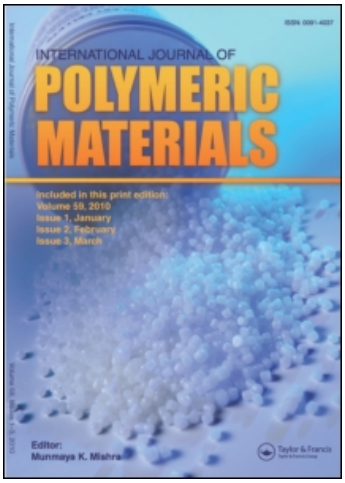

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Investigation on Molybdenum Thin Films Deposited by DC-Sputtering on Polyethylene Terephthalate Substrate

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Investigation on Molybdenum Thin Films Deposited by DC-Sputtering on Polyethylene Terephthalate Substrate

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Molybdenum (Mo) films were prepared by DC sputtering on a polyethylene terephthalate (PET) substrate with different thicknesses. The molybdenum finds use in a very broad spectrum of applications in widely different forms. The obtained results of thin films of molybdenum deposited on PET are characterized by atomic force microscopy (AFM) and X-ray diffraction (XRD) and (EDX). It was found that the thickness increases with the time of deposition and reduces the resistivity and sheet resistance. The lowest resistivity value we found for the Mo films was $1.3 \times 10^{-5}\,\Omega \cdot \mathrm{cm}$ at thickness (210 nm).

Keywords DC sputtering, molybdenum, polyethylene terephthalate

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INTRODUCTION

Molybdenum is a transition metal. The pure metal is silvery white in color and very hard. Molybdenum is used in some electronic applications as the conductive metal layers in thin-film transistors (TFTs) [1]. In many electronic applications, depositing a metal layer on a substrate can be performed by different techniques, such as thermal evaporation, electron beam evaporation, or sputtering [2–6]. Molybdenum has a high melting point (2623°C) and a low vapor pressure (3.47 Pa at 30°C) which makes molybdenum ideal for sputtering. However, the deposition of a molybdenum film as a back contact is not by itself an assurance of a high-efficiency solar cell. The deposition parameters and process play a key role in obtaining a layer with the appropriate properties. Extensive research has been done on the deposition of molybdenum thin films by DC sputtering [7,8]. The polyethylene terephthalate is an excellent commercial thermoplastic polymer resin of the polyester family. PET substrate has attracted interest in a wide array of fields because of its low cost, good thermal stability, surface inertness, good spin ability and excellent moisture resistance [9,10]. In this study, different thicknesses of Mo films deposed on PET substrates have been prepared by the DC sputtering method using low deposition temperature with different deposition conditions. The structural, optical and electrical properties of the obtained films depending on deposition parameters, such as sputtering power and working pressure, were investigated.

EXPERIMENTAL DETAILS

The PET substrate with thickness of 250 μm and dimensions 20 mm × 20 mm were washed with alcohol and then ultrasonically cleaned for 10 min. The deionized water was used to rinse the PET substrate. The PET substrate was dried by nitrogen gas. The molybdenum target with thickness of 0.3 mm, diameter 75 mm and purity of 99.95% was deposited with PET ($T_{melting}$ = 265°C) using DC sputtering (model AUTO306). The residual gas pressure in the chamber was evacuated by a rotary and diffusion pump arrangement. The target was pre-sputtered for 10 min to remove contamination.

The shutter was displaced to expose the substrates in the sputtering plasma for 30 min. The sputtering deposition was carried out in a pure argon atmosphere at a pressure from 0.05 to 2 m torr and the sputtering power at 220 W. The sputtering was done in room temperature of 25°C and the distance between the target and PET substrate was approximately 6 cm. The thickness of the Mo film deposited on PET was determined for each time by using optical reflects of meter (Model: Filmetric F20). The deposition times were (5, 10, 15, 20 and 25 min). In this work, different thicknesses of Mo film (49 nm, 89 nm,

Table 1: The thicknesses of molybdenum deposited on PET.

No.	Thicknesses (nm)	Time deposition (min)
1	49	5
2	89	10
3	150	15
4	180	20
5	210	25

150 nm, 180 nm and 210 nm) were deposited. The surface morphology of each Mo films was performed by AFM (model: Ultra Objective) and SEM (model: JSM-6460 LV). The crystallographic structure of Mo deposited on PET was determined using high-resolution X-ray diffractometer system (model: Panalytical X'Pert PRO MRD PW3040). The sheet resistance and the resistivity of the Mo deposited on PET were measured with a four-point probe (Model: Changmin Tech CMT-SR2000N).

