New structure of photoreceivers for optic communications

Valerian V. Dorogan, Tatiana S. Vieru, Andrei V. Dorogan
Laboratory of Micro-Optoelectronics, Technical University of Moldova
Phone: 23-54-37, Fax: 23-54-05, E-mail: dorogan@adm.utm.md

ABSTRACT

New p-i-n photodiodes on the basis of InP-InGaAs-InGaAsP heterostructures for optic communications, possessing original characteristics, are presented in the paper. Their specific photosensibility was achieved by placing the p-n junction in InGaAsP frontal layer near the interface with InGaAs active layer. The photosensibility of realized photodiodes can be controlled in spectral range 1.3-1.6 μm by reverse voltage. For reverse voltage less than a threshold one $U_{rev} < U_{thr}$ between frontal and active layers there is a potential barrier of about 0.4 eV for holes generated in active layer and they don't participate in photocurrent. For voltage $U_{rev} > U_{thr}$ the boundary of space charge region extends into the InGaAs active layer and the potential barrier disappears. Thus, charge carriers generated in active layer are easy separated and a photosensibility in spectral range 1.3-1.65 μm appears for $U_{rev} > U_{thr}$. These photodiodes haven't analog and can be successfully used in many fields of functional optoelectronics for receiving, decoding and processing the signals transferred by optic fibers.

Keywords: semiconductor, heterostructure, p-i-n photodiode, optic communications.

1. INTRODUCTION

The semiconductor heterostructures on the basis of InGaAsP compounds are successfully used for preparing the photoreceivers for spectral range 0.9 - 1.65 μm. The wavelengths used here are determined by optic windows of transparency for modern optic fibers ($\lambda_1 = 1.3$ μm and $\lambda_2 = 1.55$ μm). Unlike the Ge p-i-n photodiodes, which have the same spectral range of photosensibility, the InGaAsP photodiodes have much less dark currents and a much higher work frequency. This is owing to more advantageous fundamental properties of InP-InGaAsP heterostructures. Moreover the use of these compounds allows to integrate (in hybrid or monolithic variants) the photoreceivers, the radiation sources (LED, laser diodes) and the photocurrent amplifiers (FET), because the manufacturing technology of these elements makes agree in a large measure.

2. MANUFACTURING TECHNOLOGY

The method of liquid phase epitaxy was used for forming the heterostructures. This method, being relative easy in realization and less expensive in comparison with other modern methods (MBE, MOCVD etc.), allows to realize the photodiodes with rival parameters. The epitaxial growth process occurred in quartz reactors in pure hydrogen atmosphere. In-Ga-As-P liquid phase was prepared on the basis of In. InAs, GaAs and InP single crystals with uncontrollable impurities concentration of about 10^{15} cm^{-3} were used for liquid phase saturation. The liquid phase composition for growing the epitaxial layers with stipulated band gaps was calculated from phase diagrams of InP-InGaAsP system for epitaxial process temperature T = 650°C. Liquid phases were homogenized during the 30-40 min at a temperature higher with 30°C than epitaxial process temperature. i-InP and n-InP wafers with (100) crystallographic orientation were utilized as substrate. Graphite crucibles were thermal treated at T = 1000-1100 °C during the 15-20 hours. The epitaxial layers were grown from liquid phases by their cooling with 0.1-1 °C/min rate. Temperature interval of growing process varied in dependence on stipulated thickness of epitaxial layer and was 0.5-5 °C. Time interval of epitaxial deposition process was 10-300 s.

Information Technologies 2004, edited by Andrei M. Andriesh, Veacheslav L. Perju,
Proceedings of SPIE Vol. 5822 (SPIE, Bellingham, WA, 2005)
0277-786X/05/$15 · doi: 10.1117/12.612195