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Analysis of temperature-dependent *I-V* characteristics of the Au/*n*-GaSb Schottky diode

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ABSTRACT

Gallium antimonide (GaSb) has been widely used for optoelectronic devices in recent years, but the current transport mechanism at the metal-GaSb junction has not yet been clearly identified. In this work, current-voltage (*I-V*) characteristics of Au/*n*-GaSb Schottky diodes were analyzed over a wide temperature range (80–340 K) to investigate their current transport mechanisms. Based on the theory that the total current is described as a contribution of several current mechanisms, the measured *I-V* curves were separated into two components: thermionic emission (TE) current and secondary current. For the TE current, which is the primary current for general Schottky diodes, Schottky diode parameters were extracted and the inhomogeneity of the Schottky barrier was quantified using the temperature dependence of the parameters. For the secondary current, a temperature-dependent predominance between tunneling and Shockley-Read-Hall (SRH) recombination currents was identified by comparing a coefficient of the secondary current with the tunneling coefficient and 2*kT*. We also revealed that other current transport mechanisms such as Auger and radiative recombination, and leakage currents are negligible for the Au/*n*-GaSb Schottky diodes in this work. The methodology suggested in this study can be applied for detailed characterization of various Schottky diodes of which the current transport mechanisms are unidentified.

1. Introduction

Gallium antimonide (GaSb) is a versatile III-V semiconductor for high-speed-optoelectronic devices. The typical GaSb properties of 0.72 eV band-gap energy and hole mobility higher than other III-V semiconductors make this semiconductor suitable for high-speed near-infrared devices. Moreover, GaSb is a great substrate for epitaxial growth because its lattice constant matches those of various ternary and quaternary III-V compounds, such as InGaAsSb and AlGaSb. For these reasons, GaSb based multilayer systems are paid much attention as promising candidates for light-emitting diodes (LED) [1], quantum well laser diodes [2], field-effect transistors [3–5], infrared photodetectors [6,7], multi-layer solar cells [8], and thermophotovoltaic systems [9].

A metal-semiconductor Schottky contact is a basic structure used to realize the aforementioned devices. To form a stable Schottky contact, many studies have been conducted involving surface cleaning and surface passivation methods to treat properly the native oxidation of GaSb surfaces [10–20]. Various metals have also been tried to make Schottky contacts with GaSb: Au [10,12,13,16,17,20–23], Al [14,24,25], Pd [26], and Ni [27–29]. To identify and evaluate the performance of Schottky diodes, analysis of the temperature-dependent diode properties obtained from current-voltage-temperature (*I-V-T*) measurement has commonly been utilized [30–38]. Huang et al. [27] studied characteristics of the Ni/*n*-GaSb Schottky diode using *I-V-T* measurements in the temperature range of 173–373 K. However, the number of temperature points was insufficient to fully describe the temperature-dependent characteristics. In addition, they only considered a thermionic emission (TE) current to extract the Schottky diode properties, without consideration of other current mechanisms.

Schottky diodes are typically analyzed based on TE theory. However,

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