RESULTS AND DISCUSSION

The results of films of molybdenum deposited on PET are characterized by different techniques. The samples used in the experiment consisted of a thin film of molybdenum and PET. The measured values of films thicknesses range from 49 nm to 210 nm. The thicknesses of these samples are given in Table 1.

Structural Characterization

AFM images for surface morphologies of molybdenum deposited on PET are given in Figure 1(a–e). Figure 1 shows the variation of the film roughness with thickness which correlated with deposition time. The surfaces of the product Mo thin films obviously were smooth. The evaluated root mean square (rms) surface roughness of the films, were 9.35 nm and 16.79 nm for films with a thickness of 49 nm and 210 nm, respectively. These results indicate that the surface quality of Mo on PET thin films improves with a decrease of the film thickness. In all cases conical features clearly seen on the film surfaces were the cause of the surface roughness. It is important to note that surface smoothness is a highly desired parameter for the coatings that are used for optical applications in order to reduce the reflection loss due to roughness-induced surface scattering.

From the X-ray diffraction spectra, the intensity of the main peaks is determined as a quantitative measure of the crystallinity. Thus, for Mo films on the PET substrate, a broad diffraction peak corresponding to the PET substrate was observed at 2θ angle 26^0. Mo belonging to the cubic system with

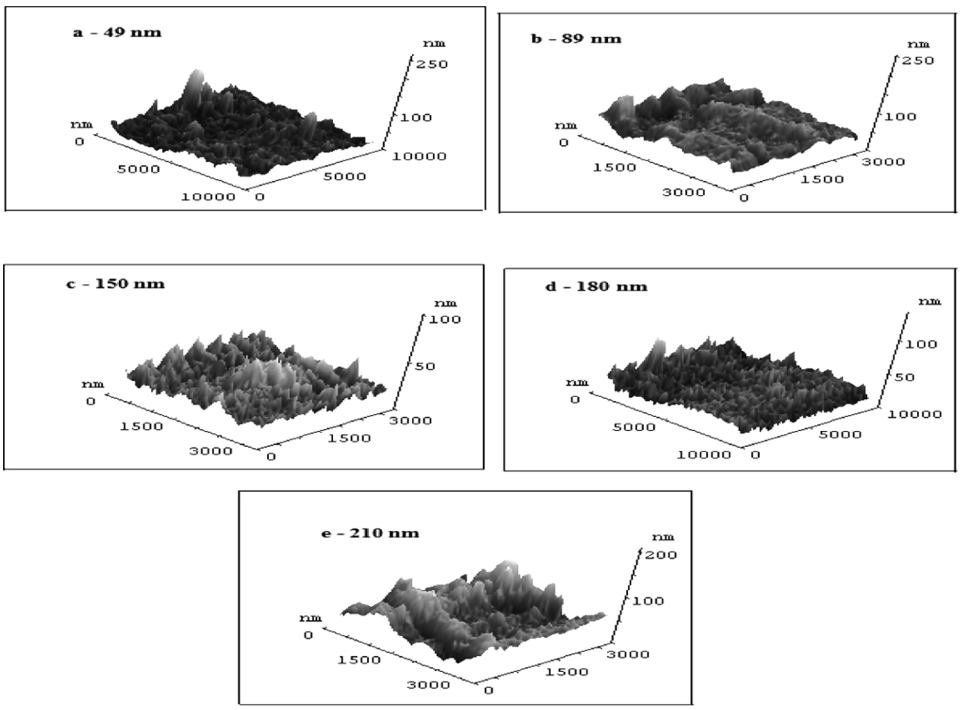


Figure 1: Variation of the Mo films roughness with thickness.

the (1 1 0) preferred orientation has been identified, as shown in Figure 2. This orientation is the most commonly presented in the literature [5]. The vertical lines below indicate the corresponding reflection peaks for Mo thin films. Figure 3 showed that the chemical components of the products were Mo, O. The presence of the oxygen small peak in the spectrum is due to the PET substrate.

