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RESEARCH ARTICLE

FABRICATION AND CHARACTERIZATION OF ZnO:3,4-DIHYDRO-2H-NAPHTHO[2,3-b] [1,4] OXAZINE-5,10-DIONE THIN FILMS FOR SOLAR CELL APPLICATION

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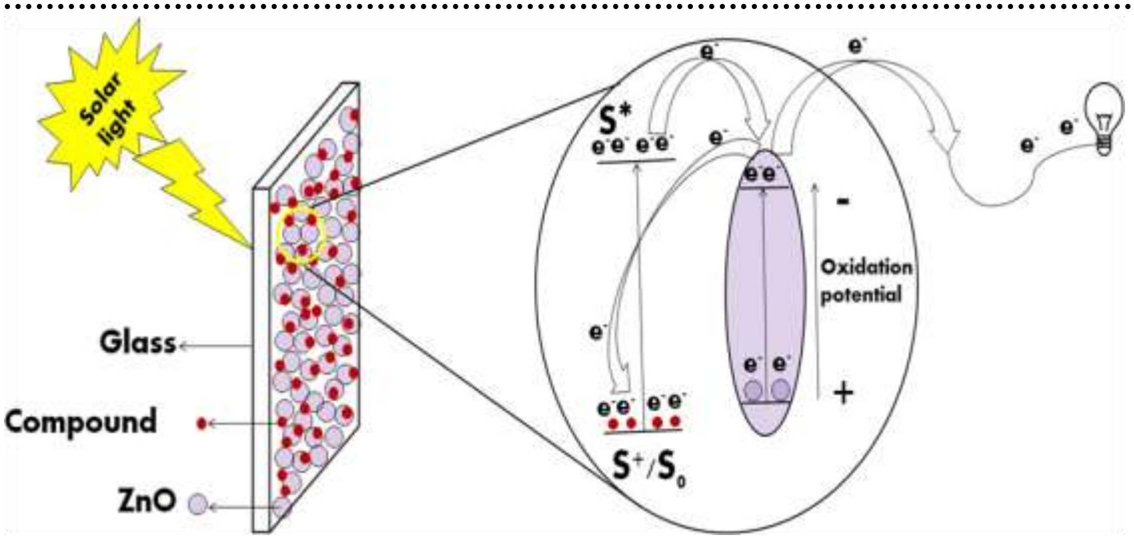
Abstract

The fabricated films were characterized by SEM, EDX and Powder x-ray diffraction (XRD) analysis also their electrical activities were tested for the solarcell application. The films **(1-5)** are tested for their solar cell application. **Film 4** shows minimum resistivity (ρ) value of $0.42X10^{-2}\Omega cm$ at 40% than that of the other films.



Introduction

Carbon Nano Tubes

Carbon nano tubes (CNTs), including single-walled CNTs (SWCNTs) and multi-walled CNTs (MWCNTs), have a high surface area, special physio chemical properties and excellent chemical and thermal stability. These unique properties inspire researchers to explore their potential in biological and biomedical applications, suchasbiosensors, culturesubstrates, and in particular drug

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delivery systems. Investigation of the bioactivities of CNTs not only facilitates their potential bio-applications, but also bene fits the risk assessment for human exposure to CNTs. Increasing reports have documented the biological activities of CNT both invitro and invivo. However, muchless work has been done the bioactivity of MWCNTs and their derivatives, especially their immune activity. SWCNTs and MWCNTs are shows slight cytotoxicity.

Functionalization of MWCNTs

In order to produce MWCNTs-COOH, the MWCNTs were sonicated with a mixture of HNO_3 and H_2SO_4 (3:1) for 24 hrs at room temperature[1] or refluxed for 1hr.[2] The carboxylic acid groups (MWCNT-COOH) in MWCNTs were converted to acid chloride (MWCNT-COCl) according to the reported procedure.[3]

ZnO-Organic Thin Films

In recent years, the scientific and technological interest on zincoxide thin films has increased phenomenally due to the novel physical and chemical properties reported in the literature. These findings make ZnO thin films good candidates for a wide variety of applications in opto-electronic devices, especially large area, cost-effective thin film solar cells. ZnO is one of the most promising semi conducting materials, suited for the fabrication of the next generation of optoelectronic devices and gas sensors. It is worth mentioning here that the detailed studies on the process parameters such as substrate temperature, doping level, concentration of the source material and aging time of the starting solution, etc., which play crucial roles in affecting the physical properties of the ZnO films, have contributed much to the development of the material.

