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Structural and optical characterization of DC reactive magnetron sputtered Cu_3N films

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ABSTRACT

Dc reactive magnetron sputtering technique was employed for deposition of copper nitride films on glass substrates under different sputtering pressures in the range $1x10^{-2}$ – $1x10^{-1}$ mbar. The influence of sputtering pressure on the structural and optical properties was systematically investigated.

Key words: DC reactive magnetron sputtered Cu_3N films.

INTRODUCTION

The interest in copper nitride films had been growing in recent years due to its potential applications as write-once optical recording media[1]. It is known to be stable at room temperature but starts to decompose into Cu and N_2 upon heating. By exploit this property of locally decomposing by electron beam irradiation, $1 \times 1\ \mu m^2$ copper dot array can be written on the copper nitride films[2]. Various thin film deposition techniques such as ion assisted deposition[3], pulsed laser deposition[4], and dc and rf sputtering[5-7] were employed for the preparation of Cu_3N films. Among these techniques, dc magnetron sputtering is industrially practiced technique for the preparation of films on large area substrates. We earlier reported the influence of nitrogen partial pressure on the electrical and optical properties of Cu_3N films[8]. The present investigation is aimed at the deposition of Cu_3N films by dc reactive magnetron sputtering at different sputtering pressures in the range 1×10^{-2}-1×10^{-1} mbar and studied the influence of sputtering pressure on the structural and optical properties.

EXPERIMENTAL

Cu_3N thin films were deposited on glass substrates by dc reactive magnetron sputtering. The sputtering system is capable of creating an ultimate vacuum of $3x10^{-6}$ mbar. Cu_3N films were deposited at a nitrogen partial pressure of 1×10^{-3} mbar and substrate temperature of 423 K under various sputtering pressures in the range 1×10^{-2} - 1×10^{-1} mbar. The films were characterized by studying the crystallographic structure by X- ray diffraction and optical properties by measuring the optical transmittance using the spectrophotometer.

RESULTS AND DISCUSSION

The deposition rate was highly influenced by the sputtering pressure. The deposition rate of the films decreased from 23 nm/min to 11.5 nm/min with the sputtering pressure increased from 1×10^{-2} mbar to 1×10^{-1}mbar respectively. When the sputtering pressure increased the density of the sputtering gas increased, the mean free path of the sputtered particle decreased. More collisions occur when the sputtered particles travel from the target to the substrate and some of the sputtered particles were scattered hence the decrease in the deposition rate with the increase of sputtering pressure[6].

The XRD patterns of Cu_3N films deposited at different sputtering pressures are shown in fig.1. The films formed at low sputtering pressure of 1.5×10^{-2} mbar exhibited two peaks related to the (100) and (111) planes of Cu_3N. The diffraction profiles indicated that the films were polycrystalline

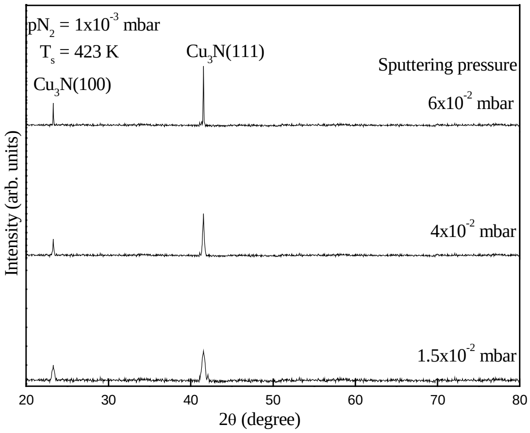

Fig.1: XRD patterns of Cu_3N films

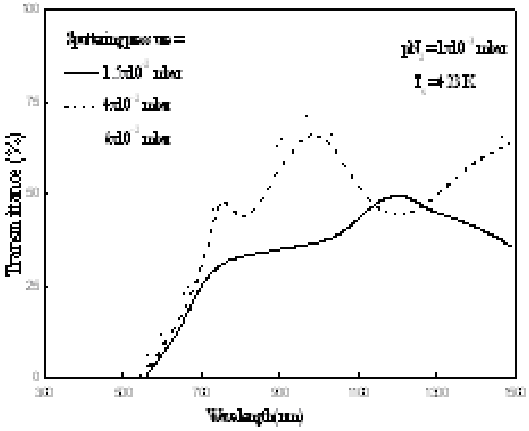

Fig. 2: Optical transmittance of Cu_3N films

in nature with cubic structure. The increase of sputtering pressure to $6x10^{-2}$ mbar the intensity of the (100) and (111) planes increased due to the improvement in the crystallinity of the films. The improvement in the crystallinity with the increase of sputtering pressure was also noticed in dc reactive sputtered ZnO films[9]. The grain size of the films was in the range 10-25 nm.

The optical transmittance spectra of the Cu_3N films formed at different sputtering pressures are shown in fig.2. The optical transmittance of the films (wavelength > 700 nm) increased with increase of sputtering pressure. At low sputtering pressures, the defect centers present in the film scatter the light hence of low optical transmittance[10]. When increasing the sputtering pressure the density of defect centers decreased thereby increase in the optical transmittance. The optical band gap of the films increased from 1.51 eV to 1.88 eV with increase of sputtering pressure from 1.5×10^{-2} mbar to 6×10^{-2} mbar.

Conclusions

Thin films of Cu_3N were deposited under various sputtering pressures in the range 1×10^{-2}-1×10^{-1} mbar by dc reactive magnetron sputtering. The films were characterized by studying the crystallographic structure and optical absorption. The films formed at a sputtering pressure of $4x10^{-2}$ mbar were polycrystalline with a grain size of 15 nm with an optical band gap of 1.84 eV.

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