Comparative Characteristics of Ohmic Contacts to Heavily Doped $n$-Silicon Layers

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It is known that all semiconductor devices require reliable ohmic contacts with low contact resistivity. This is of particular importance for devices applied in extreme electronics that operate under severe conditions (high temperatures, high current densities and voltages). Such devices are strongly heated because of high power dissipated in their active region.

At present there are practically no data on temperature dependence of contact resistivity $\rho_c$ in the operating temperature region for such devices. So the aim of this work was investigation of dependence $\rho_c(T)$ for ohmic contacts to high-power silicon IMPATT diodes whose operating temperature was 200–250 $^\circ$C.

We studied the samples of two types: (i) initial ones whose contact metallization was formed at a $n^+\text{-}n$-Si substrate heated to 350 $^\circ$C and (ii) those subjected to heat treatment in a vacuum at $T=450$ $^\circ$C for 10 min. An Au(50 nm)–Ti(50 nm)–Pd(30 nm)–$n^+\text{-}n$-Si structure served as contact metallization. The $n^+$-layer was prepared using phosphorus diffusion into silicon substrate with resistivity of $\sim0.002$ $\Omega\cdot\text{cm}$. The phosphorus concentration in the $n^+$-layer (thickness of $\sim0.8$ $\mu\text{m}$) was about $10^{20}$ $\text{cm}^{-3}$.

When studying the dependences $\rho_c(T)$, it was found that contact resistivity $\rho_c$ grew with temperature in the temperature range of 150–380 K (for the initial samples) and 220–380 K (for the samples subjected to heat treatment). Such a behavior differs from that in the conventional models for current flow in ohmic contacts. And $\rho_c$ value for the initial sample was an order of magnitude higher than that for the heat-treated one. The effects observed can be explained using the model advanced in [1] according to which the anomalous dependence $\rho_c(T)$ is due to conductivity in metal shunts associated with dislocations in the Si near-contact region.