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Dielectric Properties of Au/PVA (Cobalt-Doped)/*n*-Si Photoconductive Diodes

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The voltage (V) and frequency (f) dependence of dielectric parameters such as the dielectric constant (ε'), dielectric loss (ε''), dielectric loss tangent (tan δ), real and imaginary parts of electrical modulus (M' and M''), and alternating-current (AC) electrical conductivity (σ_{AC}) of Au/PVA (cobalt-doped)/n-Si structures have been investigated by using experimental admittance measurements conducted at room temperature. The values of ε', ε'', and tan δ were found to be strong functions of voltage and frequency, especially at low frequencies in the positive voltage region. It was observed that the values of ε' and ε'' increase as the frequency decreases. The M' values increase with increasing frequency due to increasing dielectric relaxation, while M'' values, in general, remain stable as frequency is changed. The σ_{AC} values at each bias voltage increase with increasing frequency.

Key words: Organic PVA layer, MPS structures, dielectric properties, electric modulus, AC electrical conductivity

INTRODUCTION

In addition to conventional inorganic insulator layers such as SnO_2, Si_3N_4, and SiO_2, using a thin interfacial organic insulator layer between metal and semiconductor converts a metal–semiconductor (MS) structure into a metal–insulator–semiconductor (MIS) structure. Many optoelectronic devices involve an organic/polymeric interfacial layer which can be prepared by easy processing techniques such as electrostatic spraying, spin coating, dip coating, sol–gel technique, etc. Recently, organic polymeric materials have been used extensively as interfacial layer materials in MIS structures, also known as metal/organic polymer/semiconductor (MPS) structures, due to their optical and electrical properties, in the research areas of Schottky diodes, solar cells, light-emitting diodes (LEDs), thin-film transistors (MISFETs/MPSFETs), sensors, etc.[1–6] Polyvinyl alcohol (PVA), one of the most important polymers, has been used several times as an interfacial organic layer and has attracted great attention, especially when doped with various metal ions.[1,2] PVA is a semicrystalline, water-soluble polymer with low electrical conductivity, being widely used in fiber mats, films, paper coatings, membranes, etc. due to its excellent chemical and physical properties, nontoxicity, processability, good chemical resistance, wide range of crystallinity, and good film-formation capacity.[1,2,7–9]

The insulator layer in these types of structures not only prevents interdiffusion between metal and semiconductor substrate but also alleviates the electric field reduction issue in the structure. The presence of an insulator layer in the structure gives these devices the feature of a capacitor, storing electric charge by virtue of the dielectric properties of the oxide layer.[10] A bias voltage applied across such a structure is shared by the insulator layer, depletion layer, and series resistance of the device. Therefore, the interfacial insulator layer plays an important role in the electrical and dielectric properties of MIS and MPS structures.[10–14]

In previous studies by the author,[15,16] it was concluded that Au/n-Si structures with an interfacial PVA layer doped with various metallic materials (Ni, Bi, Co) could be used as a photodiode. This

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