Field emission from non-conjugated polymers

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Abstract

We investigated a great number of polymer materials. The parameters affecting on its emission properties (namely, film thickness, temperature of polymer preparation, metal substrates and so on) were studied. We observed that emission distributed over full polymer surface with current densities up to several hundreds μA/cm^2. Some polymer samples have shown high current emission properties up to 50 μA in DC and more then 1.5 mA in sinusoidal regimes.

Introduction

At present a significant attention is focused on the search for new perspective materials for low-threshold field emission cathodes which could be work stable in the relatively low (≈10^{-6} Torr) vacuum conditions.

There are many designs of field emission cathodes on the base of carbon-like materials described in scientific publications such as: i) carbon wires; ii) massive carbon wafers prepared by irradiation technology; iii) structures with nanoclaster carbon - nanotubes [1]. The increase of emission current from Si and Mo electrodes covered by diamond at using CVD and electrophoresis technology was also described [2]. Investigation of ultra-low-threshold field emission from conjugated polymers can also be promising for a good cathode material [3].

1. Emitter construction

We obtained a low-threshold field emission from thin films (about 1μm) of non-conjugated polymers such as: i) copolymer - {co-poly[4,4'-*bis*(4''-N-phenoxy) diphenyl-sulfone-α,ω-*bis* (γ-amino propyl)oligodimethylsiloxane]imide of 1,3-*bis*(3',4-dicarboxyphenoxy)benzene}; ii) aryl-polycarbonate: neylon-60. The films were prepared by deposition of a droplet of 5 % wt. solution on the polished Mo or Nb electrodes with 5 mm in diameter. Then films were heated in air for 1 h at a constant temperature of 370-400 K to remove the major part of the polymer solvent. The polymer was the same where we previously observed high conductivity effect [4].

2. Experimental

Field emission measurements were carried out in vacuum chamber at pressure of about 4x10^{-6} Torr in construction with accelerating grid. The distance between cathode and flat grid was in a range of 0.5-1.5 mm. The fluorescence from flat phosphorus glass anode was registered by means of web camera with recording to computer. At electrical measurements we used dc as well as ac power supplies.

We obtained a stable field emission at 4 kV/mm. However for initial activation of the cathode the threshold field should be 2.5-3 times more than 4 kV/mm. The field emission from polished metals we did not observe up to 25 kV/mm. We observed a homogeneous fluorescence from the phosphorus glass anode with current emission up to 50 μA in dc and more then 1.5 mA in sinusoidal regimes. Current-voltage characteristic corresponds to Fowler-Nordheim law at small electric fields but at high electric fields there is deviation to smallest values of current Fig.1.

