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Analysis of the Temperature Dependence of the Capacitance–Voltage and Conductance–Voltage Characteristics of Au/TiO_2(rutile)/*n*-Si Structures

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The capacitance–voltage–temperature (C–V–T) and the conductance/angular frequency–voltage–temperature (G/ω–V–T) characteristics of Au/TiO_2(rutile)/*n*-Si Schottky barrier diodes (SBDs) were investigated over the temperature range from 200 K to 380 K by considering the series resistance effect. Titanium dioxide (TiO_2) was deposited on *n*-type silicon (Si) substrate using a direct-current (DC) magnetron sputtering system at 200°C. To improve the crystal quality, the deposited film was annealed at 900°C to promote a phase transition from the amorphous to rutile phase. The C^{-2} versus V plots gave a straight line in the reverse-bias region. The main electrical parameters, such as the doping concentration (N_D), Fermi energy level (E_F), depletion layer width (W_D), barrier height (ϕ_{CV}), and series resistance (R_S), of Au/TiO_2(rutile)/*n*-Si SBDs were calculated from the C–V–T and the G/ω–V–T characteristics. The obtained results show that ϕ_{CV}, R_S, and W_D values decrease, while E_F and N_D values increase, with increasing temperature.

Key words: TiO_2(rutile), DC magnetron sputtering, capacitance–voltage–temperature characteristic, conductance–voltage–temperature characteristic

INTRODUCTION

TiO_2 thin film has been used in many optical and electrical device applications, such as solar cells, optical filters, high-speed memory devices, and antireflection coatings, due to its high refractive index, large bandgap, and high dielectric constant.[1–19] TiO_2 thin films can be prepared by various techniques, such as the sol–gel method,[20–22] chemical vapor deposition,[23] electron-beam evaporation,[24] and DC reactive magnetron sputtering.[25,26] Among these techniques, the DC reactive magnetron sputtering method is widely utilized due to its ability to obtain uniform, dense, and precise stoichiometric TiO_2 thin films. Bulk TiO_2 is a potential candidate because it has different phases, such as anatase, rutile, and brookite, the most common of which are the anatase and rutile phases.[4,6]

Metal–insulator–semiconductor (MIS) structures play an important role in modern device technology. The performance and reliability of these devices depend on various parameters, such as the surface preparation process, the formation of the barrier height and interface states (N_{SS}) at the M–S interface, substrate temperature, applied bias voltage, and R_S.[27–33] Among these, R_S is only effective in the downward curvature region (accumulation region) of the C–V characteristic. Several researchers have studied the electrical characteristics of MS structures with a TiO_2 interfacial insulator layer.[5–8] Altuntas et al.[5] examined the temperature-dependent forward- and reverse-bias I–V characteristics of Au/TiO_2/*n*-Si Shcottky barrier diodes (SBDs). They showed that the obtained ideality factor values decrease, while the values of zero-bias barrier height increase, with increasing temperature. Bengi et al.[6]

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