Organic Solar Cells

Organic photovoltaic cells (OPVs) employing electron-donating (p-type) and electron-accepting (n-type) organic semiconducting materials for solar energy harvesting are a promising alternative to silicon solar cells due to their low cost, light weight, mechanical flexibility and solution processing.[4] With the increasing demands for clean energy, solar cells have become a fore most device for energy production. The use of solar cells to convert sun light energy to electricity is becoming rapidly extended but the cost of the existing technologies is far too high to compete on a large scale with the traditional carbon dioxide-producing energy sources. Therefore, the research to improve the efficiency of existing solar cells and to develop new cost-effective technologies has become a major focus of scientific and industrial activities. Dye-sensitized solar cells (DSCs)[5-7] and organic bulk hetero junction (BHJ) [8,9] solar cells have evolved to viable devices, with efficiencies above 12% and 8% respectively, and increasing stability on outdoor conditions.[10-12]

Experimental

SEM analysis

Morphology of the compounds were studied using the SUPRA 55–CARL ZEISS Field Emission Scanning Electron Microscope (FE-SEM) with Energy-dispersive X-ray spectroscopy (EDX).

Powder XRD analysis

The structural properties of the films were studied using x-ray diffractometer (PAN alytical-PW340/60X′ Pert PRO) with Cu-Kα radiation of wave length 1.5406Å.

UV measurement

The optical transmittance was recorded using a UV–vis NIR double beam spectro photometer (LAMBDA-35).

Film thickness measurement

The thicknesses of the films were measured using a profilometer (Surf Test SJ-301).

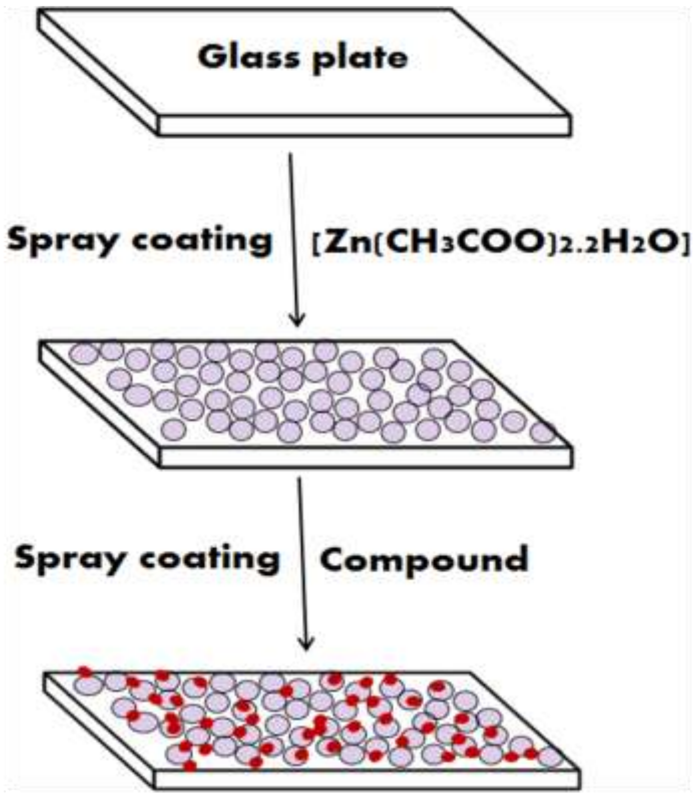
Electrical parameters measurement

The electrical parameters of the films were determined using the four point probe technique with vander Pauw configuration and Hall Effect apparatus (ECOPIAHMS-3000).

Result and Discussion

ZnO:3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione thin films

ZnO:3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione thin films (**1-5**) were obtained by employing a simplified and low-cost spray pyrolysis technique from solutions of zinc acetate dihysdrate [$Zn(CH_3COO)_2.2H_2O$] and suitable proportion of 3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione **(Scheme 1)**. The doping level of the solution was 10-50%.



