*Radioelectronics and Communications Systems*
*Vol. 48, No. 7, pp. 44–47, 2005*

*Izvestiya VUZ. Radioelektronika*
*Vol. 48, No. 7, pp. 63–68, 2005*
*UDC 621.315.592*

# IMPACT OF HEAT TREATMENT ON RESISTIVITY OF OHMIC CONTACTS IN GAAS *P*-TYPE MONOCRYSTALS

Ye. P. Markovskii

*Institute of Physics of Semiconductors at NAS of Ukraine, Kiev, Ukraine*

**The paper is devoted to inquiries in resistivity of ohmic contacts with heavily-doped semiconductor ($2{\cdot}10^{18}$ cm$^{-3}$) made of *p*-type GaAs, in the case of many-layer structure of the contact — Au/TiB$_x$/Ti. As shown by measurements, this ohmic system is competitive enough and has some advantages over other ohmic structures.**

**Introduction**. Creation of metal contacts with *p*-type gallium arsenide presents some difficulties in selecting a metal whose work function shall be greater than that of semiconductor. Because of this, the issue of establishment of ohmic contact even with heavily doped $p^+$-GaAs remains a pressing problem [1–11]. The purpose of this work is investigation of impact of heat treatment conditions on resistivity of the ohmic contact $R_c$, fabricated as a multilayer structure (Au/TiB$_x$/Ti), with the *p*-type GaAs semiconductor substrate, doped with silicon up to concentration $2{\cdot}10^{18}$ cm$^{-3}$, with flat and textured surface, prior to and after heat treatment.

**The specimens and method of measurement**. The contacting layers were produced by the method of magnetron sputtering of targets onto flat and textured surfaces of the $p^+$-type GaAs after their treatment by the photon cleaning technique. The titanium layer about 100 Å thick was applied to the substrate heated to 350 °C. The thickness of the buffer layer (TiB$_x$) and of metallization (Au) was 800 and 3000 Å, respectively.

The contact pads, with their diameter 20 to 180 μm and spacing 20 μm, and with diameter 400 μm, were created by photolithography. The slice was divided into 3 parts — initial, and annealed in hydrogen atmosphere at 500 and 600 °C.

Calculation of the contact resistivity was carried out by the method of current-flow spread-out (the Kos-Streck method). The measurements were performed on specimens with different contact areas, different texture of semiconductor surface, and heat treatment. The resistivity magnitudes of ohmic contacts, at different thermal treatment conditions, were $0.8{\cdot}10^{-4}$, $1.08{\cdot}10^{-4}$, and $1.22{\cdot}10^{-4}$ Ω·cm$^2$ — for the initial segment and those annealed at 500 and 600 °C, respectively.

In order to determine the contact resistivity by the measured full resistance $R_0$ of the experimental specimens, we used the method of current flow spread-out (the Kos-Streck method), with the measurement accuracy about $10^{-6}$ Ω·cm$^2$ [12, 13]. The contact resistivity can be determined from measurements of the full resistance of the ohmic contact structure under investigation [13]:

$$R_0 = \frac{\rho_s}{\pi d} \arctan\left(\frac{4t}{d}\right) + \frac{4R_c}{\pi d^2} \qquad (1)$$

where $\rho_s$ is the semiconductor resistivity, $t$ is its thickness, $d$ is the diameter of the contact, and $\arctan(4t/d)$ accounts for the current flow spread-out in the semiconductor.

For implementation of this method we must measure several tens of resistances for different diameters, and plot the dependence of full resistivity of the structure on the electrode diameter. In the ideal case the graph represents a straight line

**REFERENCES**

1. Yu. A. Gol'dberg, D. N. Nasledov, and B. V. Tsarenkov, Thin multilayer gallium arsenide — metal contacts [in Russian], PTE [Solid-State Electron Devices], No. 6, pp. 180–184, 1966.

2. L. D. Libov, S. S. Meskin et al., PTE, No. 4, pp. 14–21, 1965.

3. M. F. Zhut, A. H. Hamdi, M.-A. Nicolet, and J. L. Tandon, Thin Solid Films, No. 119, pp. 5–9, 1984.

4. A. Escobosa, H. Krдutle, and H. Beneking, Journal of Crystal Growth, Vol. 56, Issue 2, pp. 376–381, 2 January 1982.

5. R. D. Briggs, A. J. Howard, A. G. Baca, M. J. Haffeh, and G. A. Vawter, Thin Solid Films, Vol. 290–291, pp. 508–512, 15 December 1996.

6. Krishnamachar Prasad, A common metallization scheme for ohmic contacts to *n*-type and *p*-type GaAs: the Al—Ni—Sn system, Materials Science and Engineering B., Vol. 27, Issues 2–3, pp. L21–L23, November 1994.

7. Chih-Hung Wu, Sen-Mao Liao, and Kai-Cheng Chang, Ni/Pd/Au ohmic contact for *p*-GaAs and its application in red RCLED, Materials Science and Engineering B., Vol. 117, Issue 2, pp. 205–209, 15 March 2005.

8. B. M. Henrya, A. E. Staton-Bevana, V. K. M. Sharmaa, and M. A. Crouchb, A SIMS and TEM investigation of Au/Ti/Pd solid state ohmic contacts on *p*-GaAs, Applied Surface Science, Vol. 108, Issue 4, pp. 485–493, April 1997.

9. Yen-Tang Lyua, Kuo-Liang Jawa, Ching-Ting Lee, Chang-Da Tsaia, Yow-Jon Lina, and Ya-Tung Cherngb, Ohmic performance comparison for Ti/Ni/Au and Ti/Pt/Au on InAs graded InGaAs/GaAs layers, Materials Chemistry and Physics, Vol. 63, Issue 2, pp. 122–126, 28 February 2000.

10. A. G. Baca, F. Ren, J. C. Zolper, R. D. Briggs, S. J. Pearton, A survey of ohmic contacts to III–V compound semiconductors, Thin Films 308–309, pp. 599–606, 1997.

11, H. Shimawaki, N. Furuhata, and K. Honjo, Ohmic contacts to *p*-GaAs with $p^+/p$ regrown structures formed by metal organic molecular beam epitaxy, J. Appl. Phys. 69(11), pp. 7939–7941, June 1991.

12. Yu. A. Gol'dberg, Fizika i Tekhnika Poluprovodnikov, Vol. 28, Iss. 10, pp. 1681–1698, 1994.

13. E. C. Roderick, Metal-Semiconductor Contacts [Russian translation, ed. by G. V. Stepanov], Radio i Svyaz', Moscow, 1982.

14. S. M. Sze, Physics of Semiconductor Devices, Book 1 [Russian translation], Mir, Moscow, 1984.

13 April 2005