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DEPOSITION OF ALUMINIUM NITRIDE THIN FILM ON KAPTON FILM USING SPUTTERING METHOD

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ABSTRACT

Many attempts have been made to deposited aluminium nitride (AlN) thin film by using sputtering method on flexible substrates. Deposition of AlN thin film on kapton film can potentially be used for development of flexible electronics and lab-on-chip systems. In this study, AlN thin films grown on the kapton film using radio-frequency sputtering method were explored. The AlN thin films were deposited by reactive RF sputtering of a pure aluminium target (99.999%), in an argon and nitrogen atmosphere. The structural and surface morphology properties of the deposited thin films were investigated by X-ray diffraction , field-emission scanning electron microscope and dispersive X-ray spectroscopy; while the optical properties of the deposited thin films were determined by using Fourier transform infrared spectrometer.

Keywords: Aluminium nitride; Sputtering; Thin film

INTRODUCTION

Aluminium nitride (AIN) have attracted great interest because of their appealing properties with a wide band gap (6.2eV), high hardness and high thermal conductivity [1]. Moreover, AlN also possesses properties like high resistivity, excellent chemical stability and low dielectric constant [2]. AlN films have received considerable interest as promising candidates in electronic materials for thermal dissipation, dielectric and passivation layers [3]. Its ultrahigh band-gap makes AlN an especially key material for applications in the microelectronic and optoelectronic devices such as ultraviolet detector, light emitting diodes, thermal conductor, buffer layer for GaN and ZnO due to the same wurtzite crystal structure and close lattice parameter [4] and piezoelectric materials in surface acoustic wave devices [5]. In addition to this, thermal and chemical stability of AlN films make it suitable for applications in difficult environment.

There are many techniques for growing AlN films on various substrates, such as metal organic chemical vapor deposition [6], plasma-assisted molecular beam epitaxy [7], pulsed laser deposition [8], and RF reactive sputtering [9]. The flexible substrates such as kapton films that have advantages over those on rigid substrates as they are robust, light weight, low cost and are able to absorb mechanical stress. However, growth of AlN on flexible substrates is very different from that on rigid substrates due to temperature limitations, differences in thermal expansion coefficient, and amorphous state of the polymer substrates, thus presenting a technological challenge to deposit high-quality AlN films on flexible substrates [10]. Although some effort has been made to fabricate AlN thin film-based devices on polymer substrates, the research is at a very early stage.

In this paper, the AlN films were deposited on Kapton polymide film substrates by RF reactive sputtering. The the structural and surface morphology properties of the deposited thin films were determined by using by X-rays diffraction (XRD), field-emission scanning electron microscope (FESEM) and energy dispersive X-rays spectroscopy (EDX) and while optical properties of the thin films were investigated Fourier transform infrared (FTIR) spectrometer.

EXPERIMENTAL DETAILS

The AlN thin films were prepared by RF reactive magnetron sputtering from an aluminum target of 99.99% purity in high purity argon and nitrogen gas mixture. AlN films were deposited onto Kapton polymide film at room temperature (RT) and substrate temperature at 200 ^{o}C. The base pressure in the reactor chamber was less than 2×10^{-3} Pa. The applied power was kept constant at 250 W and working pressure was 8.12×10^{-2} Pa. The deposition parameters of AlN films are summarized in Table 1. The structural properties of the thin films were investigated by XRD (PANalyticalX'Pert Pro MRD) with a Cu-kα_1 radiation source (λ=1.5406Å) whereas the surface morphology and elementary analysis the thin films were examined by FE-SEM and EDX (NOVA NANO SEM450). The optical properties of the deposited thin films were determined by using a FTIR spectrometer (Spectrum GXFT-IR, Perkin-Elmer) .

Table 1 Deposition parameters of AlN films.