Films	1	2	3	4	5
% of Compound	10	20	30	40	50

Scheme1 fabrication of thin films 1-5

SEM and EDX analysis of film 1

The Scanning Electron Microscopy (SEM) was employed to gain insights into the surface morphology of film **1**as shown in **Figure-1**. The SEM image of the film **1** shows spherical like morphology. The EDX spectrum of the film**1** (**Figure-2**) further confirms the presence of zinc in the film. The weight percentages and the atomic percentages of Zinc, Oxygen and Carbon, obtained from the EDX spectrum are given in **Table-1**. The zinc is present with a weight percentage of 6.70% and anatomic percentage of 1.60% in the film.

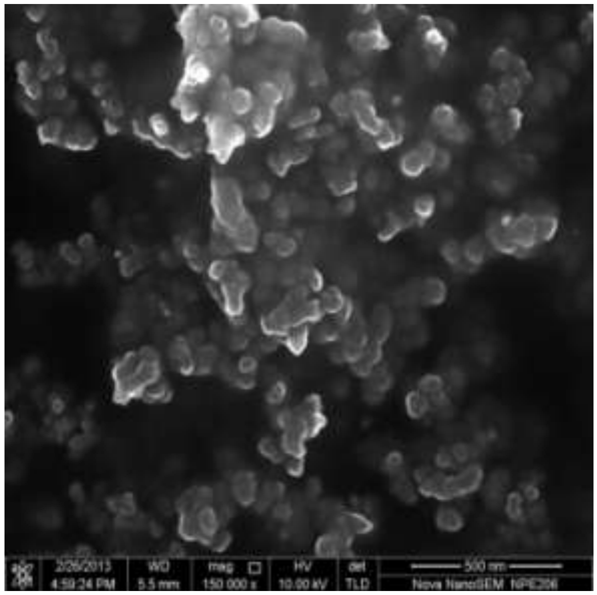


Figure 1 SEM image of film1.

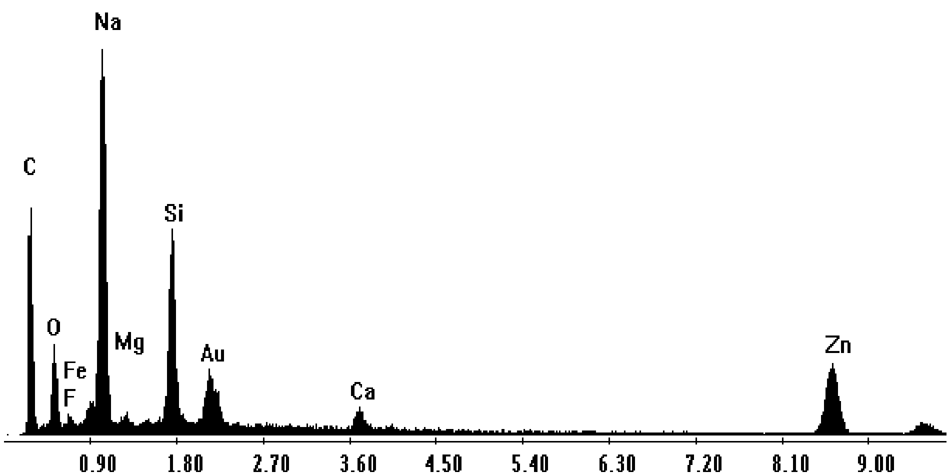


Figure 2 EDX spectrum of film1.

Table 1:-The weight percentages and the atomic percentagesofZinc,OxygenandCarbon.

Element	Wt%	At%
C	56.92	74
O	10.51	10.26
Zn	6.7	1.6

Powder XRD analysis of films 1-5

Figure-3 depicts the x-ray diffraction (XRD) patterns of undoped ZnO and ZnO:3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione films with various loading levels from 10 to 50%. The positions of all the diffraction peaks observed in these samples matched well with the hexagonal wurtzite structure of ZnO (JCPDS: 36-1451). From **figure-3**, it was observed that the ZnO:3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione films exhibits highly intense (002) orientation along with the (101), (102) and (103) orientations. Generally, in ZnO films, due to the minimization of the internal stress and surface energy, an easy growth could be achieved only along c-axis orientation i.e. along the (002) plane.

Solar cell application

All the fabricated films **1-5** are tested for their solar cell application with electrical studies. The addition percentage of 3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione, transmittance, film thickness, resistivity and absorption coefficients of the films are given in **table-2**. All the films are having almost equal transmittance percentage **figure-4** (98-72%) and the film thickness are 462-552nm.

