Methodological aspects of measuring the resistivity of contacts to high-resistance semiconductors

V.S. Slipokurov¹, M.M. Dub², A.K. Tkachenko², Ya.Ya. Kudryk¹
¹V. Lashkaryov Institute of Semiconductor Physics, NAS of Ukraine, 41, prospect Nauky, 03650 Kyiv, Ukraine, e-mail: kudryk@isp.kiev.ua
²I. Franko Zhitomir State University

Abstract. Proposed has been the method of formation a thermally stable ohmic contact to the diamond without high-temperature annealing with the resistivity ~50 to 80 Ohm·cm² when \(R_\sigma = 3 \times 10^7\) Ohm/\(\Omega\). Being based on the analysis of correlation dependence between the resistivity of contact and that of semiconductor for the unannealed sample and the sample after rapid thermal annealing it has been shown that variation of the contact resistance on the plate is related with that of semiconductor and may be caused by inhomogeneity of the dopant distribution.

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uniformly distributed along the contact length \( S \), but decreases exponentially from the edge deep into the contact. For large values of \( S \), the current through the contact will not depend on \( S \), but it will be determined by the characteristic length of current transfer deep into the contact, the so-called transfer length \( (L_t) \). Under this condition the resistance between two rectangular contacts can be written as [5]:

\[
R_t = \frac{R_s L_i}{W} + \frac{L_s R_s}{W},
\]

where \( R_s \) is the surface resistance of semiconductor between the contacts, \( L_s = \sqrt{\frac{\rho_s}{R_s}} \), \( L_i \) is the distance between the contacts (see Fig. 1b). After plotting the dependence \( R = f(L_i) \), using the slope of the straight line, we calculate \( R_s \) (Fig. 3a). A line segment intercepted on the \( x \)-axis by extrapolation to \( R = 0 \) of the dependence \( R = f(L_i) \) is equal to \( 2L_t \), where the contact resistivity \( \rho_c = L_t^2 R_s \).

Both in the sample without annealing and in the annealed one, strong variation of the contact resistivity is observed. In order to identify the reasons for this variation, we will plot the correlation dependences between resistivity of the contact and that of semiconductor for unannealed and processed RTA samples (Fig. 3b). We see that in both cases there is a
significant positive correlation, which can be explained by a common cause of the change in the resistivity of contact and that of semiconductor – inhomogeneity of doping the diamond substrate.

Fig. 2b shows that for the same values of the substrate resistivity, the semiconductor resistivity is substantially identical before and after annealing, which can be explained by formation of a titanium carbide phase already in the process of magnetron sputtering titanium on the substrate heated to 350 °C. For example, the same was observed in [6], where in the contact Ti-C already at 300 °C annealing interfacial reaction occurred and a transition layer with the thickness 300 nm was formed. In the work [7], the beginning of the interfacial reactions was fixed at 400 °C.

Thus, we have proposed the method to form ohmic contacts to diamond without high-temperature annealing, which is resistant to rapid thermal annealing at 800 °C for 60 s. As a result of measuring the contact resistance by using the TLM at room temperature, we has obtained value of $\rho_c \sim 50$ to 80 Ohm·cm$^2$ at $R_s = 3 \times 10^7$ Ohm/□.

References


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