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# Organic Field Effect Transistor Based on Composite Polymer

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*Abstract*—**Recently, composites based on organic polymers with introduced inorganic nanaparticules arepromising materials for organic field effect transistors (OFET) active layers [1]. The introduction of metalnanoparticles as gold into an OFET dielectric layer leads to the appearance of memory effects which manifest themselves in the hysteresis of current-voltage (I-V) characteristics and transient characteristics of OFETs [2,3]. Aother characteristic feature of such composite OFETs is a significant increase in the charge carrier mobility, observed with increasing ZnO nanoparticle concentration in the composite active layer [4]. The gate insulators play an important role for the proper functioning of field effect transistors. The insulator materials must have high resistivity to prevent the leakage current between the gate metal and the semiconductor channel, and high dielectric constant to have enough capacitance for channel current flow [5]. The aim of this paper is to present an experimental study of electrical properties of field effect transistor structures with a composite insulator layer based on a soluble insulator polymer which is poly 4, vinyl phenol (PVP) and semiconductor nanoparticles of Zinc Oxide (ZnO).**

*Keywords*— **Orgnic field effect transistor, nanoparticles ZnO, spin-coating, PVP, top contact transistor, bottom contact transistor.**

## I. INTRODUCTION

Theneed of new devices more powerful and more reliable pushes development of the microelectronics. Among the different ways of this development, the use of organic materials takes an important place in the actual research technology. The organic electronic presents several advantages versus the classical electronic, among these advantages, the low cost of manufacturing process and the flexibility of its manufacturing support. We have elaborated two series of organics transistors field effect. In the first one, the ploy(4-vinyl phenol (PVP) represents the gate insulator. In the second, the insulator layer is based on insulator polymer, i.e., poly (4 vinylphenol) and inorganic ZnO nanoparticles. Electrical properties will be compared between the two series.The gate insulators play an important role for the proper functioning of organic field effect transistors. This insulator must have high resistivity to prevent the leakage current between the gate metal and the semiconductor channel and high dielectric constant to have enough capacitance for channel current flow [4]. The organics insulators should combine low functioning voltage and high stability.

## II. STRUCTURESDEVICEANDMETHODSOFELABORATION

Field effect transistor structures with a composite insulator layer based on insulator polymer, i.e., poly (4 vinylphenol) and inorganic ZnO nanoparticles were realized, with concentrations of (0% ZnO + 100% PVP) and (50% ZnO + 50% PVP). After their elaboration, the field effect transistor structures were characterised to determine their comportment like as transistor. The insulator polymer PVP used in the present study were purchased from Sigma-Aldrich and used with no additional treatment. PVP was dissolved in isopropanol. The obtained solution was mixed, stirred and annealed at temperature of "50°C (323K)" for "30 min". The solution of ZnO nanoparticles used in the present study was purchased from genesink and used without additional treatment.

The structure fabricated top contact field effect transistor is shown in Figure 1. The metal gate is made of Indium Tin Oxide (ITO), with sheet resistance of 15Ω/□. The gate is etched with a heated hydrochloric acid and layer thickness of "150 nm". The solutions of polymer are deposited by spin coating and then were dried at "120°C (393K)" for "1h30 min". The layer thickness was estimated using a Bruker DEKTAK XT, it is around"0.9 µm". The active layer thickness of pentacene 50 nm thick is deposited using vacuum evaporator, and gold source-drain electrodes are deposited with the same technical. The layer thickness of electrode was "30 nm", the electrode width is "4 mm" and the channel length is 50µm

Direct current- voltage characteristics of field effect transistor structures based on PVP:ZnO were measured in dark, in atmospheric vacuum at ambient temperature, in a voltage range from "-40 to +40", using an automated setup for the measuring current-voltage (I-V) characteristics, based on a Keithley-4200 SMU.

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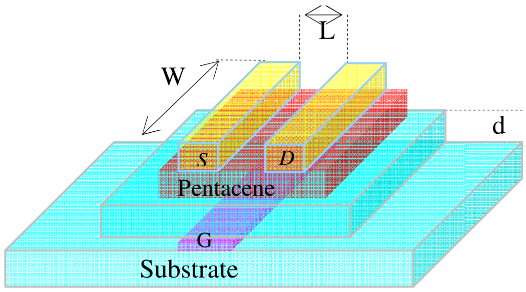


Fig.1 Structure of top contact transistor studied with PVP:ZnO gate insulator, where W is the channel width, L is the channel length and d the layer thickness of insulator polymer