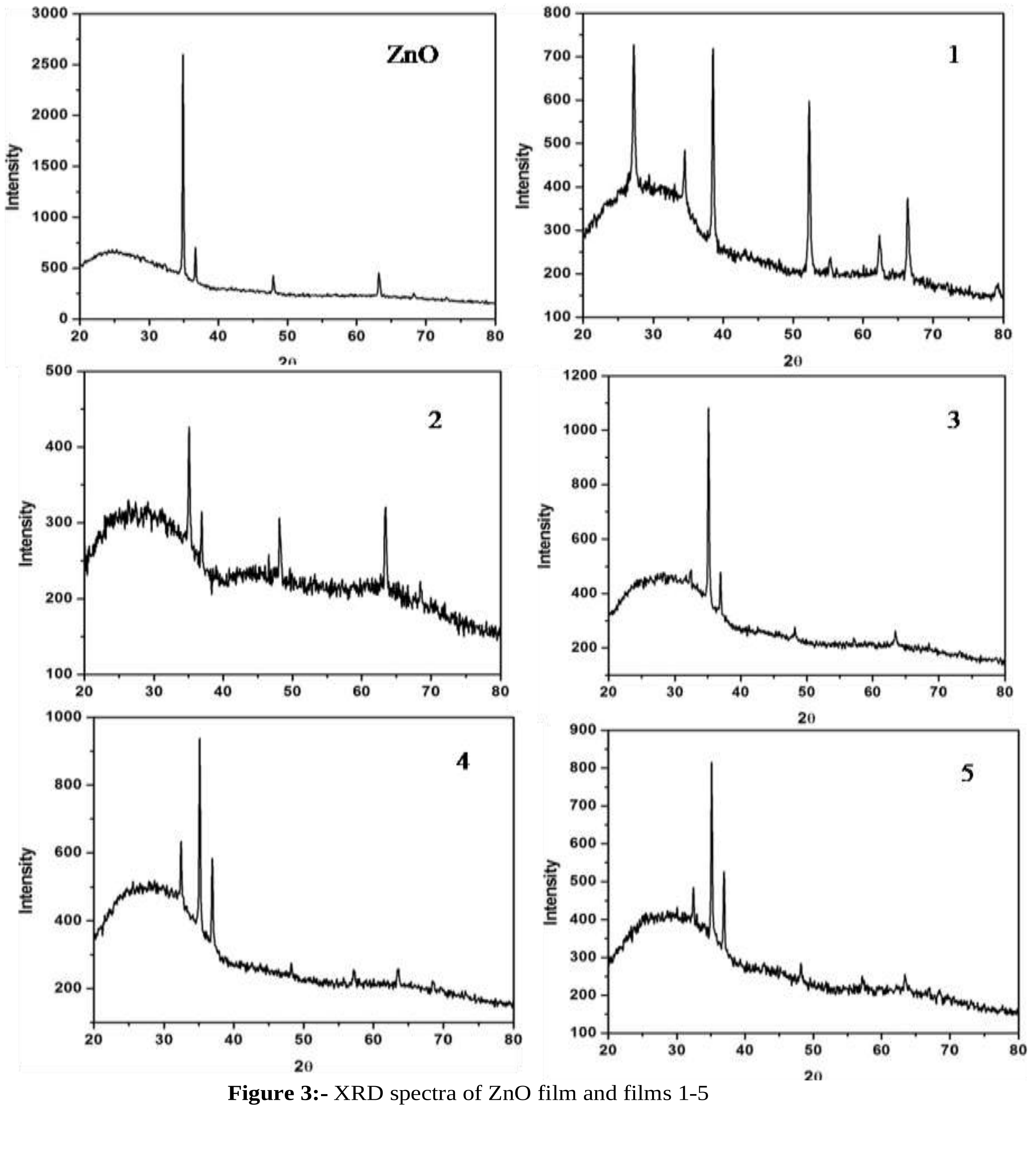


Figure 3:- XRD spectra of ZnO film and films 1-5

Table 2 Electrical properties of films 1-5.

