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Effect of Temperature Cycling on Conduction Mechanisms in CdTe Thin Films

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CdTe thin films of 500 Å thickness prepared by thermal evaporation technique were analyzed for leakage current and conduction mechanisms. Metal–insulator–metal (MIM) capacitors were fabricated using these films as a dielectric. These films have many possible applications, such as passivation for infrared diodes that operate at low temperatures (80 K). Direct-current (DC) current–voltage (*I*–*V*) and capacitance–voltage (*C*–*V*) measurements were performed on these films. Furthermore, the films were subjected to thermal cycling from 300 K to 80 K and back to 300 K. Typical minimum leakage currents near zero bias at room temperature varied between 0.9 nA and 0.1 μA, while low-temperature leakage currents were in the range of 9.5 pA to 0.5 nA, corresponding to resistivity values on the order of 10^8 Ω-cm and 10^{10} Ω-cm, respectively. Well-known conduction mechanisms from the literature were utilized for fitting of measured *I*–*V* data. Our analysis indicates that the conduction mechanism in general is Ohmic for low fields $<5 \times 10^4$ V cm^{-1}, while the conduction mechanism for fields $>6 \times 10^4$ V cm^{-1} is modified Poole–Frenkel (MPF) and Fowler–Nordheim (FN) tunneling at room temperature. At 80 K, Schottky-type conduction dominates. A significant observation is that the film did not show any appreciable degradation in leakage current characteristics due to the thermal cycling.

Key words: CdTe thin film, MIM, conduction mechanism, modified Poole–Frenkel, Richardson Schottky

INTRODUCTION

CdTe is a promising material for diverse optoelectronic applications such as solar cells, infrared (IR) detectors, field-effect transistors, nuclear radiation detectors, etc.[1–4] One such application is passivation for narrow-gap semiconductor (NGS) devices such as infrared detectors fabricated from $Hg_{1-x}Cd_xTe$. CdTe is transparent to infrared light, and is nearly lattice matched and chemically compatible with these NGS. The performance of devices of small size and fabricated using high-quality semiconductor materials is normally limited by surface leakage currents and leakage through the passivation.[5–8] *In situ* passivation of semiconductor surfaces using CdTe is done by molecular beam epitaxy (MBE) or metalorganic chemical vapor deposition (MOCVD). However, the overall device fabrication process involves a number of steps and requires *ex situ* deposition of CdTe passivant also. The general procedure in such cases has been to passivate the surface by e-beam evaporation or thermal evaporation of CdTe at vacuum on the order of 10^{-6} Torr to obtain good-quality films.[6] The example considered here is that of infrared detectors fabricated on $Hg_{1-x}Cd_xTe$ epitaxial layers grown by liquid-phase epitaxy (LPE). Interfaces of these devices are reported to yield low defect density and hence low surface state density, thus improving the effective lifetime of photogenerated carriers.[5,6,9] However, it is important to tailor the properties of the CdTe/semiconductor interface to reduce the leakage current through the film and minimize the surface recombination velocity (SRV). Control and study of

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