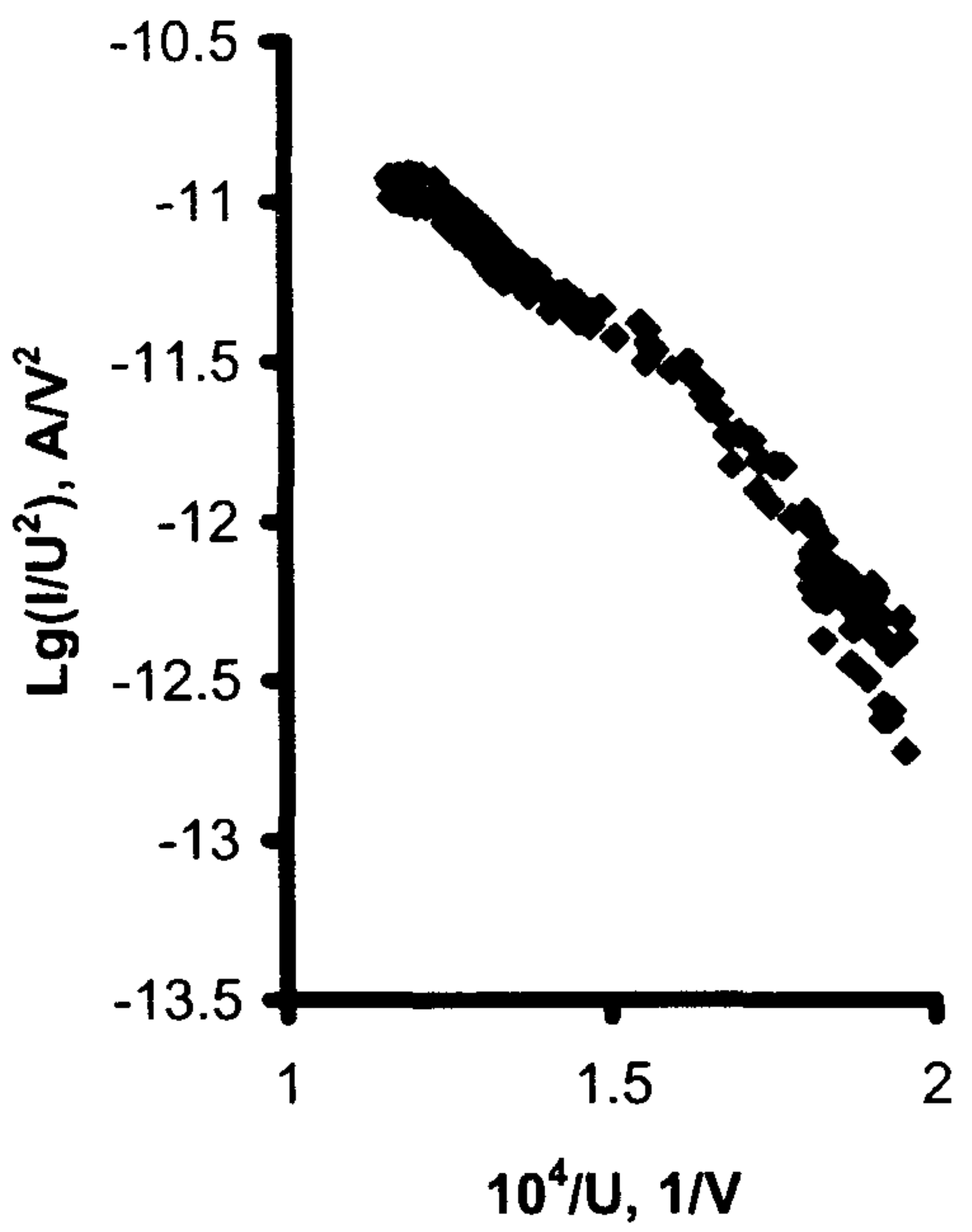

Fig.1. Fauler-Nordgeim law at low electrical field with a kink at high fields.

Topography of the polymer film surfaces was analyzed by an atomic force microscope before and after action of electrical field. Initially polymers had smooth surfaces but after a threshold field emission the surfaces were modified very strong: spikes were formed up to 400 nm in high Fig.2.

3. Summary

We consider that polymer accepted the charge from metal (cathode). Under the action of external electric

field the soft polymer surface was modified and a field emission is appeared from needles.
We speculate about some parameters and preparing conditions of the non-conjugated polymer films, which affect on the low-threshold field emission from cathodes with polymers as well as field emission stability.

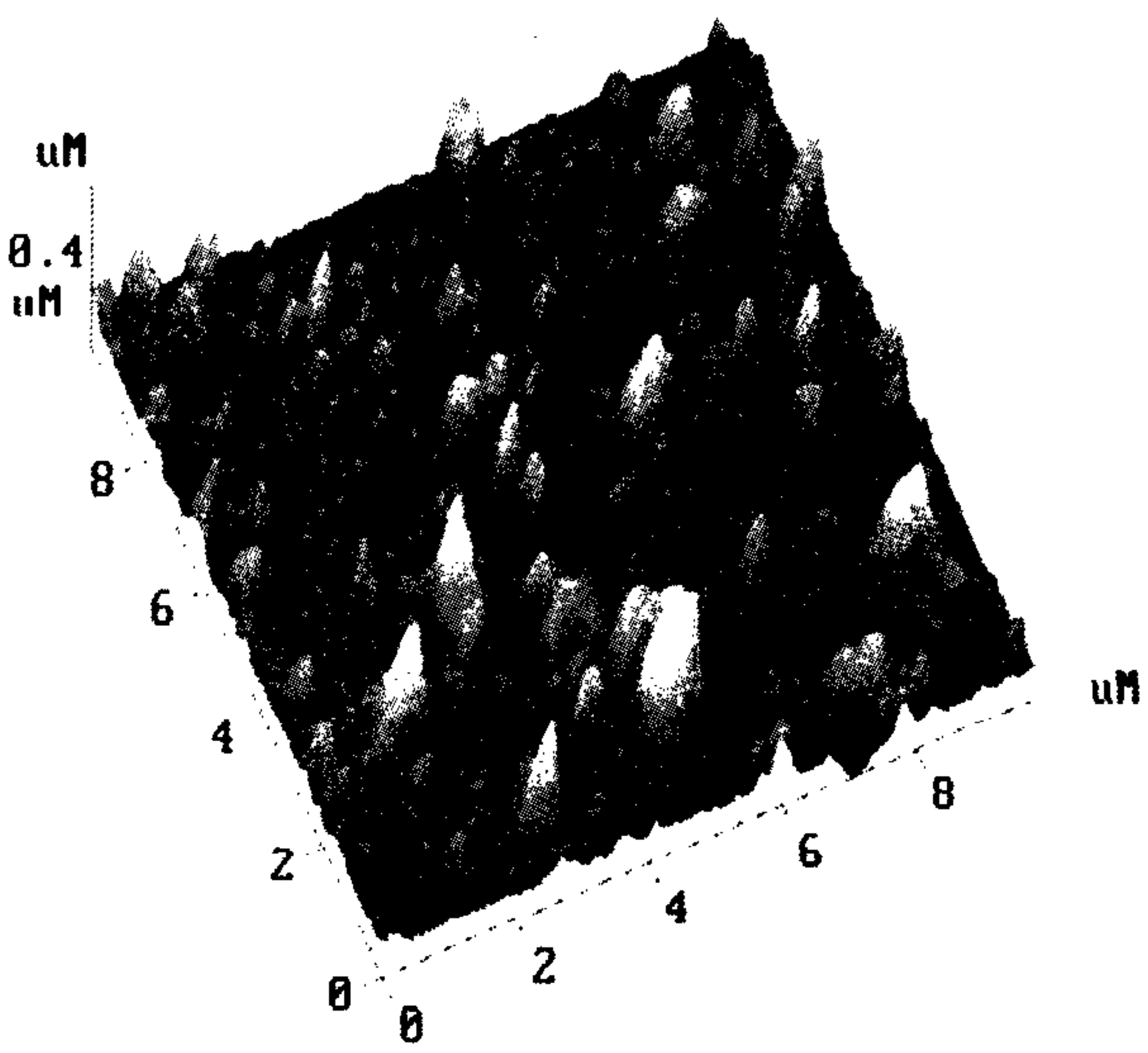

Fig.2. Atomic Force Microscope topography of polymer surface after the action of external electrical field (4-8 kV/mm)

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