Superlattices and Microstructures 71 (2014) 134–146

Contents lists available at ScienceDirect

Superlattices and Microstructures

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

# Electrical and structural properties of tungsten Schottky contacts to p-type InP at different annealing temperatures

V. Rajagopal Reddy [a,b,*], D. Sri Silpa [a], Hyung-Joong Yun [b,c], Chel-Jong Choi [b,*]

[a] Department of Physics, Sri Venkateswara University, Tirupati 517 502, India
[b] School of Semiconductor and Chemical Engineering, Semiconductor Physics Research Center, (SPRC), Chonbuk National University, Jeonju 561-756, Republic of Korea
[c] Division of Material Science, Korea Basic Science Institute, Daejeon 305-806, Republic of Korea

ARTICLE INFO

*Article history:*
Received 13 January 2014
Received in revised form 5 March 2014
Accepted 12 March 2014
Available online 27 March 2014

*Keywords:*
InP
W Schottky contacts
Annealing effects
Interface state density
Depth profiles
X-ray diffraction

ABSTRACT

The electrical and structural properties of a fabricated W/p-InP Schottky barrier diode (SBD) have been investigated as a function of annealing temperature. The W/p-InP SBD exhibits good rectification behavior. The barrier height (BH) and ideality factor of the W/p-InP SBD are determined to be 0.82 eV (*I–V*)/0.98 eV (*C–V*) and 1.34, respectively. However, the BH is increases to 0.87 eV (*I–V*)/1.08 eV (*C–V*) after annealing at 300 °C. When the SBD is annealed at 400 °C, the BH decreases to 0.74 eV (*I–V*)/0.86 eV (*C–V*) and the ideality factor increases to 1.45. Results indicate that a maximum BH is obtained on the W/p-InP SBD at 300 °C. Norde method is also employed to determine BHs of W/p-InP SBD which are in good agreement with those estimated by the *I–V* method. Further, Cheung method is used to estimate the series resistance of the W/p-InP SBD, and the consistency is checked using the Norde method. Besides, the energy distribution of interface state density is determined from the forward bias *I–V* data at different annealing temperatures. Auger electron spectroscopy and X-ray diffraction studies revealed that the formation of W-P interfacial phases at the W/p-InP interface may be the cause for the increase of BH upon annealing at 300 °C. AFM results indicated that the overall surface morphology of the W/p-InP SBD did not change significantly at elevated temperatures.
© 2014 Elsevier Ltd. All rights reserved.

* Corresponding authors. Address: Department of Physics, Sri Venkateswara University, Tirupati 517 502, India. Tel.: +91 8772249472 (V. Rajagopal Reddy).
*E-mail addresses:* reddy_vrg@rediffmail.com (V. Rajagopal Reddy), cjchoi@chonbuk.ac.kr (C.-J. Choi).

http://dx.doi.org/10.1016/j.spmi.2014.03.016
0749-6036/© 2014 Elsevier Ltd. All rights reserved.

## 1. Introduction

III–V compound semiconductors, especially indium phosphide (InP) are attractive material for electronic and optoelectronic device applications such as solar cells, laser diodes, photo-detectors, high electronic mobility transistors (HEMTs) and high speed metal–insulator–semiconductor field effect transistors (MISFETS), microwave sources and amplifiers operating at high power and high frequencies with low noise due to the direct band gap, high electron mobility, high substrate velocity and breakdown voltage [1–5]. Since, the electrical characteristics of the Schottky barrier diode (SBD) strongly depend on the quality of metal–semiconductor (MS) interface [6–8], it is essential for the development of high quality MS contacts. The performance of MS contacts depends mostly on the selection of the metal, the doping density of the semiconductor and the quality of the semiconductor surface prior to the metal deposition. Therefore, the development of Schottky contacts to InP with high barrier height and low-reverse leakage current is still a scientific challenge.

Previously, various metallization schemes have used for the fabrication of Schottky rectifiers on p-type InP by several research groups [9–16]. For example, Asubay et al. [10] investigated the electrical properties of Au/p-InP/Zn–Au SBDs by current–voltage (*I*–*V*) method. They found that the barrier height of the as-deposited SBDs varied from 0.58 to 0.72 eV and ideality factor $n$ from 1.14 to 1.47, and for the annealed at 400 °C SBDs varied from 0.76 to 0.82 eV and ideality factor n from 1.17 to 1.39. Varenne et al. [11] fabricated the Pd and Au pseudo-Schottky contact on p-InP as a function of metal species and thickness and studied its electrical parameters by *I*–*V* measurements. They found that the pseudo-Schottky junctions exhibited a significant barrier height enhancement. Ejderha et al. [12] investigated the electrical characteristics of the sputtered Ni/p-InP Schottky diodes in the temperature range of 60–400 K, and reported that the series resistance ($R_s$) and the interface state density ($N_{ss}$) values increase with a decrease in temperature. Asubay [13] prepared Al/p-InP Schottky diodes and investigated its electrical properties by *I*–*V* and *C*–*V* measurements. They showed that the effective barrier heights were varied from diode to diode ranged from 0.83 ± 0.01 to 0.87 ± 0.01 eV (*I*–*V*) and 0.86 ± 0.04 to 1.00 ± 0.04 eV (*C*–*V*)). Korucu and Duman [14] investigated the current–voltage–temperature (*I*–*V*–*T*) properties of a fabricated Au/p-InP SBD, reported that the particular contact fabrication process produces a relatively high value of barrier height (0.78 eV) at room temperature. Reddy et al. [15] investigated the electrical properties and interface states of Yb/p-InP Schottky diode by current–voltage (*I*–*V*), capacitance–voltage–frequency (*C*–*V*–*f*) and conductance–voltage–frequency (*G*–*V*–*f*) measurements at room temperature. They reported that the barrier height and ideality factor of the Yb/p-InP Schottky diode were 0.68 eV (*I*–*V*)/0.79 eV (*C*–*V*) and 1.24, respectively. Very recently, Dasaradha Rao et al. [16] studied the effect of annealing temperature on the electrical and structural properties of Er/p-InP Schottky diode. They found that the increase or decrease in Schottky barrier heights upon annealing at elevated temperatures could be attributed to the formation of interfacial phases at the Er/p-InP interface vicinity according to the AES and XRD results.

In the present work, our aim is to fabricate tungsten (W) Schottky contacts on p-type InP and study its electrical and structural properties as a function of annealing temperature. There is a little information about the effects of annealing temperature, particularly rapid thermal annealing on the electrical and structural characteristics of metal/p-InP interface. Hence, it is important to know what happens to the metal contacts on p-InP during the rapid thermal annealing process. In the present work, tungsten (W) is selected because of its refractory nature and reactivity with InP. In this work, therefore, we investigate the electrical, structural and morphological properties of W/p-InP SBD at different annealing temperatures. The electronic parameters of W/p-InP SBD such as barrier height ($\Phi_b$), ideality factor ($n$), and series resistance ($R_s$) are analyzed as a function of annealing temperature. Also, these parameters are cross-checked by using different analysis techniques (forward *I*–*V*, *C*–*V*, Cheung and Norde methods) for their consistency and validity. Moreover, the interface analysis of W/p-InP SBD is discussed by auger electron spectroscopy (AES) depth profile and X-ray diffraction (XRD) measurements at different annealing temperatures.

Download English Version:

https://daneshyari.com/en/article/1553679

Download Persian Version:

https://daneshyari.com/article/1553679

Daneshyari.com