## III. RESULTS AND DISCUSSION

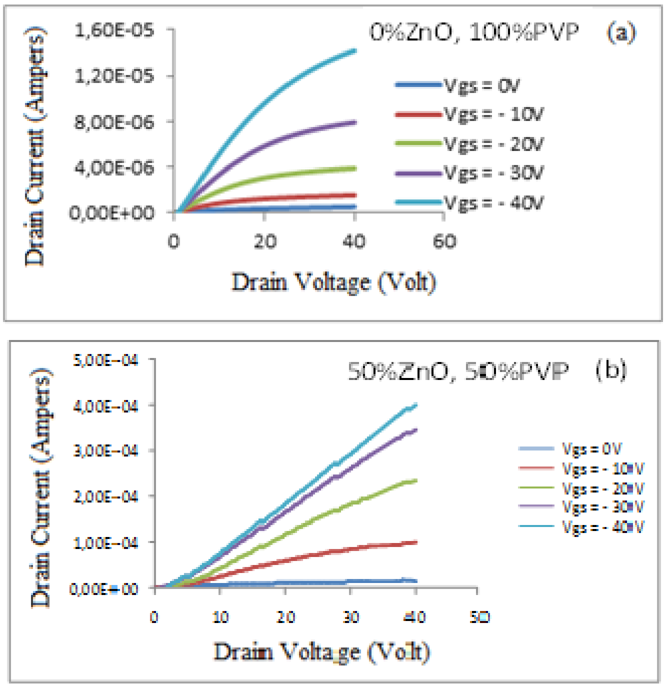


Fig.2 Current-voltage characteristics top contact field effect transistor with a composite insulator layer based on PVP:ZnO gate, with (a) for '$V_{GS}$= - 10V', and (b) for '$V_{GS}$= - 20V'

Figures 2a and 2b show the I-V characteristics of the field effect transistor with a composite insulator layer based on PVP:ZnO operating at various drain voltages $V_D$ at the gate-source voltage. An improvement of drain current is observed with the addition of ZnO nanoparticles (concentration of ZnO is "ZnO ~ 1wt %") in the matrix of insulating polymer PVP. The three operating modes of a field effect transistor exist for the transistors realized only with PVP, in the case of insulator based on solutions PVP:ZnO the saturation regime does not exist this drawback is probably related to current leakage through the gate . For a better comparison, the current-voltage characteristics of the two solutions for fixed gate voltages are represented on the same graph.

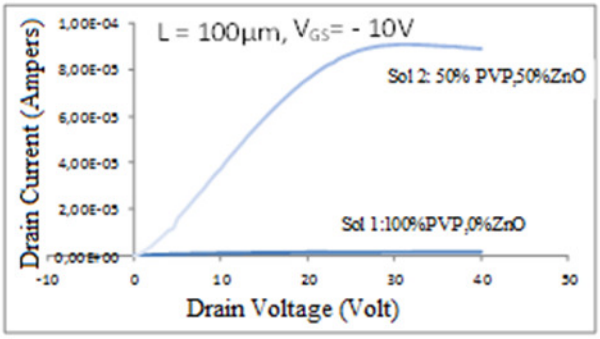


Fig.3Current-Voltage characteristics top contact field effect transistor with a composite insulator layer based on PVP:ZnO gate, with for the first solution "$V_{GS}$=-1", and the second solution for "$V_{GS}$=-20V".

The comparison of the drain current between transistor based on solution (100% PVP and 0% ZnO nanoparticles) and the transistor based on solution of (50% ZnO nanoparticles and 50% PVP)shows (figure 3) a clear improvement in the drain electric current with ZnO concentration (ZnO ~ 1 wt%) by a factor 40. The ZnO nanoparticles have an important role in the operation of the organic field effect transistor, a composite insulator layer based on PVP: ZnO (ZnO ~ 1wt %) have an influence on the characteristics of the field effect transistor by increasing significantly the insulator permittivity**.** The field effect is better for the solution adding ZnO nanoparticles.

## IV. CONCLUSIONS

The study was carried out from a polymer insulator often used for organic transistors: PVP (poly 4, vinylphenol) [7, 8], where the relative dielectric permittivity is "3.6". The insertion of ZnO nanoparticle in the matrix of insulating polymer PVP is to improve the permittivity of the insulator and the electrical performance of organic field effect transistor. The inclusion ofnanoparticleswhosedipole momentis importantin a polymerused to tune the electrical currentof the transistor but with the risk of the occurence of leakage current.

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