Al target (purity)	99.99%
RF power (W)	250
Base pressure	Less than 2×10^{-3} Pa
Substrate	Kapton polymide film
Working pressure	8.12×10^{-2} Pa
Substrate temperature	Room temperature, 200 ^{o}C

RESULTS AND DISCUSSION

Figure 1 shows XRD pattern of AlN films deposited on Kapton polymide films at room temperature and 200 ^{o}C. For thin film deposited at room temperature only peak Kapton polymide film was shown. It has been shown that, for sample at 200 ^{o}C, only the low intensity (100) reflection of wurtzite hexagonal phase of AlN was found with an appreciable amount of shift. This may be due to poor crystallinity of films with large amount of stress present, probably due to the low deposition temperature and sputtering power.

Figure 2 shows the FESEM images of the deposited AlN films at room temperature and 200 ^{o}C. It can be seen that at room temperature, the deposited AlN thin film showed a smooth and uniform surface. With the increase of the substrate temperatures at 200 ^{o}C [Figure 2(b)], its exhibited densely packed grains. Besides that, it shows a pebble-like structure. A similar morphology was also observed in other works [11]. In addition, the grain size increases obviously. It is attributed to the improved surface mobility of the adatoms caused by increasing the substrate temperature [2]. These images showed that the application of growth temperature has a significant influence on the surface morphology of the synthesized films.

