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Technological Fabrication Features of Microwave Device with Schottky Barriers

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Abstract—At present, research and development of heterojunctions are conducted in the directions of searching for new compositions and technological regimes for the creation of ohmic and barrier transitions for gallium arsenide. The transition to silver-based metallization, which has large thermal and electrical conductivity comparing with gold and a relatively low diffusion coefficient to gallium arsenide, should improve the technical characteristics of the devices. One of the most important technological operations in the formation of Schottky ohmic contacts and barriers is thermal annealing. Silver to gallium arsenide contacts are made in vacuum by the method of thermal evaporation. The deposition and thermal treatment regimes for creating ohmic contacts of Ag–Ge–In/n–n^+GaAs with specific contact resistance $\rho_c = (5...7)\times10^{-5}\ \Omega\cdot\text{cm}^2$ are developed. The influence of the substrate temperature during the silver deposition and the annealing temperature on the height of the Schottky barrier Ag/n–n^+GaAs, the injection coefficient γ and the nonideality factor η is established.

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INTRODUCTION

The development of mobile communications and tablet devices, the use of high-speed wireless telecommunications, the increase in the capacity of fiber-optic systems that requires an increase in the data transfer rate, necessitates a sharp increase in the share of microwave electronic devices [1–6], which are made on the basis of electronic gallium arsenide.

At present, research and development of heterojunctions are conducted in the search for new metal-gallium arsenide compositions [7–9], the development of technological regimes [8–10], which can ensure the reproducibility of the parameters of microwave devices with Schottky barriers (SB).

Despite the fact that the key physical processes in heterojunctions of metal-gallium arsenide have been thoroughly studied [10–12], there are still disagreements about the reasons for deviation of current–voltage characteristics from ideal ones [13–16], which is related to the technological features of their fabrication.

At present, the most advanced technologies for fabricating metal–gallium arsenide heterojunctions are based on gold [13–16]. However, the transition to silver-based metallization, which has a large thermal and electrical conductivity compared with gold and a relatively low diffusion coefficient to gallium arsenide [10–12], should improve the technical characteristics of the devices. Therefore, the development of technological regimes for manufacturing ohmic and barrier transitions to Ag-based GaAs is relevant from the scientific and practical point of view.

PROBLEM STATEMENT

The main problems of metal-gallium arsenide heterojunctions [7, 9, 10, 12, 18–20] are: the absence of uniform wetting of the metal, surface roughness, segregation of metal into the contact region, the presence of multiple metal–semiconductor phases, erosion of the contact surface and low thermal stability of contact electrical parameters.

During the fabrication process of microwave semiconductor devices and integrated microcircuits based on gallium arsenide, one of the most important technological operations is thermal annealing in the process of formation of ohmic contacts (OC) [21, 22] and Schottky barriers [23, 24].

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