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Fabrication of Nanorods using α - Quaterthiophene (α -4T) Thin Films

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ABSTRACT: α -4T thin films of various thicknesses are prepared by thermal evaporation method. The micrographs of as deposited and annealed α -4T thin films of thicknesses 50 nm, 100 nm and 200 nm have been recorded using scanning electron microscope. The micrographs of thin films are analysed. It is observed from the micrographs that no nanorods are could form until the film thickness attains 200 nm. The length and diameter of nanorods are found to increase with increase in annealing temperature.

KEYWORDS: α -4T, thermal evaporation, scanning electron micrographs, nanorods.

I. INTRODUCTION

Oligothiophenes are widely considered as an interesting material in organic electronic industry because of their high stability to withstand oxidation. Oligothiophenes attract remarkable attention as an organic semiconductor. It shows nonlinear optical, electrical, and liquid crystalline properties. These properties are dependent on various film deposition parameters. Their physical properties can be attained by incorporating minor structural modifications by altering parameters like deposition rate, film thickness, substrate temperature, annealing temperature and annealing time. Among oligothiophenes, α -quaterthiophene (α -4T) is widely studied because of its promising applications in organic electronic industry.

Quaterthiophene (α -4T) is a good photosensitive organic material which shows considerable absorption in the short wavelength region of the UV-visible spectrum. α -4T thin film is suited for organic and optoelectronic device applications. Organic semiconductors are useful in microelectronics and nanotechnology applications. α -oligothiophenes (α -Nt) are oligomers of thiophene which is highly promising for applications in thin film transistor devices. The solubility of α -4T makes it a more potential candidate for solution phase film deposition. The capability of α -4T to dissolve in organic solvents at room temperature is advantageous. Hence it can be used easily to process organic semiconducting material.

Oligothiophene consists of thiophene sub units bonded each other by σ bonds via its α carbon atoms to form oligomers of thiophene. Four thiophene sub units are bonded to form α -quaterthiophene (α -4T) molecule. Since it has high vapour pressure, it is possible to form thin films by thermal evaporation by vapour deposition technique on sublimation in high vacuum. It has good electrical characteristics suitable for the fabrication of organic field effect transistors (OFETs), organic photovoltaics (OPVs), organic light emitting diodes (OLEDs), solar cells and electro chromic devices (ECDs). Organic electronics is an emerging field in electronic industry where organic semiconductors can be used in the fabrication of electronic devices.



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II. EXPERIMENTAL DETAILS

α -Quaterthiophene powder of 96% purity from Sigma Aldrich has been used as source material in the preparation of α -4T thin films. Hind Hivac coating unit (Model 12A4-D) has been used for the preparation of thin films. Thermal evaporation technique has been employed in vacuum coating unit for the deposition of thin films. The thin films of α -4T of thicknesses 50 nm, 100 nm and 200 nm have been deposited on thoroughly cleaned glass substrates of dimensions 75 mm x 25mm x 1.35 mm. substrates are cleaned well in light soap solution and soaked well in dilute nitric acid. It is washed thoroughly in distilled water and subjected to ultrasonic agitation in acetone for 2 to 5 minutes. Thereafter it is rinsed with isopropyl alcohol and dried using hot air. It is further subjected to HT cleaning provided with vacuum coating unit for 2-5 minutes. These glass substrates which are totally free from any sort of contamination have been used for the deposition of thin films. α -4T powder has been placed in pre-cleaned molybdenum boat of dimension 23 x 13x 11 mm and the cleaned glass substrates are placed at distance of 20 cm above the boat and well enclosed by the bell jar of the coating unit. Using rotary pump, a fore vacuum of 10^{-3} m.bar as measured by pirani gauge has been created inside the vacuum chamber to fulfil the pre-requisite vacuum for the operation of diffusion pump. A high vacuum of 10^{-6} m.bar as indicated by penning gauge has been produced use of the diffusion pump. α -4T thin films have been deposited at deposition rate of 2 Å/sec till the thickness monitor indicates the formation of α -4T thin film of required thickness. The prepared thin films of thicknesses 50 nm, 100 nm and 200 nm have been annealed in vacuum at 60 °C, 80 °C, 100 °C and 120 °C. The scanning electron micrographs of as deposited and annealed thin films of thicknesses 50 nm, 100 nm and 200 nm have been recorded using scanning electron microscope (JEOL, JSM 6390). The electron micrographs have been analysed in detail.