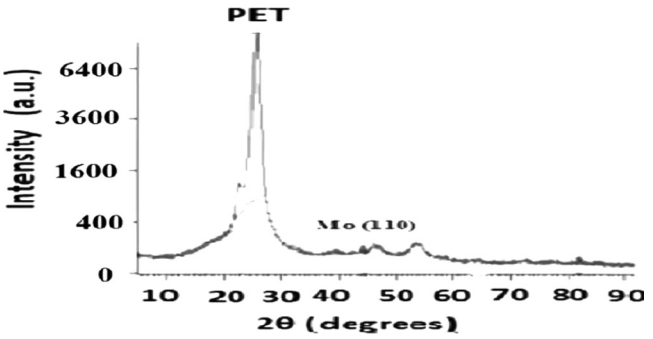


Figure 2: XRD spectrum of Mo on PET substrates.

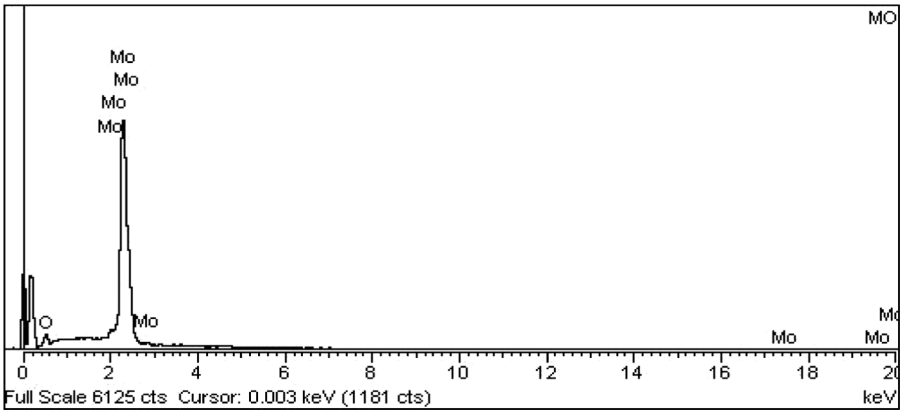
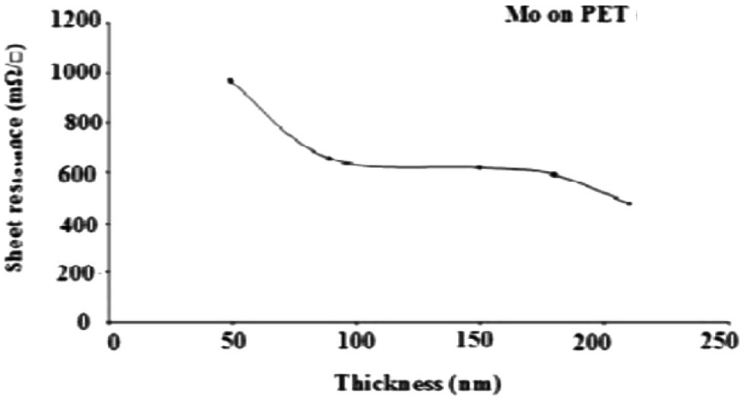
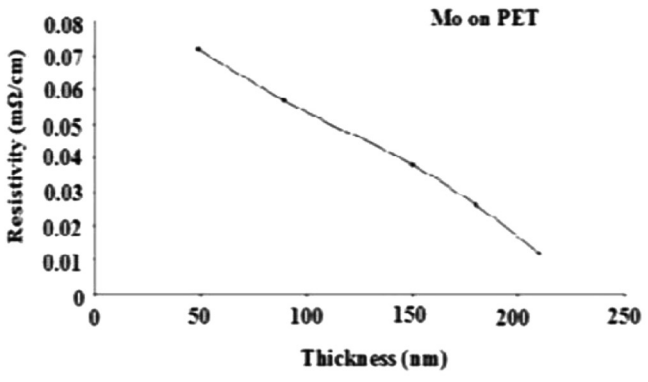


Figure 3: EDX of Mo deposited on PET.



(a)



(b)

Figure 4: Variation thickness with (a) sheet resistance and (b) resistivity.

Electrical Characterization

Figure 4 shows results indicating that increasing the film thickness can also reduce the resistivity and sheet resistance of the Mo on PET films. This behavior could also be attributed to an increase of the carrier mobility induced by increasing the grain size. The lowest resistivity value we found for the Mo films was $1.3 \times 10^{-5}\,\Omega \cdot \mathrm{cm}$ at thickness (210 nm).

CONCLUSION

Mo thin films have been deposited onto PET substrates by using DC sputtering kept at room temperature. The thickness of the films varied from 49 nm to 210 nm by changing deposition times. From AFM images it was found that the root mean square roughness of film surface increased as the film thickness increased. The variations of electrical parameters such as the resistivity and sheet resistance with film thickness are correlated to the changes in the films microstructure.

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