18p-A11-2

Electronic conductivity of impurity-doped Zn_3N_2 thin films

Chubu Univ.　°X. Cao, K. Watarai, Y. Ninomiya, A. Sato, N. Yamada

E-mail: jscaoxiang@126.com

***INTRODUCTION*:**　Zn_3N_2 is an n-type nitride semiconductor. It has a relatively wide band-gap value of 3.26~2.30 eV [1] and a small electron effective mass of ~0.3m_0 (m_0 denotes free electron mass). Therefore, Zn_3N_2 is expected to be a transparent conductor with excellent conductivity. We have investigated electrical and optical properties of undoped Zn_3N_2 polycrystalline films fabricated by sputtering. Nitrogen-deficient $Zn_3N_{2-\delta}$ films showed low resistivities (ρ) of the order of 10^{-3} Ω cm [2]. To establish Zn_3N_2 as a transparent conductor, further reduction of ρ is still needed. One way to reduce ρ is impurity-doping. Thus, we have tried impurity doping into Zn_3N_2. We found that oxygen is one of effective dopants to suppress ρ.

***EXPERIMENTS*:**　Oxygen-doped Zn_3N_2 thin films were deposited on glass substrates heated at 200 °C by reactive RF magnetron sputtering method using a metal Zn target. Film deposition was conducted in a mixture gas of Ar, N_2, and O_2 with various flow ratios of $f(O_2) = O_2 / (Ar + N_2 + O_2)$ ranging from 0.0% to 0.5% at 0.1% interval. Meanwhile, $f(N_2) = N_2 / (Ar + N_2 + O_2)$ was kept fixed at 80%.

RESULTS & DISCUSSION: X-ray diffraction (XRD) patterns shown in Fig. 1 indicate that all the films were phase-pure Zn_3N_2 polycrystalline films. Fig. 2 displays ρ, carrier density (n_e) and Hall mobility (μ_H) as functions of $f(O_2)$. The minimum ρ value of 6.2×10^{-4} Ω cm was obtained at $f(O_2)$=0.2%, where n_e reached the maximum value of 1.2×10^{20} cm^{-3}. From these results, we inferred that oxygen acts as an effective electron donor in the Zn_3N_2 films. As $f(O_2)$ increased from 0.2% to 0.5%, ρ increased as a result of a reduction of n_e. The n_e reduction is probably due to the degradation of crystallinity as shown in Fig. 1. It should be noted that oxygen-doped Zn_3N_2 films have μ_H values larger than 60 $cm^2 V^{-1} s^{-1}$. These values are 1.5 times larger than those of conventional transparent conductors like Sn-doped In_2O_3. Therefore, oxygen-doped Zn_3N_2 can be a high-mobility transparent conductor.

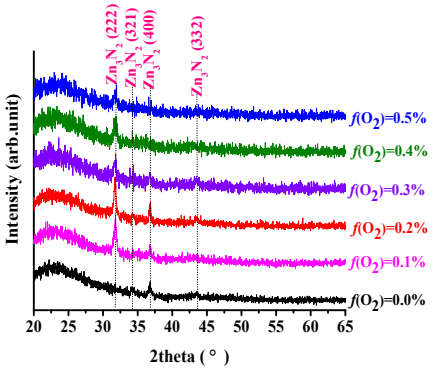

Fig.1 XRD patterns of Zn_3N_2 films deposited at various $f(O_2)$.

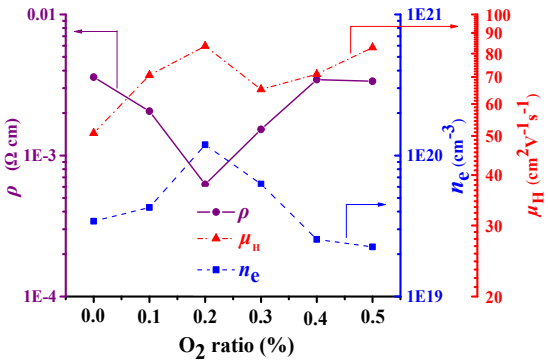

Fig.2 Plots of ρ, n_e, and μ_H as function of $f(O_2)$.

REFERENCES

[1] Futsuhara *et al.*, Thin Solid Films. **317**, 322 (1998).

[2] Yamada *et al.*, Jpn. J. Appl. Phys. **53**, 05FX01 (2014).