III. RESULTS AND DISCUSSION

The scanning electron micrographs of as deposited and annealed α -4T thin films of thicknesses 50 nm, 100 nm and 200 nm have been recorded using scanning electron microscope. The of micrographs α -4T thin films of thickness 50 nm, 100 nm and 200 nm at room temperature are shown in figures 1, 2 and 3 respectively. The micrographs of thin films are analysed. It is observed from the micrographs that no nanorods could form until the film thickness attains 200 nm. This can be attributed with sticking of more atoms into nanorods. The length and diameter of nanorods fabricated using as deposited and annealed α -4T thin films of thickness 200 nm are given in table 1. Nanorods formed in α -4T thin films of thickness 200 nm are shown figure 3.

Table 1 variation of length and diameter of the nanorods fabricated using α -4T thin film of thickness 200 nm

Temperature (°C)	Average length of nanorod (nm)	Average diameter of nanorod (nm)
30	428	111
60	467	119
80	475	123
100	484	134



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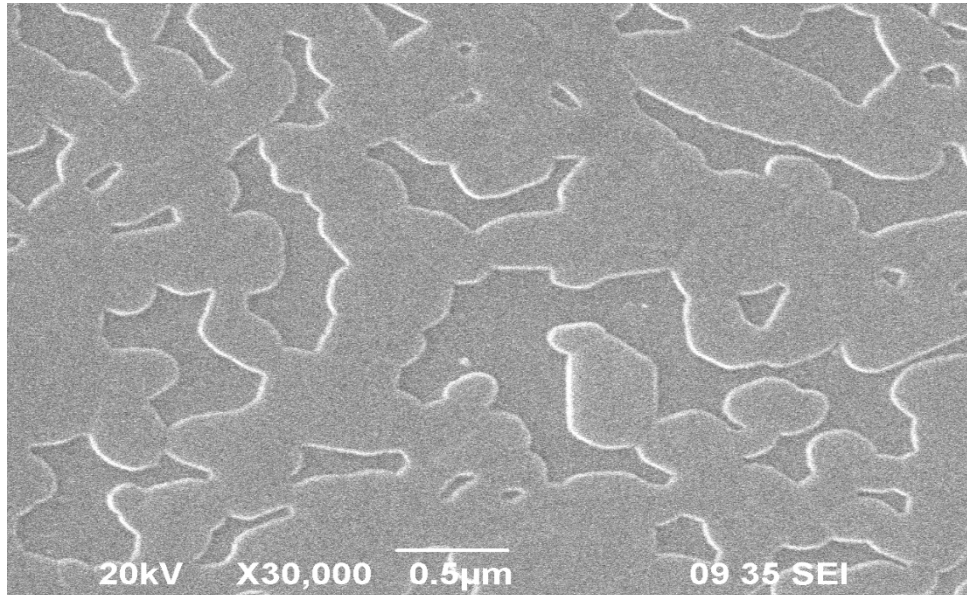


Fig. 1 Scanning Electron Micrograph of α -4T thin film of thickness 50 nm annealed at 60 °C

