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Field effect transistor from dispersion polymerized aniline

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Abstract : We report here the fabrication of all polymer Polyaniline-Polyvinyl alcohol (PANI-PVA) FET and observation of FET characteristics. The FET is made in four different substrates, *viz*, Si, glass, PVA and transparent sheet. The I-V characteristics of these all polymers FET's, show clear FET behaviour for a p-channel semiconductor. The films are characterized by SEM and X-ray diffraction for morphology and structure study The characteristics results give clear indication of formation of nanometer sized polyaniline spheres in PVA matrix.

Keywords : Conducting polymer, Polyaniline composite, Nanoparticles, Logic circuits

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1. Introduction

Tremendous amount of research has been carried out in the field of conducting polymer since 1977 when the conjugated polymer polyacetylene was discovered to conduct electricity through halogen doping [1-3]. The 2000 Nobel Prize in Chemistry recognized the discovery of conducting polymers and over 25 years of progress in this field [4, 5].

Among conducting polymers, polyaniline is of particular interest due to its excellent air stability, low cost, ease of polymerization *etc*, making it a potential candidate for many advanced technological applications [6, 7]. The intriguing optical and electronic properties of π-conjugate backbone conducting polymers have captivated much interest in the scientific community. There are numerous works on PANI nanocomposites with inorganic hybrids, polymer emulsion or polymer in micellar medium [9, 10]. One of the key problem related to the potential application of polyaniline is its difficulty in processibility; either from melt or from solution. With a rigid π-conjugated backbone, polyaniline decomposes without melting when heated, also it is not soluble in common solvents. Processability in PANI

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can be achieved in number of ways *viz*, using functionalized monomer, co-polymerization with other polymer and by polymerizing in some synthetic high polymer matrix using dispersion polymerization method This kind of PANI dispersion can be used as transparent coating for EMI shielding, anti corrosion protection for metals *etc* PANI nano is believed to be superior to its bulk counterpart [8] in many of these applications Another noble application of this type of π-conjugated polymers is in the fabrication of field effect transistor (FET) Study of conducting polymer nano FET's is an emerging area of research [11-14] This type of π-conjugate polymers have another application as it forms one of the most fundamental components of electronic circuitry and the basic building blocks of logic circuits and switches for display also conducting polymer FET's are being used as efficient gas sensor

In this paper, we report the electrical conductivity of PANI-PVA film in FET configuration on different substrates PANI is synthesized in PVA matrix taking aniline to PVA monomer ratio as 1 9 The nano dispersion is very stable particularly for this ratio, and stays for more than fifteen days without any precipitation These films are also characterized by SEM and XRD to assign particle size and shape

2. Experimental details

All the chemicals and reagents used are obtained from Emerck and Sigma chemical company and are of very high purity 99 99% However, aniline is purified by repeated distillation under vacuum prior to use Dispersion polymerization of aniline is carried out by usual technique in aqueous solution with HCl in PVA using ammonium persulphate as oxidant Immediately after the solution turn bluish green homogenously the reaction was stopped and films are spin cast on different substrates and dried The dried films are again washed with deionized water to remove any unreacted reagent and dried again Source and drain contacts (at distance ~ 0 2mm) are made on top surface of film and gate contact is taken from the bottom

The I-V characteristics are measured by Keithley CV meter (model 595) and a Hewlett Packard multimeter (E2373A), XRD data by Seifert XRD 3000 pdiffractrometer with Cu-K_α radiation (0 15418nm) and FESEM images are recorded by JSM-6700F, JEOL, Japan

3. Results and discussion

Figure 1 shows field emission scanning electron microscope image of PANI-PVA film The image shows spherical particles of nanometer dimension with average particle diameter of 20nm. The picture also shows that nanoparticles are nicely oriented along particular direction. This is achieved because high concentration of PVA molecules (capping) hinders aggregate formation and inhomogeneity

Figure 2 shows the X-ray diffraction spectrum for PANI-PVA film. It shows peaks at 2θ values of 11.72°, 19.54°, 26.23° and 29 15° and an extra sharp peak at 2θ value of

35.3°, which indicate more crystallinity in the film similar to as that has been found by Kim *et al* [10]. These peaks correspond to (011), (101), (200) and (022) planes respectively.

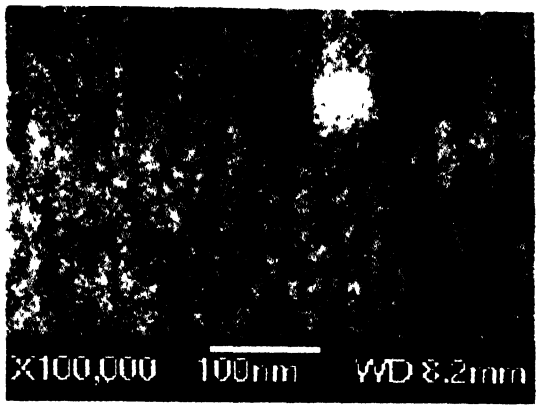

Figure 1. SEM picture for PANI-PVA film.

