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Structural studies of ZnS thin films grown on GaAs by RF magnetron sputtering

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X-ray diffraction (XRD) studies of ZnS thin films grown on GaAs (001) substrates at different temperatures by rf magnetron sputtering have been carried out using CuKα radiation. XRD analysis reveals that deposited films below 335 °C, assumed the zinc blend structure. Samples annealed at above 335 °C showed mixed phases of the zinc blend and wurzite structures. Information about crystallite size is obtained from (001), (111) and (104) diffraction peaks. The average crystallite size of the film was determined to be ~ 32 nm using the Scherrer formula.

1. Introduction

Wide band gap semiconductors containing a great number of defects, surface states or doped with optically active luminescence centres, have created new opportunities for optical studies and development of applications [1–4]. Deep-level energy bands allow semiconductor materials to emit at longer wavelengths. Then it is possible to fabricate LEDs from these materials [5]. Nevertheless for some uses, it has been shown that such materials must be grown with a monocrystalline structure and a smooth surface [6,7]. Zinc sulfide (ZnS), an important semiconductor compound of the IIB-VI groups, is mostly found in one of two structural forms cubic sphalerite or hexagonal wurtzite, which have wide bandgaps of 3.54 eV and 3.80 eV, respectively at 300 K [8]. It is a well-known luminescence material having prominent and promising applications in displays, sensors and blue-light emission device application [9].

ZnS has been grown on Si and GaAs substrates [9–11]. It is closely lattice matched with Si (0.2%), which makes it a promising material for the integration in optoelectronic devices on Si substrates. However, ZnS and Si exhibit a large thermal expansion coefficient mismatch (136%) while the thermal expansion coefficients of ZnS and GaAs are better matched (10.5%). Furthermore, ZnS and GaAs exhibit a large lattice constant mismatch (4.5%). Growth of ZnS thin films has been conventionally done using several methods, such as chemical vapour deposition (CVD) [12], molecular beam epitaxy (MBE) [13], atomic layer epitaxy (ALE) [14], metallorganic chemical vapour deposition (MOCVD) [15], successive ionic layer adsorption and reaction methods (SILAR) [10], metallorganic vapour phase epitaxy (MOVPE) [16], pulsed laser deposition (PLD) [17] and electron induced epitaxy (EIE) [11].

Recently, we have used rf magnetron sputtering to grow a variety of materials including GaAs, Ge, Si and some other combinations of them [18–23]. This technique can deposit large area films of well-controlled compositions economically and the growth rate is high enough for thick films and low enough for ultrathin films by changing the sputtering time [24].

In the present work, we report the growth and structural studies of ZnS thin films on GaAs (001) at various temperatures (180–630 °C) using a rf planar magnetron sputtering system. Effects of temperature during the sputtering with Ar plasma on crystalline quality, particle size and morphology, of the thin films were studied by X-ray diffraction (XRD) and Atomic Force Microscopy (AFM).

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