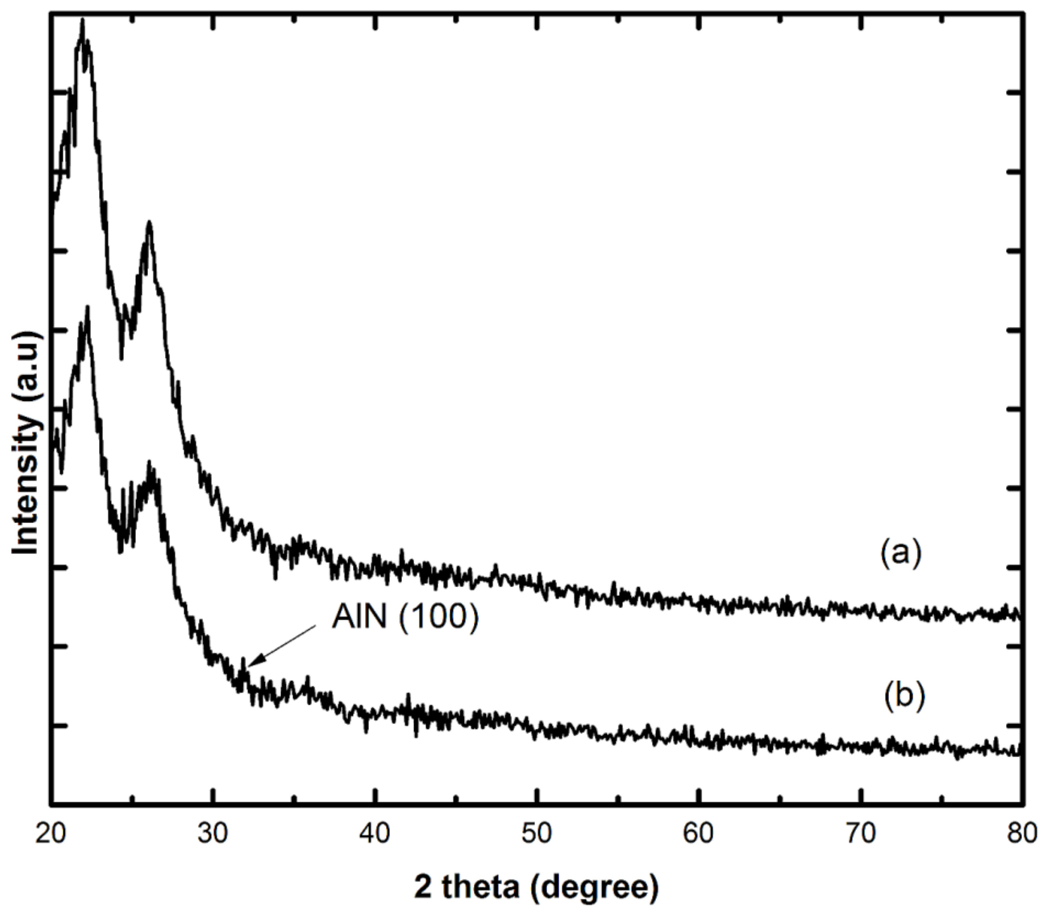

Figure 1: XRD patterns of the deposited AlN thin films on Kapton polymide film at : (a) room temperature and (b) 200 °C.

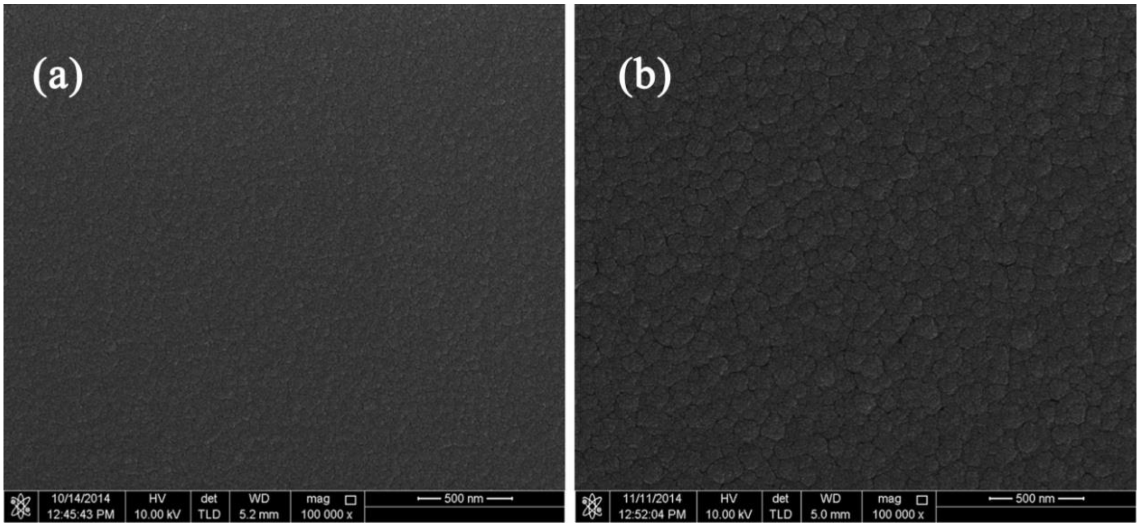

Figure 2: FESEM images of AlN thin films deposited on Kapton polymide film substrates at different substrate temperatures: (a) room temperature and (b) 200 °C

Table 2 shows the EDX analysis for AlN thin films on Kapton polymide films. This part focuses on the atomic percentage of the elements that presence in the films. The results show the presence of nitrogen (N), oxygen (O) and aluminum (Al) elements in the films. It can be seen the atomic percentages for Al and N increased with increasing of substrate temperature. However, atomic percentages for O decreased with increasing of substrate temperature. The presence of the oxygen in the deposited thin film is associated to the common contamination of AlN in non-equilibrium growth techniques such as sputtering [12].

Table 2: The EDX atomic percentage of AlN thin films on Kapton polymide films

Sample	**Element (atomic %)**		
	Aluminium	**Nitrogen**	**Oxygen**
RT	27.02	12.63	60.35
200 ^{o}C	31.41	27.39	41.2

FTIR is an effective technique to investigate the characteristic vibrational modes of the lattice [13]. Figure 3 depicts FTIR reflectance spectra for AlN thin films deposited on Kapton polymide films substrates over the entire range from 400 to 7000 cm^{-1}. It is observed that the optical phonon corresponds to the E_1(TO) of the AlN located at approximately 668 cm^{-1} and 678 cm^{-1} for room temperature and 200 ^{o}C, respectively. The obtained E_1(TO) values are slightly shifted from the reported value 670 cm^{-1} [14]. On the other hand, the spectrums revealed a dip at approximately 850 cm^{-1} and 810 cm^{-1} corresponds to the coupled phonon-plasmon mode arising from the impurity scattering happened at the lateral surface [15, 16]. The occurrence is probably induced by the incorporation of oxygen contaminants in the deposited thin films.