Among these peaks, the one at 2θ, 19.54° is the characteristics amorphous peaks of PANI [15].

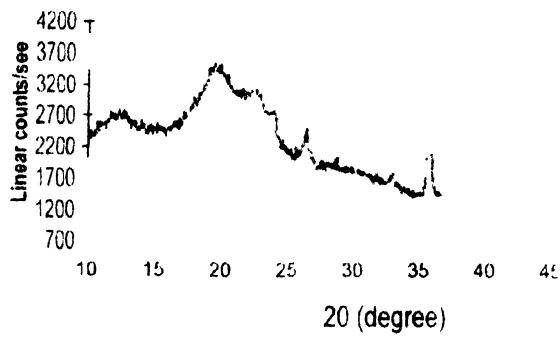

Figure 2. Diffraction spectra for the PANI-PVA film

Figure 3 shows the output characteristics of the FET device for different gate voltages (V_G) in volt. The drain current (I_{DS}) *vs* drain voltage (V_{DS}) curves show the behaviour expected from a p-channel FET, being initially linear with V_{DS} and saturation at higher V_{DS} as observed by Liu *et al* [13]. However the saturation region is not quite attained in the FET's fabricated on glass slide. Also I_{DS} decreases with increasing V_G This further confirms that the device operates as a FET and that the majority carriers are holes as expected for doped polyanilines [12, 17, 18]. The characteristics on different substrates show different saturation range of drain current. Of different substrates used transparent sheet, PVA and p-doped Si wafer (some extend) show a good saturation region. Possible reason for that may be larger thickness of glass and silicon wafers. This increases source gate gap which hampers FET functioning.

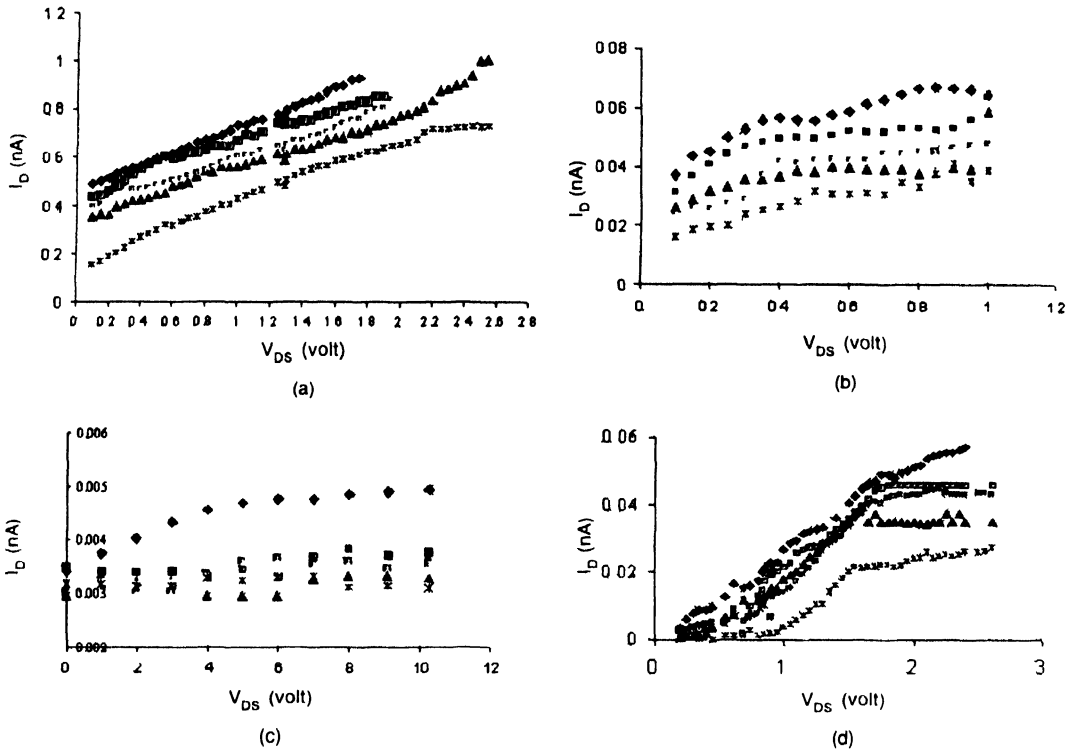

Figure 3 FET characteristic of PANI PVA on (a) PVA, (b) glass slide, (c) p- doped silicon and (d) transparent sheet film at gate voltages of -8 (◆) −4 (■), 0 (▩) 4 (▲), 8 (✳)

4. Conclusions

Highly oriented nanospheres of PANI are obtained by dispersion polymers in PVA matrix The films show very good p-channel FET characteristics on transparent sheet and PVA substrate and moderate on p-doped Si wafers These further confirm the fact that polyanilines are p-type semiconductors and have potential for use in electronic circuits and sensors

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