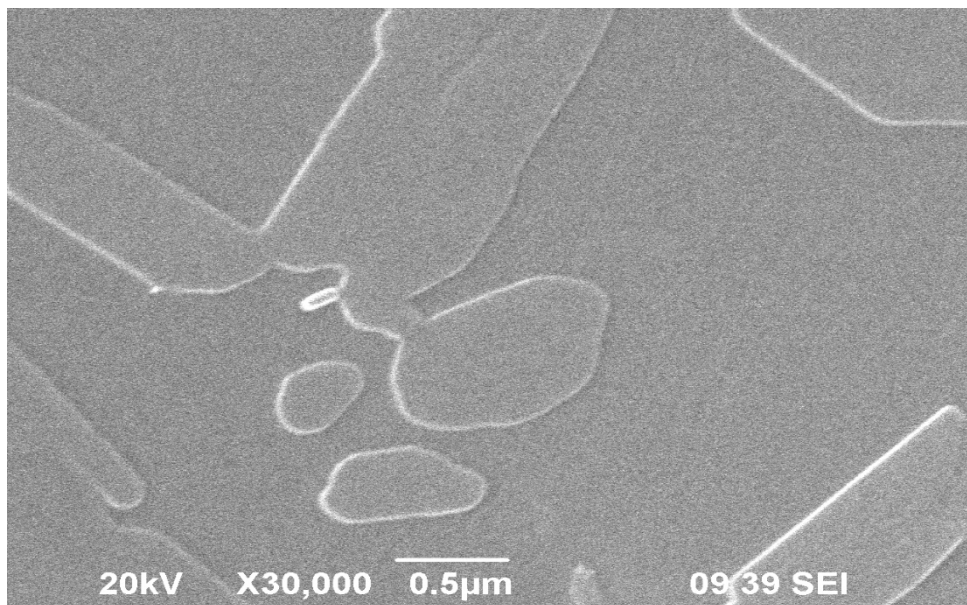


Fig. 2 Scanning Electron Micrograph of α -4T thin film of thickness 100 nm annealed at 60 °C

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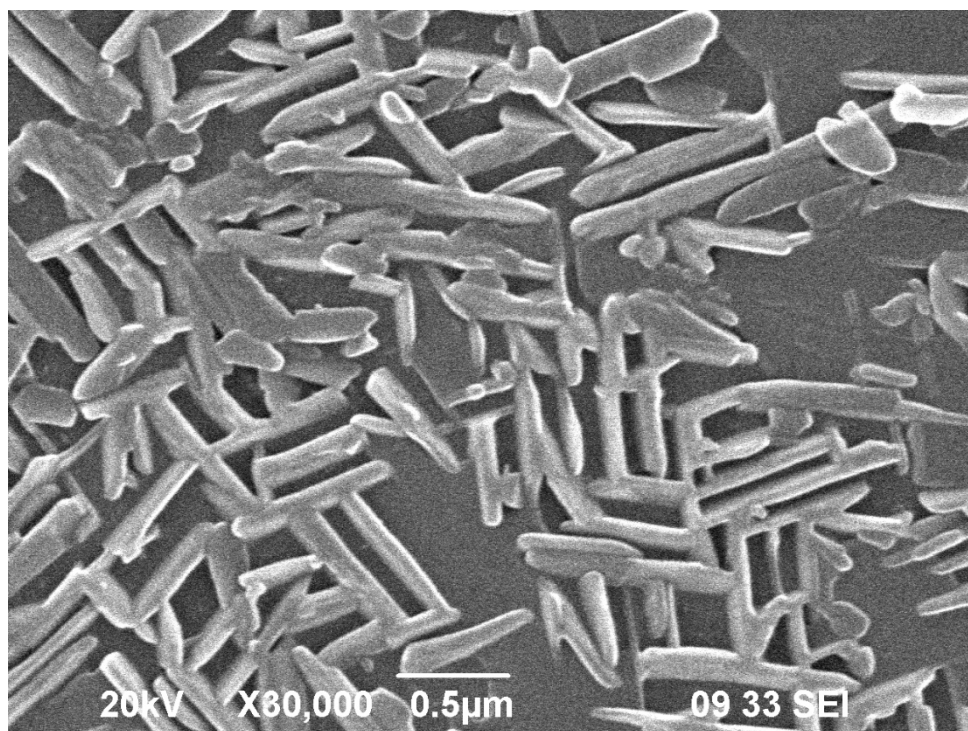


Fig. 3 Scanning Electron Micrograph of α -4T thin film of thickness 200 nm annealed at 60 °C

IV. CONCLUSIONS

It is observed from the micrographs that no nanorods could form until the film thickness attains 200 nm. The length and diameter of nanorods are found to increase with increase in annealing temperatures.

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