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ELECTRICAL PROPERTIES OF Au/n-$GaAs_{1-x}Sb_x$ CONTACTS*

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The Schottky barrier heights of Au on n-type $GaAs_{1-x}Sb_x$ were measured with I–V, C–V, and photoresponse (PR) techniques. The barrier height was determined to be 0.65, 0.75 and 0.7 eV, respectively.

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1. Introduction

Recently GaSb-based compound semiconductor mixed crystals have received an increasing attention since the wavelength corresponding to their alloy energy bandgap covers a wide spectral range from near infrared (in GaAsSb ternary) to a few micrometer (in InGaSb system) [1]. Along with InP-based crystals those based on GaSb compounds are alternative promising candidates for a successful conquest of middle- and long-wavelength photonics. Rectifying metal–semiconductor contacts are key elements in technology of high-speed semiconductor devices. Such contacts have been widely studied for conventional materials. The aim of the present paper is to determine the Schottky barrier height (SBH) for Au/$GaAs_{1-x}Sb_x$ contacts ($x = 0.05$). Current–voltage (I–V) measurements were performed for temperature range of 77 to 363 K. The SBH's were determined both from a linear extrapolation of the forward I–V characteristics to the zero bias and from the activation energy analysis of the reciprocal temperature dependence of the zero-bias saturation current density per square temperature. At room temperature SBH was also determined from capacitance–voltage (C–V) measurements (at 1 MHz) and photoelectric characteristics.

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2. Experimental details

The $GaAs_{1-x}Sb_x$ samples used in the present study were obtained by a thermal liquid-phase epitaxy on Te-doped GaAs substrates [1]. Prior to metal deposition the $GaAs_{1-x}Sb_x$ layers were etched in Br_2-methanol solution, and rinsed in methanol. Top-surface rectifying contacts were made by high-vacuum Au deposition, whereas indium was used to give ohmic back-surface contacts. Mesa shape was then defined by chemical etching to reduce leakage currents in the diodes.

3.Results

I − V measurements

At 270 K and above, the diodes show a good ideality factor which remains essentially unchanged with temperature, and its value was determined to be $n = 1.1 \pm 0.02$. However, below 270 K the ideality factor increases (up to $n = 2.8$ at 77 K) with the decreasing temperature. Therefore, we will restrict our further consideration only to the data obtained at 270 K and above. The forward *I–V* characteristics plotted in Fig. 1 show exemplary results. As the ideality factor is close to unity the thermionic emission equations can be used to determine the effective SBH from the *I–V* measurements. The SBH obtained this way was $\Phi^{\mathrm{B}}_{I-V} = 0.65$ eV.

C − V measurements

C–V measurements also rendered it possible to determine SBH. These were carried out at 1 MHz at room temperature. A linear voltage dependence of $1/C^2$ was found in voltage range of 0–2 V reverse bias. The results are presented in Fig. 2. The diffusion potential, V_{D}, of the Schottky diode was estimated from the intersection of the voltage axis with the $1/C^2$ curve (r.m.s. fit). The slope of this curve yielded an average value for donor concentration: $N_{\mathrm{D}} = 9 \times 10^{16}$ cm^{-3} which remains in good agreement with that obtained from the electrical transport measurements. The difference between the Fermi level and the bottom of the conduction band in the crystal was found to be 0.03 eV. The *C–V* barrier height (Φ^{B}_{C-V}) was then calculated by adding this value to the diffusion potential, what gave $\Phi^{\mathrm{B}}_{C-V} = 0.75$ eV.

Photoresponse measurements

The photoresponse spectra were measured at 300 K in photon energy range of 0.6–1.5 eV. In some part a plot of the photoyield was linear, and the determined barrier height was equal to $\Phi^{\mathrm{B}}_{\mathrm{Ph}} = 0.70$ eV.