Entry	% of compound	Thickness (t)	Transmittance (%)	Resistivity (ρ)	Absorption coefficients (-)
ZnO	0	462	98	2.56	2.118
1	10	478	92	6.48	2.191
2	20	486	91	3.72	2.192
3	30	508	87	1.46	2.268
4	40	511	81	0.42	2.245
5	50	552	72	0.56	2.360

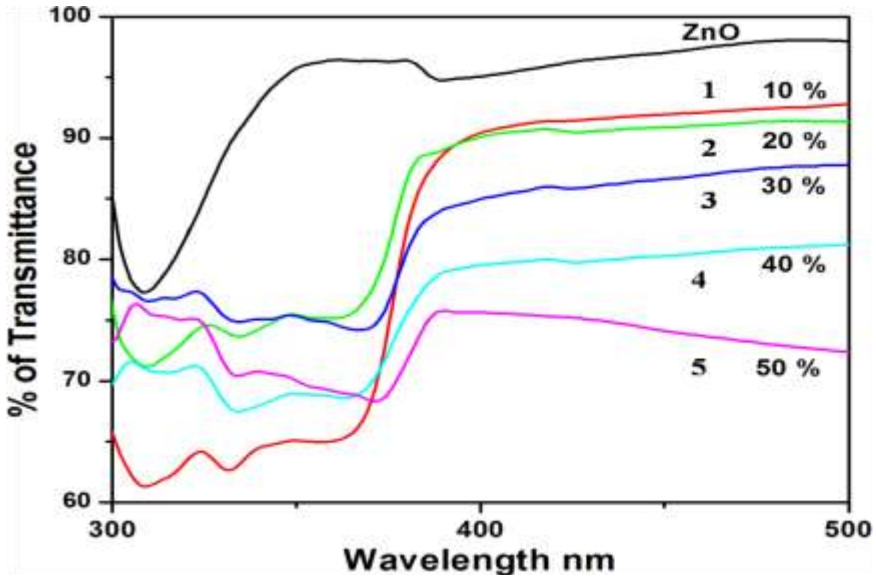


Figure 4 UV spectra of films ZnO and 1-5

The formation mechanism of these compounds can be explained as follows **(figure-5)**, when 3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione molecule comes in contact with Zn^{2+} ion (which already donated two free carriers to the lattice) that is present around the grain boundaries, in the excitation the electron transfer form HOMO level to LUMO level (ie, S^{+}/S^{0} to S*) of the 3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione that electrons are donated to the Zn^{2+} ion.

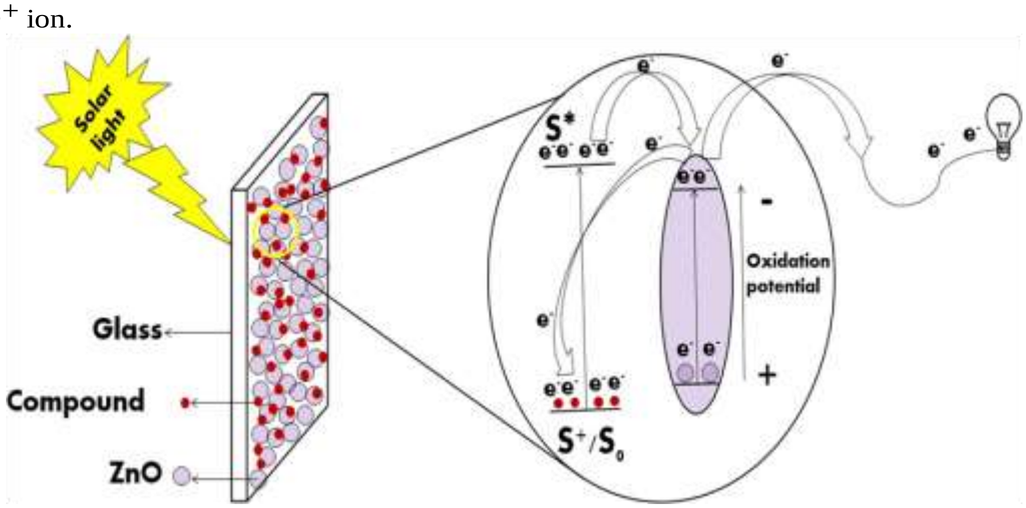


Figure 5 Mechanism of films1-5

Electrical studies

Figure-6,7 shows the variation in sheet resistance (Rsh) andresistivity (ρ) of ZnO:3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione thin films respectively as a function of 3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione addition level. As all the films have almost the identical thickness, a similar trend in variation is observed for resistivity (ρ) also. From **figure-7**, it was observed that, the ZnO film with 10% of 3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione shows higher Rsh value than that of ZnO films. With further increase in the 3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione addition level, the Rsh of ZnO:3,4-dihydro-2H-naphtho[2,3-b][1,4]oxazine-5,10-dione thin films decreases, attaining a minimum resistivity (ρ) value of 0.42 X $10^{-2}\Omega$ cm at 40% and then increases with further addition. Three trials of this experiment were carried out and it is worth mentioning here that, a similar trend in the variation of Rsh was obtained for all the three sets of samples.

