + 2HNO_3 + 6H_2O$$

$$Zn(OCH_3)_2 + NaOH \longrightarrow Zn(OH)_2 + 2CH_3ONa$$

$$Zn(OH)_2 \longrightarrow ZnO + H_2O$$

$$Ga(NO_3)_2 + Zn(NO_3)_2 + Fuel \longrightarrow Ga_2ZnO_2 + CO_2 + N_2 + H_2O$$

After the fabrication of Ga doped ZnO/PVDF film, now the thin film is ready to use for the electrode contact purpose. Thin copper sheet of thickness 0.28mm used as top and bottom electrode of film. The schematic diagram and the actual photograph of the fabricated nanogenerator are shown in Fig. 1. And Fig. 2. respectively.

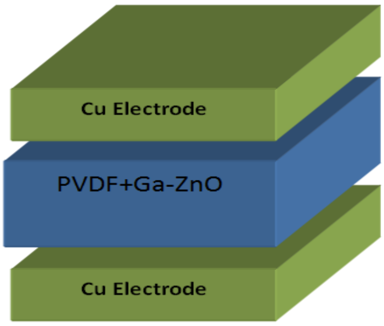

Figure. 1: Schematic diagram of nanogenerator

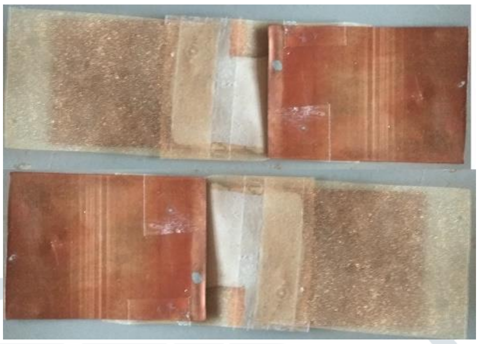

Figure. 2: Fabricated nanogenerator

III. RESULTS AND DISCUSSION

A. The morphology of Ga-ZnO/PVDF nanogenerator was observed using field emission scanning electron microscopy (FE-SEM). Fig. 3a shows the top view of the Ga-ZnO/PVDF nanogenerator

For 0.5% sample SEM results shows high dense of NPs and accumulated at certain area. For 1% sample, shows decrease in dense of NPs and started dispersing over entire area. For 2% sample results shows less dense and dispersed NPs.

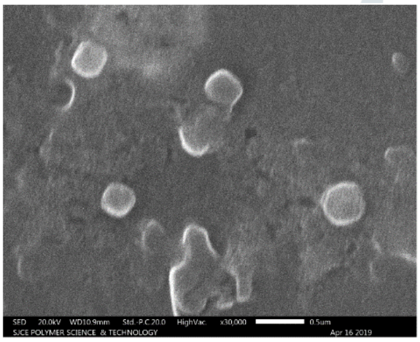

Fig 3a Top view of 0.5% Ga-ZnO/PVDF NG

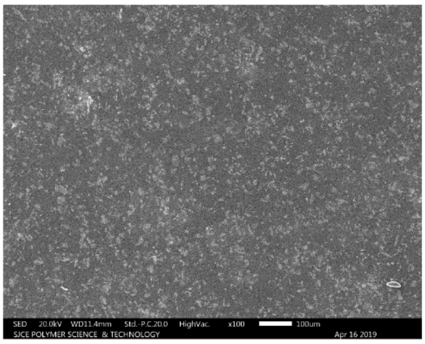

Fig 3b Top view of 1% Ga-ZnO/PVDF NG

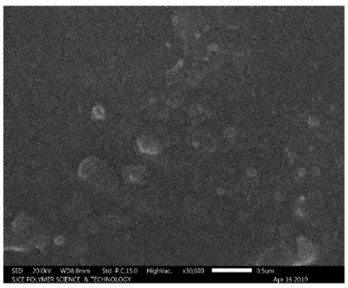

Fig 3c Top view of 2% Ga-ZnO/PVDF NG

B. Performance of Nanogenerator

The fabricated nanogenerator was directly connected to Multimeter. In order to see the suitability for energy harvesting application, dynamic force was applied on the nanogenerator using fingertip impacts. The typical response obtained from the nanogenerator due to the dynamic force of human finger impact is given in Fig. 4a-4d. The maximum output voltage produced for 0.5%, 1%, 2% Ga doped ZnO/PVDF Nano generator are 16mV, 18mV, 54mV respectively. For the sensing application point of view, 0.5% and 1% films are serially connected. When the films are serially connected output voltage of the film is increased, a total voltage of 74mV is produced.

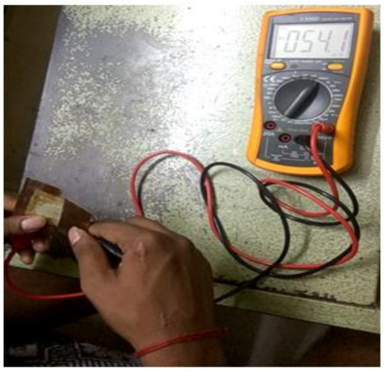

Fig 4a Output voltage of 2% Ga-ZnO/PVDF NG Fig 4b Output voltage of series 0.5% & 1% Ga-ZnO/PVDF NG

For testing, the film is pressed by finger as the repeating mode of the contact electrification method is used. The pressure exerted by fingers is measured and corresponding voltage is noted down. As the pressure increases the voltage output of the NG is also increases.

Pressure in Pa	Voltage in mV
1471.00	25
2451.66	52
3922.67	63
4855.65	74

Table 1 O/P voltage of series connection

IV.CONCLUSION

We have reported on the piezoelectric Ga-ZnO/PVDF nanogenerator. The different percentage doping of Ga in ZnO nanoparticles is performed by Sol-gel method and were characterized using FE-SEM. The response of the nanogenerator was studied due to human fingertip impacts. Results obtained indicate the potential application possibilities of the nanogenerator for energy harvesting and sensing applications. Besides, increasing work on Nano generators showed that providing flexibility to these devices will contribute to producing more ergonomic smart systems.

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