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

V.L. Gayou a,b,*, B. Salazar-Hernandez b, M.E. Constantino b, E. Rosendo Andrés c, T. Díaz c, R. Delgado Macuila a, M. Rojas López a

a Centro de Investigación en Biotecnología Aplicada. Instituto Politécnico Nacional-Tlaxcala Km. 1.5 Carretera Estatal Tecuexcomac-Tepetitla, Tepetitla de Lardizabal, C.P. 90700 Tlaxcala, México
b Centro de Investigaciones en Ingeniería y Ciencias Aplicadas. Facultad de Ciencias Químicas e Ingeniería. Universidad Autónoma del Estado de Morelos. Av. Universidad # 1001, Col. Chamilpa, Cuernavaca, Morelos C.P. 62210, México
c Centro de Investigación en Dispositivos Semiconductores. Instituto de Ciencias de la Universidad Autónoma de Puebla. 14 Sur y San Claudio Col. San Manuel, Puebla, Pue. C.P. 72570, México

PACS: 61.46.-w
68.37.Ps
68.55.-a

Keywords: Sputtering Nanoparticles ZnS XRD AFM

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 II-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).