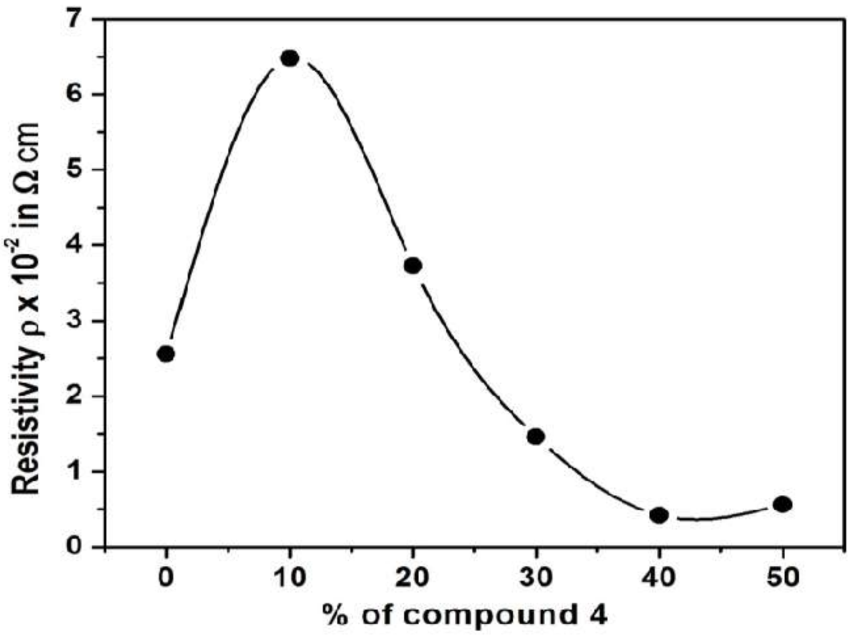


Figure 6 Sheet resistance Vs % of compound 4.

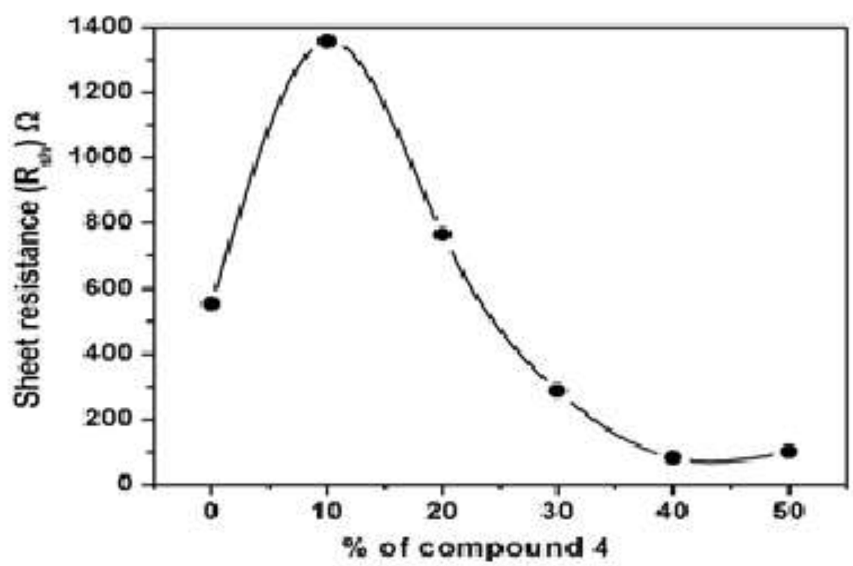


Figure 7 Resistivity Vs % of compound 4.

Conclusion:-

The fabricated films **(1-5)** were characterized by SEM, EDX and Powder X-ray diffraction (XRD) analysis also their electrical activities were tested for the solar cell application. The films **(1-2)** are tested for their solar cell application. Film **4** shows minimum resistivity (ρ) value of $0.42X10^{-2}$ Ωcm at 40% than that of the other films.

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