OPTICAL ABSORPTION IN EPITAXIAL STRUCTURES BASED ON INAS AT TEMPERATURES OF 80 K AND 300 K

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Epitaxial structures n-InAs growing on heavily doped substrate n++-InAs by the chloride hydride epitaxy method were investigated. Experimental spectrums of n++-InAs absorption coefficient at 83 K and 300 K were presented. Comparison of spectral dependences of the absorbed radiation portion in epitaxial layer at irradiation from the substrate side with different doping level n = (0,6-3,3)·10¹⁸ cm⁻³ was made.

Keywords: indium arsenide, InAs, the absorption coefficient, the effect of doping, Burstein-Moss effect

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Introduction

Single and matrix photo receivers with radiation sensitivity of 2,0-4,0 micron are used in gas analysis devices [1], medical thermal imaging [2], IR microscopes for scientific researches [3], laser location systems, environmental monitoring and remote Earth sensing from space [4]. Indium arsenide photodetectors are best suited for operation in this spectral range.

Photo receivers of that type are photodiodes or MIS-structures, with absorbing layer that is an epitaxial layer of undoped InAs with n-type conductivity, grown on highly doped n++-InAs substrate [5]. Photoresist exposure are usually made via highly doped substrate, with absorption band edge shifted to the short-wave spectrum range, due to the Burstein-Moss effect. Various data known from scientific publications on n++-InAs substrate bandwidth have notable differences [6, 7].

Methods and research results

Results of the research of optical absorption in n++-InAs plates, used as substrates for epitaxial growth, and in n-InAs epitaxial layers in dependence of temperature and substrate doping level are presented in this article. A comparison of spectral characteristics of absorption in epitaxial layers exposed through the substrate is made at different doping levels and temperatures.

Measurements of optical absorption were made on InAs mono-crystalline substrates IMES(100) 1,8-2,0 mm thick, in-plane positioned (100) and doped with sulfur to n = (0,6-3,3)·10¹⁸ cm⁻³. Before being measured, substrates were subject to chemical-mechanical polishing with technique described in [8]. Epitaxial layers n-InAs were grown from gas phase by chloride-hydride method [5]. Layers thickness was 6-10 micron and was operated by interference imaging in IR range [9]. Charge carrier concentration in epitaxial layer was 2-3·10¹⁵ cm⁻³.

Measurements were conducted by infrared Fourier-spectrometer VERTEX 80 (Bruker Optics), prototypes were put in closed-cycle helium cryostat. Spectrum of substrate absorption coefficient a(λ) and reflection R(λ) coefficients using a model accounting multiple reflections of scanning ray in substrate. To determine a spectrum
of undoped layer absorption coefficient, measurements of transmission and reflection coefficients were conducted for structure with epitaxial layer grown on a substrate with carrier concentration of $1.8 \times 10^{18}$ cm$^{-3}$.

As a result, spectral characteristics of absorption coefficient for prototypes with different doping level at 83 K and 300 K were obtained [10]. Increase of doping level widens the spectral bandwidth to the short-wave spectrum range. However that increases the absorption on free carriers that leads to the decrease in bandwidth at long-wave spectrum range.

Based on obtained absorption spectrums in layers deposited on $n^{++}$-InAs substrate with $n = 1.8 \times 10^{18}$ cm$^{-3}$, were conducted measurements of radiation absorption proportion in epitaxial layer with exposure through substrate with different thickness and doping levels. Reflection coefficient from air-to-substrate junction was taken equal to the measured overall structure reflection coefficient, reflection of light on substrate-to-layer junction was neglected. Results at two different temperatures are given in Fig. 1.

In a case of thin substrate (400 micron) the absorption share in $n$-InAs epitaxial layer at temperature of 83 K is insignificantly varies with the changing of charge carrier concentration. But that causes noticeable change in position of short-wave absorption border in structure.

With thick substrate (2 mm) its doping level influence is much more sufficient. At 83 K the main factor decreasing the transparency of substrate in spectral bandwidth is the absorption on free charge carriers. Thus, the choice of optimal substrate doping level not only determines short-wave border position but also allows increase the amount of irradiation to epitaxial layer.

At temperature of 300 K the use of thick substrates is inappropriate (dotted line in long-wave region on Fig. 1). Obtained results for thin substrates are in a good agreement with independent data on InAs flip-chip photodiode spectral sensitivity at room temperature [11].

Decrease in substrate transmission ability at temperature of 300 K is caused not by the absorption on free carriers (on lower temperatures), but by the degradation of $n^{++}$-InAs own absorption border, shifted according the Burstein-Moss effect. Because of that the absolute absorption value in layer is increasing with substrate doping level.

**Conclusion**

In this research bandwidth and reflection spectrums of $n$-InAs epitaxial structures were evaluated using the Fourier-spectroscopy method, and absorption coefficients at temperatures of 83 K and 300 K with doping concentration $(0.6-3.3) \times 10^{18}$ cm$^{-3}$ were determined. Spectral absorption characteristics in $n$-InAs epitaxial layer with exposure through the substrate at different temperatures and substrate doping concentration were measured.

**References**


the matrix of 128x128 FPA operating in the spectral range 2.8-3.05 microns. *Avtometriya*, 1998, no. 4, p. 5.


