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Investigations of 2.9-GHz Resonant Microwave-Sensitive Ag/MgO/Ge/Ag Tunneling Diodes

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In this work, a resonant microwave-sensitive tunneling diode has been designed and investigated. The device, which is composed of a magnesium oxide (MgO) layer on an amorphous germanium (Ge) thin film, was characterized by means of temperature-dependent current (I)–voltage (V), room-temperature differential resistance (R)–voltage, and capacitance (C)–voltage characteristics. The device resonating signal was also tested and evaluated at 2.9 GHz. The I–V curves reflected weak temperature dependence and a wide tunneling region with peak-to-valley current ratio of ~1.1. The negative differential resistance region shifts toward lower biasing voltages as temperature increases. The true operational limit of the device was determined as 350 K. A novel response of the measured R–V and C–V to the incident alternating-current (ac) signal was observed at 300 K. Particularly, the response to a 100-MHz signal power ranging from the standard Bluetooth limit to the maximum output power of third-generation mobile phones reflects a wide range of tunability with discrete switching property at particular power limits. In addition, when the tunnel device was implanted as an amplifier for a 2.90-GHz resonating signal of the power of wireless local-area network (LAN) levels, signal gain of 80% with signal quality factor of 4.6×10^4 was registered. These remarkable properties make devices based on MgO-Ge interfaces suitable as electronic circuit elements for microwave applications, bias- and time-dependent electronic switches, and central processing unit (CPU) clocks.

Key words: Semiconductor devices, MgO, Ge thin films, electrical

INTRODUCTION

In the last decade, magnesium-oxide-based tunnel barriers have attracted the attention of scientists due to the novel characteristics that they exhibit. This type of device covers a wide range of applications including electronics and spintronics.[1] Particularly, Fe/MgO/Ge diodes find application in detecting electron spin accumulation.[2] Epitaxial Fe/MgO/Ge (001) heterostructures are also used for room-temperature integrated detection of light helicity at wavelength of 1300 nm.[3] The degree of circular polarization of light, which is related to the spin direction of photoexcited carriers in Ge, was reported to be filtered by the MgO barrier. In addition, the electrical spin injection and accumulation in CoFe/MgO/Ge contacts are investigated by employing three-terminal Hanle measurements. A sizable spin signal of 170 kΩ μm^2 was observed at room temperature. Analysis of this device using a single-step tunneling model reflected a spin lifetime of 120 ps and a spin diffusion length of 683 nm in Ge. The observed spin signal displayed asymmetric bias and temperature dependences which are reported to be strongly dependent on the asymmetry of the tunneling process in the device.[4] Furthermore, structured MgO films which were synthesized on stainless-steel electrodes were used for reduction of the glow discharge inception voltage in a

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