Characterization of Au/Ti/InAlAs Schottky barrier used in microwave photodiodes

I. B. Chistokhin, M. S. Aksenov,* N. A. Valisheva, D. V. Dmitriev, K. S. Zhuravlev
Rzhanov Institute of Semiconductor Physics SBRAS, 13 Lavrentiev Aven., Novosibirsk,630090, Russia

The microwave photonics is a new scientific technical direction that synthesizes of optoelectronic and microwave electronics technologies and offers grate improvement for communication, information processing or transmission and control devices [1]. The basic elements of microwave photonics are lasers, optical modulators and phase shifters and high-speed photodetectors. The InAlAs/InGaAs/InP photodiode with Schottky barrier (SB) is one of the promising microwave photodetector designs for analog fiber-optic links [2].

The main current flow mechanism in SB is the thermionic emission (TE) through an energy barrier, which is determined by the metal and bulk semiconductor layer parameters, as well as the metal/semiconductor interface properties (atomic structure, morphology, chemical composition) [3,4]. The I-V characteristics method is among the most common techniques for SB parameters (ideality factor n and barrier height at zero bias φ_{b0}) determination, with the I-V temperature dependences giving more detailed information.

In present work, to characterize Au/Ti/n-InAlAs SB, we studied the InAlAs surface morphology and chemical composition, as well as the Au/Ti/InAlAs interface morphology, and analyzed the I-V characteristic in the temperature range of 100-380 K.

It was shown that, the I-V characteristics of the Au/Ti/n-InAlAs SB in the temperature range of 200-380 K [Fig. 1 (a)] are well described with the TE theory at φ_{b0}=0.7 eV and n=1.09 [Fig. 1 (b)]. The 0.9 increase of the n may be associated with the presence of a ~2 nm thick native oxide layer on the Ti/InAlAs interface, which was found by the XPS and HREM techniques. In the temperature range of 100-200 K, the φ_{b0} and n behavior [Fig. 1 (b)] is governed by the contact local inhomogeneities with the Gaussian barrier height distribution (Tung model) [3, 4]. The homogeneous barrier height value 0.88 eV, its standard Gaussian distribution deviation 10^{-4} $cm^{2/3}V^{1/3}$, Richardson constant 10.7 $Acm^{-2}K^{-2}$, the patch diameter (~80 nm) and the area fraction occupied by the patches (24%) were calculated according to this model. The comparison of the calculations based on Tung model and the AFM data suggests that the patches can be associated with sharp spikes at the InAlAs surface.

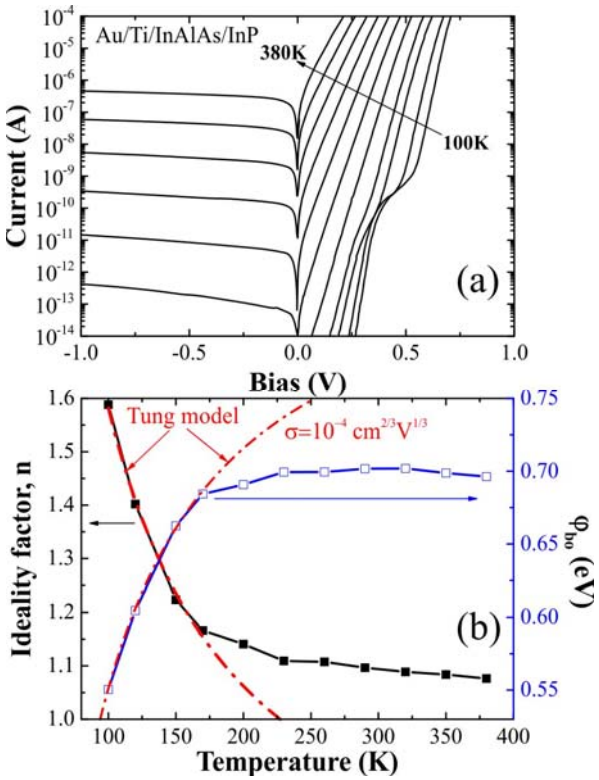

Fig. 1 (a) The Au/Ti/n-InAlAs SB I-V characteristics at temperatures 100 K, 120 K, 150 K, then from 170 K to 380 K with spacing 30 K. (b) The n, φ_{b0} temperature dependences in the range of 100-380 K.

[1] T. Berceli et al., IEEE TMTT, 58, p. 2992, 2010
[2] A. Chizh et al., MWP, 2015.
[3] R. M. Tung, Appl. Phys. Rev. 1, p. 011304, 2014.
[4] J. Sullivan et al., Appl. Phys. 70, p. 7403, 1991.

* Email: aksenov@isp.nsc.ru