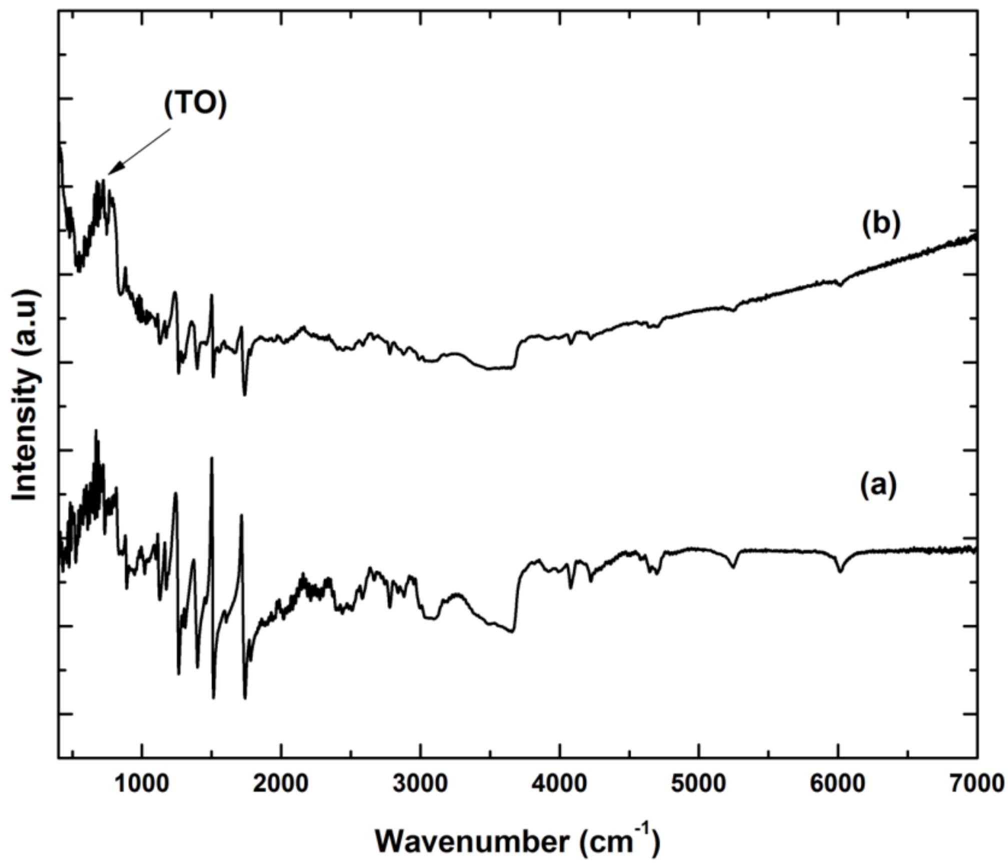

Figure 3: FTIR reflectance spectra of AlN thin films deposited on kapton polymide films at : (a) room temperature and (b) 200 °C

CONCLUSION

In conclusions, the AlN thin film were deposited on Kapton polyimide films by RF sputtering method. The structural, surface morphologies and optical properties of thin films were systematically investigated. All the results revealed that the RF sputtering is a feasible technique to produce AlN thin film on Kapton polymide films. The obtained results revealed that substrate temperatures play an important role for the growth of AlN thin films. The application of substrate temperature during the growth process has played an important role in defining the surface morphology of the deposited thin films. However, further optimization need to be done to improve the crystalline quality of the deposited thin films.

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