Superlattices and Microstructures 56 (2013) 64–76

Contents lists available at SciVerse ScienceDirect

Superlattices and Microstructures

journal homepage: www.elsevier.com/locate/superlattices

Electrical and structural properties of Ir/Ru Schottky rectifiers on n-type InGaN at different annealing temperatures

R. Padma, B. Prasanna Lakshmi, M. Siva Pratap Reddy, V. Rajagopal Reddy *

Department of Physics, Sri Venkateswara University, Tirupati 517 502, India

ARTICLE INFO

Article history:
Received 1 September 2012
Received in revised form 18 December 2012
Accepted 28 December 2012
Available online 9 January 2013

Keywords:
Electrical and structural properties
Ir/Ru Schottky contacts
n-Type InGaN
Interface state density
Auger electron spectroscopy
X-ray diffraction

ABSTRACT

The effect of annealing temperature on interface properties of iridium/ruthenium (Ir/Ru) Schottky contacts on n-type InGaN have been investigated by current–voltage (*I–V*), capacitance–voltage (*C–V*), Auger electron spectroscopy (AES) and X-ray diffraction (XRD) techniques. An as-deposited Ru/Ir/n-InGaN Schottky diode exhibits a barrier height of 0.61 eV (*I–V*) and 0.79 eV (*C–V*), which increases to 0.71 eV (*I–V*) and 0.96 eV (*C–V*) after annealing at 200 °C. A maximum barrier height of 0.73 eV (*I–V*) and 1.02 eV (*C–V*) is achieved for the Ir/Ru Schottky contacts after annealing at 300 °C. Further, it is observed that the Schottky barrier height slightly decreases upon annealing at temperatures of 400 °C and 500 °C and the obtained values are 0.68 eV (*I–V*), 0.93 eV (*C–V*) and 0.66 eV (*I–V*), 0.86 eV (*C–V*), respectively. The Norde and Cheung's methods are used to extract the barrier height (Φ_b), ideality factor (n) and series resistance (R_s). The interface state density is also determined by Terman's method. According to the above results, the optimum annealing temperature for Ru/Ir/n-InGaN Schottky diode is 300 °C. Based on the AES and XRD analysis, the formation of gallide phases at the Ru/Ir/n-InGaN interface could be the reason for the increase of Schottky barrier heights upon annealing temperatures. It is noted that overall surface morphology of Ir/Ru Schottky contacts is reasonably smooth even after annealing at 500 °C as observed from AFM results.

© 2013 Elsevier Ltd. All rights reserved.

* Corresponding author. Tel./fax: +91 877 2249472.
E-mail address: reddy_vrg@rediffmail.com (V. Rajagopal Reddy).

0749-6036/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.spmi.2012.12.016

1. Introduction

Gallium nitride (GaN) and related alloys have been of great interest in the fabrication of electronic devices due to their superior properties such as high breakdown field, good thermal conductivity, and high electron saturation velocity [1]. Although, $Al_xGa_{1-x}N$ alloys are important for power devices and deep ultraviolet emitters, $In_xGa_{1-x}N$ alloys with band gap ranging from 0.7 to 3.4 eV covering the entire visible spectrum are of interest for many future optoelectronics and energy applications. Besides, high indium (In) composition $In_xGa_{1-x}N$ alloys also posses significant potential for high speed device applications due to their small effective mass and high mobility [2]. In recent years, applications of InGaN alloys have expanded into areas such as optoelectronics/photonics, solar cells, photo electrochemical cells for hydrogen generation, and thermoelectric materials for converting heat to electricity [3–8]. It is very important to obtain high quality Schottky contacts to improve device performance and reliability. In particular, high temperature device applications require good thermal stability as well as high Schottky barrier height with low leakage current. Hence, it is essential to understand the behavior of metal contacts to InGaN at high temperatures.

Several research groups have extensively studied the electrical properties of n-InGaN Schottky diodes using various metallization schemes [9–15]. For example, Jang et al. [9] fabricated Pt Schottky contacts on n-InGaN and studied its electrical properties by means of the *I–V* and *C–V* methods. They reported that there was a large difference in the SBHs obtained by the TE and TFE modes using *I–V* data. Jun-Jun et al. [10] fabricated Au/Pt/$In_{0.2}Ga_{0.8}N$/GaN heterostructure Schottky prototype solar cell, reported that the thermionic emission is a dominating current transport mechanism at the Pt/InGaN interface. Cheng et al. [11] fabricated AlInGaN metal–insulator-semiconductor (MIS), ultraviolet (UV-C) photodetectors with a Ni/Ir/Au multilayer contact. They found that the dark current of photodetectors significantly reduced and enhance the device performance after inserting high work function metal (Ir). Sang et al. [12] prepared the thermally stable high performance InGaN MIS photodetectors (PDs) by using CaF_2 as the insulation layer. They studied reverse leakage current and UV responsivity at −3 V under 523 K without observing the persistent photoconductivity. Lin et al. [13] fabricated Ni/InGaN/GaN Schottky barrier solar cells with different indium (In) contents (x = 0.07/0.13). They found that the high crystal quality was a key factor to obtain high performance InGaN-based Schottky barrier solar cells. Shao et al. [14] investigated the current transport mechanisms of InGaN metal–insulator-semiconductor (MIS) photo detectors with two different insulating layers of Si_3N_4 and Al_2O_3. They reported that the photoelectric responsivity of metal-Si_3N_4–InGaN photodetector has lower than the metal-Al_2O_3–InGaN photodetector. Recently, Reddy et al. [15] investigated the detailed electrical properties of rapidly annealed Ir and Ir/Au Schottky contacts on n-InGaN. They found that 300 °C was the optimum annealing temperature for both Ir and Ir/Au Schottky contacts on n-InGaN.

There are, however, only limited works on n-InGaN-based Schottky barrier diodes because of their low carrier mobility and a large amount of surface defects in InGaN layers (compared with GaN) [16]. A good Schottky contact will induce a large barrier height which can lead to better device characteristics such as small leakage current and high breakdown voltage. Therefore, the main goal of the present work is to fabricate and characterize the Ir/Ru Schottky contacts on n-type InGaN. To the best of our knowledge, Ir/Ru metal scheme has not been explored as Schottky contacts on n-type InGaN to date. In this work, we investigate the detailed electrical, structural and surface morphological properties of Ir/Ru Schottky contacts on n-InGaN ($N_d = 7 \times 10^{17}\ cm^{-3}$) as a function of annealing temperature.

2. Experimental details

The samples used in this work were 2 μm thick unintentionally doped GaN layer on a 40-nm-thick nucleation layer/(0001) sapphire substrate was grown by metal organic chemical vapour deposition (MOCVD), followed by the growth of 0.25 μm-thick-n-InGaN:Si with indium composition of 10%. The carrier concentration obtained by means of Hall measurements (Lake Shore Model-7604) was $7 \times 10^{17}\ cm^{-3}$. First, the n-InGaN layer was ultrasonically degreased with warm trichloroethylene

Download English Version:

https://daneshyari.com/en/article/1553729

Download Persian Version:

https://daneshyari.com/article/1553729

Daneshyari.com