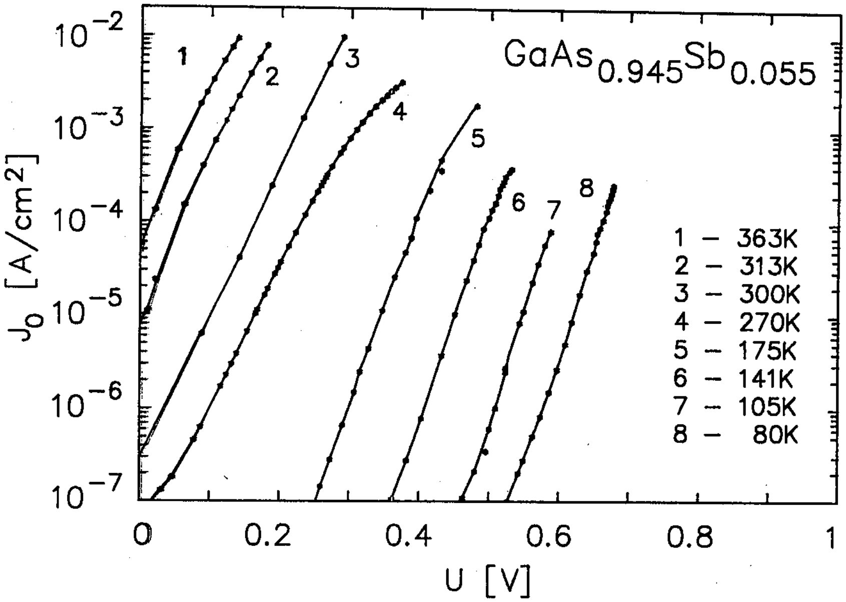

Fig. 1. Current–voltage characteristics of Au-GaAs$_{1-x}$Sb$_x$ contact ($x = 0.05$) at different temperatures.

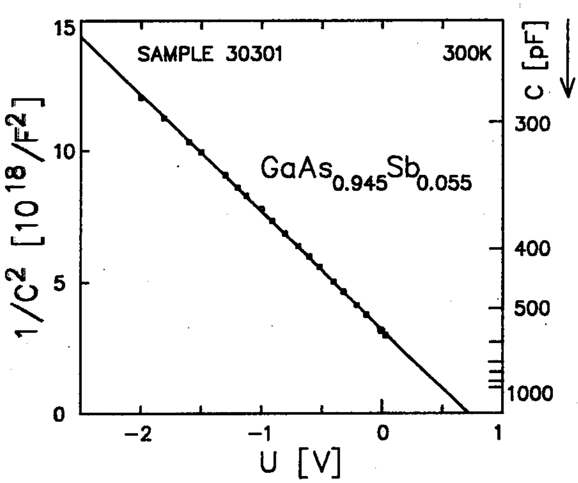

Fig. 2. $1/C^2$–voltage characteristic of Au-GaAs$_{1-x}$Sb$_x$ ($x = 0.05$) contact at room temperature (frequency = 1 MHz).

4. Discussion

The SBH's determined from three independent techniques as I–V, C–V, and photoresponse measurements were equal to 0.65, 0.75, and 0.7 eV, respectively. They show the following ascending order: $\Phi^{\mathrm{B}}_{I-V} < \Phi^{\mathrm{B}}_{\mathrm{PR}} < \Phi^{\mathrm{B}}_{C-V}$. A discrepancy among the results may be ascribed to the surface features changed in its preparation which affected the respective measurements to different extents. Recombination centres in the vicinity of the interface increase the saturation current and in consequence, reduce the effective barrier height in the I–V measurements. Whereas the oxide layer and the etchant traces, always present after chemical preparation, will decrease the measured capacitance. Consequently, the barrier height Φ^{B}_{C-V} will be overestimated. Undoubtedly, the as-grown surface state of the investigated crystal plays significant role, too. The performed measurements and analyses may, we hope, contribute to better understanding of the mixed crystal surface nature.

References

[1] E.B. Radojewska, *Epitaksjalne krysztaly mieszane $GaAs_{1-x}Sb_x$ - wytwarzanie, wlasnosci i zastosowanie.* (Monografia nr 14, Prace Nauk. Inst. Fizyki Politechn. Wroclawskiej nr 25) Wydawn. Politechniki Wrocławskiej, Wrocław 1989.