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Dark current improvement due to dry-etch process in InAs/GaSb type-II superlattice LWIR photodetector with nBn structure

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Abstract

The dark current of long wavelength infrared (LWIR) detector should be reduced to improve performance and decrease the system size, weight and power consumption (SWaP). In this work, we present the process to reduce the dark current of T2SL LWIR detector with nBn structure. The nBn structure consists of InAs/GaSb 14/7 monolayers (MLs) contact layer and absorber separated by $Al_{0.2}Ga_{0.8}Sb$ barrier. For T2SL LWIR detector, the barrier structure is often used to reduce the dark current and passivate absorber. However, the barrier itself is very fragile and easily damaged during the device process. The proposed process was developed so that $Al_{0.2}Ga_{0.8}Sb$ barrier is not damaged by any solution from the isolation etch process to the passivation process. In this process, CHF_3 plasma treatment after the isolation etch with ICP reduced significantly the dark current. We attribute this to damage reduction of $Al_{0.2}Ga_{0.8}Sb$ barrier by CHF_3 plasma treatment. The 15 μm pitch devices fabricated with optimal process conditions showed the dark current density of less than 2.0×10^{-5} A/cm^2 at -0.3 V and 80 K.

Keywords: InAs/GaSb type-II superlattice, Long wavelength infrared, nBn detector, Dark current

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1. Introduction

LWIR imaging is used in various applications such as missile detection and tracking, satellite surveillance and monitoring of atmospheric temperature in military and civil. As the bandgap engineering technology of various compound semiconductors has developed over the last 20 years, a new type of LWIR detector such as T2SL and nBn detector with lower generation-recombination(G-R) current has been developed [1]. Especially, InAs/GaSb T2SL is characterized by suppressed auger recombination compared to bulk mercury-cadmium-telluride (MCT), thereby improving the limitation of operating temperature [2]. T2SL has high quantum efficiency by vertical absorption [3] and less compositional non-uniformity than MCT [4]. In addition, it is generally known that III-V substrates can be grown with lower defect density compared with II-VI materials [5]. For these reasons, T2SL has been considered as an alternative to MCT.

nBn structure is composed of n-type narrow bandgap contact layer and absorber separated by a thin barrier with a relatively high conduction band energy [6]. This barrier reduces the dark current by blocking the flow of electrons (majority carrier) and permits the flow of holes (minority carrier) generated by light [7]. Because T2SL nBn structure with almost no valence band offset can be implemented by bandgap engineering using 6.1 Å family III-V materials, focal plane

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