INSTITUTE OF PHYSICS PUBLISHING SEMICONDUCTOR SCIENCE AND TECHNOLOGY

Semicond. Sci. Technol. **18** (2003) L9–L11 PII: S0268-1242(03)52349-5

LETTER TO THE EDITOR

Sharp variations in the temperature dependence of optical reflectivity from AlN/GaN heterostructures

V V Ursaki[1], I M Tiginyanu[1], N N Syrbu[1], V V Zalamai[1], S Hubbard[2] and D Pavlidis[2]

[1] Laboratory of Low-Dimensional Semiconductor Structures, Institute of Applied Physics, Technical University of Moldova, Chisinau 2004, Moldova
[2] Solid State Electronics Laboratory, The University of Michigan, Ann Arbor, MI 48109-2122, USA

E-mail: tiginyan@mail.utm.md

Received 13 August 2002, in final form 5 December 2002
Published 24 December 2002
Online at stacks.iop.org/SST/18/L9

Abstract

Sharp variations in optical reflectivity were observed when cooling and heating AlN/GaN heterostructures on sapphire substrates between room temperature and 10 K. The reflectivity was found to decrease at a definite temperature T_k in the downward temperature run, and to recover at $T_\mathrm{r} > T_\mathrm{k}$ in the subsequent upward temperature run. The temperature behaviour of reflectivity exhibits memory on the cooling–heating cycles previously subjected to samples.

GaN and related alloys are presently the most attractive materials for fabrication of optoelectronic devices in the ultraviolet and blue energy regions [1, 2]. Apart from this, the AlGaN/GaN heterostructure field-effect transistors (FETs) have emerged as attractive candidates for high-voltage, high-power operation at micro-wave frequencies [3–5]. Due to the lack of suitable nitride substrate material, heteroepitaxial growth on sapphire or 6H-SiC substrates is a common practice. The lattice mismatch between GaN and substrate materials causes the growth of GaN layers exhibiting a specific morphological feature, namely mosaicity or domain structure [6]. From crystallographic point of view, the submicrometre-size single crystalline domains are usually tilted and/or rotated (twisted) with respect to each other [6, 7]. According to [8], a GaN epilayer may be considered as a heterogeneous system consisting of three phases, namely of single crystalline GaN grains, inter-granulated material and pipes (voids). The morphology of GaN epilayer, in its turn, strongly influences the crystalline quality of the top AlN film.

In this work, we used optical reflectivity to characterize AlN/GaN heterostructures in the temperature range 10–300 K. Sharp temperature-induced changes in optical reflectivity were observed which are believed to be initiated by the variation of strains with temperature.

The GaN and AlN layers were grown by low-pressure (60–110 Torr) metalorganic chemical-vapour deposition (MOCVD) on *c*-plane (0001) sapphire substrates. Standard precursors of trimethylgallium (TMGa), trimethylaluminium (TMAl) and ammonia (NH_3) were used as alkyl and hydride sources [9]. The alkyl and hydride sources were kept separate until reaching the quartz reactor. The carrier gas was Pd-cell purified hydrogen (H_2). Heating was accomplished by RF induction of the graphite susceptor. Switching of all valves and manifolds was done using computer control. The sapphire substrates were initially cleaned in trichloroethylene, acetone, isopropyl alcohol and H_2SO_4/H_3PO_4. After a high-temperature (1200 °C) cleaning in H_2, the growth temperature was lowered to 500 °C. Nitridation was performed and then an ~20 nm thick GaN nucleation layer was grown. After ramping the temperature to 1100 °C, a 1300 nm unintentionally doped GaN channel layer was grown. The thickness of the top AlN film was 5 nm.

The quality of the GaN layer and the presence of the AlN thin film were confirmed using a high-resolution x-ray diffractometer (HRXRD). The $\theta/2\theta$ XRD scans have shown