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Development of Conducting Polymers towards Molecular Electronics

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1. Introduction

Conducting polymers have sp_2 hybridized molecular orbital structure in the carbon backbone chain [1]. Upon doping, the film forms of conducting polymers become insulating, semiconducting and metallic [2, 3]. The semiconducting polymers have shown the electroluminescence (EL) of various colors for different side groups in the backbone chain [4]. Furthermore, the high field magneto resistance (MR) studies of the metallic polymers have shown the effect of nanojunctions in the randomly entangled fibrillar morphology of the thin film [5]. In the recent few years, the studies on single fiber of conducting polymers have been progressed remarkably in cooperation with the submicron spacing electrodes patterning by e-beam lithography and the Scanning Probe Microscopy (SPM) techniques [6]. The MR studies of single fiber of polyacetylene revealed that the Zener-type tunneling conduction of charged soliton kinks created by high electric field is the dominant charge transport mechanism at low temperature [7]. The result can be applied to use the conducting polymer nanofibers for the molecular nanowires in high density memory devices. The randomly entangled fibrillar structure of conducting polymer films can be developed to nature made random register logic devices. Furthermore, studies on the PPV nanotubes lead to develop the nano electroluminescent devices. The composites of polymer nano fiber/tube and carbon nanotube (and the functionalized carbon nanotubes) also improve the nano scale device characteristics. Therefore, the extraction/synthesis as well as the electrical and optical characterizations of the single fiber/tube of conducting polymers open up the future applicabilities of conducting polymers for the molecular electronics. In this paper we introduce the photoluminescence measurement result of the individual PPV nanotube, which can be developed to a nano electroluminescence device made of the PPV nanotubes.

2. Experiments and Results

We prepared PPV nanotubes and nanorods by polymerizing a,a'-dichloro-*p*-xylene by the CVD polymerization method in the pores of alumina or polycarbonate filters having nominal pore diameters of 200 nm. This synthetic method requires two steps to prepare PPV: In the first step the precursor polymer is formed, which has to be further converted to PPV at 150-270 °C under vacuum[8].

The heavily doped Si substrate was thermally oxidized and was spin-coated by an e-beam resist (PMMA) on the oxidized substrate. We draw the electrode pattern directly using an e-beam lithography machine. After development, a negative PMMA pattern remained. A NiCr alloy was deposited to improve adhesion to the substrate before a thick Pt layer which was evaporated by e-gun. In the lift-off process, we removed remained PMMA using acetone. In this way, a Pt electrode on the oxidized substrate was fabricated.

The samples were prepared onto the substrate by deposing ethanol suspension of PPV nanotubes. The PPV nanotube deposited electrode was attached to a chip carrier by silver paste. The electrode and external probes were connected by wire bonder. The sub-micrometer sized device of the undoped polymeric semiconductor was measured at room temperature. Constant voltage was applied and the current was measured using Keithley 4200 semiconductor characterization system.

As shown in Fig. , we measured current-voltage (I-V) characteristics of PPV nanotube. The measured I-V characteristics at room temperature showed non-linear behavior, as for diode rectification.

The optical characterization is performed on PPV nanotubes deposited onto fused silica substrates. The photoluminescence (PL) measurments are carried out with spectrofluorometer in air (Fig. 2). Aggregates of PPV nanotubes show a strong yellow PL. We attribute this characteristics to self absorption of the PPV nanotubes

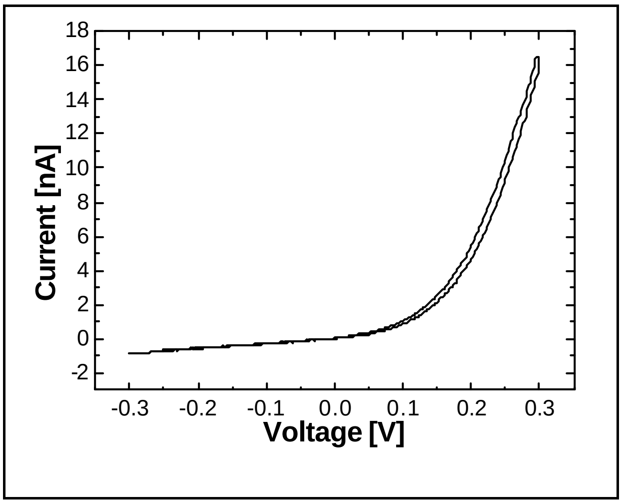

Fig. 1 I-V characteristics of PPV nanotubes at room temperature.

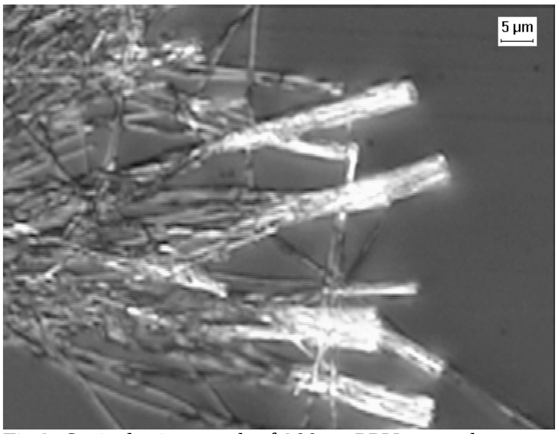

Fig.2. Optical micrograph of 200nm PPV nanotubes

3. Summary

We have measured the photo luminescence (PL) of individual PPV nanotube. Although further investigations are necessary, it open a possibility of fabricating the nano electroluminescent device made of PPV nanotubes. Studies on developing other molecular electronics devices made of various conducting polymer nanofibers/tubes as well as the composite of polymer nanofibers and the carbon nanotube are on going.

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