Institute of Physics Publishing | Semiconductor Science and Technology
Semicond. Sci. Technol. **19** (2004) 1273–1279 | PII: S0268-1242(04)77562-8

GaN Schottky multiplier diodes prepared by electroplating: a study of passivation technology

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Received 12 March 2004, in final form 29 July 2004
Published 16 September 2004
Online at stacks.iop.org/SST/19/1273
doi:10.1088/0268-1242/19/11/011

Abstract
This paper presents the results of a Pt/n-GaN Schottky contact technology development based on electrochemical metal deposition. Three different technological approaches are used to fabricate GaN varactor diodes. The effects of SiN_x-surface passivation and reactive ion etching (RIE) as required to define the micrometre-size Schottky contacts are investigated using photoluminescence (PL) spectroscopy and electrical characterization of the fabricated Schottky diodes. The perspective of Pt/n-GaN Schottky varactor diodes for high-frequency multipliers is estimated on the basis of dc parameters measured for a structure with a 5 μm electrode diameter.

(Some figures in this article are in colour only in the electronic version)

1. Introduction

Recently, GaN and related nitrides became the most intensively investigated semiconductor materials due to their applications in high-efficiency light emitting devices for ultraviolet and blue energy regions [1, 2]. Favourable material properties, such as high electron mobility, high chemical stability and high thermal conductivity suggest a large perspective for nitrides in the fabrication of electronic devices operating at high temperature/power and in harsh environments [3, 4]. The band gap of wurtzite GaN as large as 3.39 eV results in a large breakdown field of about 5×10^6 V cm^{-1} [5]. A high-energy separation between Γ valley and M–L valleys of 1.1–1.9 eV and the low effective electron mass in the Γ valley enable high electron drift velocity with a saturation value around 3.1×10^7 cm s^{-1} [6], which is even higher than that of GaAs traditionally used for high-frequency Schottky components. These material properties make GaN a concurrent candidate for Schottky varactor diodes suitable for high-power frequency multipliers. Unfortunately, our literature search revealed a lack of information about GaN Schottky diodes as a nonlinear element in frequency multipliers.

The development of metal–GaN contacts is critical for the successful realization of these devices. Due to the fact that the barrier height of the metal–GaN Schottky contact is not strongly pinned and significantly depends on the metal work function [7–9], Pt is one of the most important metals for GaN-based device fabrication because of its high work function, excellent electrical conductivity and chemical stability. However, there are still large discrepancies in the reported parameters of Pt/n-GaN Schottky contacts [10]. The variability appears to result from the island nature of the GaN growth on lattice-mismatched substrates on the one hand and the condition of the surface on the other hand. The metallization techniques play an important role in the Schottky barrier formation [11]. Commonly, ultra-high vacuum equipment is employed for Schottky-metal deposition. However, high energies of the metal atoms incident on the GaN surface induce interfacial defects which play a significant role in the Schottky barrier formation [12]. On the other hand,