The Influence of Oxygen Doping of Channel of Organic Field-Effect Transistor Based on Nickel Phthalocyanine on the Output Parameters

Pavlo Stakhira, Vladyslav Cherpak, Georgiy Pakhomov, Dmytro Volynyuk, Zoya Dutchak, Mykhaylo Hladun

Abstract – **The influence of nickel phthalocyanine (NiPc) thin film doping by oxygen on electric parameters of organic transistor structures of Si/SiO_2/NiPc/Au was investigated. The complex analysis of structure and electrical&physical characteristics of thin films of organic low-molecular semiconductor after influence of oxygen during seven days was carried out.**

Keywords – **OFET, organic semiconductors, thin films.**

I. INTRODUCTION

Due to photosensitivity, high thermal and chemical stability, relatively high mobility of charge carriers and low price the organic semiconductor - nickel phthalocyanine (NiPc) finds wide applications in different types of microelectronic devices, in particular field-effect transistors [1-3]. Unfortunately the majority of phthalocyanines possesses low conductivity which limits their use in photoconverters and transistor devices [4-6]. The effective method of increase of free carrier concentration in phthalocyanines is doping by oxygen molecules. The aim of the work is investigation of influence of oxygen doping of channel in organic field-effect transistor based on nickel phthalocyanine on its output characteristics.

II. EXPERIMENTAL

NiPc thin films were deposited by the thermal evaporation method. Si/SiO_2 were used as substrates in this experiment. The base pressure in the chamber was less than 10^{-3} Pa. Dispersive NiPc powder (Sigma Aldrich ltd.) was placed in the molybdenum boat, which was resistively heated to 400±10 °C. Substrates were heated to 100°C during the thin film deposition process. These deposition parameters provide thickness uniformity of the film, and assure that molecular content of the film is equivalent to that of the powder. X-ray diffraction (XRD) analysis on the samples was performed on Rigaku Rapid diffractometer. The x-ray beam was incident on the sample at 3^o angle. Diffracted pattern of Cu Kα radiation (λ=0.154 nm) was registered by a cylindrical detector. The conductivity of the NiPc film on quartz was measured by using four probe-techniques. The current density - voltage characteristics of the structures were recorded with a standard L2-56 curve tracer.

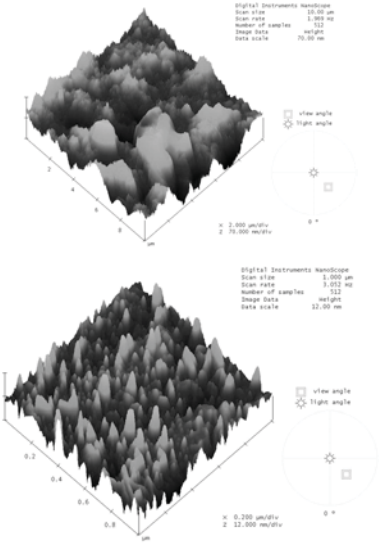

Fig.1. AFM images of undoped NiPc films (a) and oxygen doped NiPc films (b) (a – scanning area 10 μm^2, b – scanning area 1 μm^2)

III. CONCLUSION

It is shown that oxygen doping of NiPc films from one point of view leads to film structure ordering – crystalline order increase, from the other point of view it leads to significant (up to four orders) increase of charge carrier concentration. The comparative analysis of electrical parameters of transistors based on doped and undoped NiPc film shows that oxygen doping leads to improvement of conductivity in transistor channel and increase of threshold voltage, the last factor is probably connected with formation of O^{2-} complexes in phthalocyanine.

REFERENCES

[1] T. D. Anthopoulos, T. S. Shafai// Appl. Phys. Lett. 2003. 82. №10. – P. 1628-1630.
[2] A Belghachi, R A Collins// J. Phys. D: Appl. Phys. 1988. 21. – P. 1647-1651.
[3] C.J. Liu, J.J. Shih, Y.H. Ju// Sensors and Actuators B. 2004. 99. – P. 344–349.
[4] M. Passard, A. Pauly, J.P. Germain, C. Maleysson// Synth. Met. 1996. 80. – P. 25-28.
[5] W. Hu1, M. Matsumura// J. Phys. D: Appl. Phys. 2004. 37. – P. 1434–1438.
[6] T.D. Anthopoulos, T.S. Shafai// Thin Solid Films. 2003. 441. – P. 207–213.

Pavlo Stakhira, Vladyslav Cherpak, Dmytro Volynyuk, Zoya Dutchak - Lviv Polytechnic National University , S. Bandery Str., 12, Lviv, 79013, UKRAINE, E-mail: stakhira@polynet.lviv.ua
Georgiy Pakhomov - Institute for Physics of Microstructures of the Russian Academy of Sciences Russian Federation, 603950 Nizhny Novgorod, GSP-105
Mykhaylo Hladun – European University, Lviv Branch, Kushevych Str., 7, 79000, UKRAINE