Microstructures and Optoelectronic Properties of Cu_3N Thin Films and its Diode Rectification Characteristics

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Rapidly growing applications of p-type Copper nitride (Cu_3N) films in optical storage media, photovoltaics etc. has motivated us to study Cu_3N thin films which were deposited on glass and silicon substrates by reactive magnetron sputtering at 150˚C from a metallic copper target. Until now, few researchers have studied the p-type conductivity of Cu_3N films which is low compared to the result obtained in our experiment. In this work, we discuss the effects of working pressure on the microstructures, electrical, and optical properties of the Cu_3N films. The working pressures were varied from 5 mtorr to 23 mtorr while gas flow rate was kept constant at $N_2/(Ar+N_2)\%=40\%$. When the working pressure increases, the Cu_3N (111) peak intensity decreases as evident from XRD studies. Meanwhile, conduction type changes from n-type to p-type. When working pressure is increased to 15 mtorr, the resistivity is 1.575 Ω•cm and the sample shows p-type conduction. This is possibly due to the formation of many copper vacancies (i.e. vacancies at Cu cation sites) in the films. When the working pressure is 5 mtorr, a Cu (111) pattern was observed from selected area electron diffraction (SAED) by TEM analysis. It disappears upon increasing the working pressure to 15 mtorr. It was also found that the ratio of Cu^{2+}/Cu^{+} increases from 0.39 to 0.93 when the working pressure is raised from 5 mtorr to 20 mtorr. More substitution of Cu^{2+} for Cu^{+} results in the formation of more Cu vacancies, which leads to the transition in conduction from n-type to p-type. Finally, n-type Cu_3N/p-type Cu_3N homojunctions and n-type ZnO/p-type Cu_3N heterojunctions diodes were fabricated. It was found that homojunction devices Al/n-type Cu_3N/p-type Cu_3N do not show significant rectification effects. As we observed, at ±3Volts, the I_{on}/I_{off} was only 0.24. Whereas, in heterojunction devices Al/n-type ZnO/p-type Cu_3N, a higher I_{on}/I_{off} of 3118 can be achieved. Heterojunction devices outperform the homojunction devices instead of interfacial issues indicating the superior electrical properties which are explained considering the mismatch in the built-in potentials of the p-n junctions.

Keywords: Cu_3N thin films, reactive magnetron sputtering, homojunctions, heterojunctions, working pressure. Thin films, sputtering, homojunctions, heterojunctions, and electrical properties

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