Inelastic Electron Tunneling Spectroscopy Study of MOS Diodes Based on High-κ Gate Dielectrics

S.L. YOU, C.C. HUANG, C.J. WANG, H.C. HO, J. KWO, Department of Physics, National Tsing Hua University, Hsinchu, Taiwan, W.C. LEE, K.Y. LEE, Y.D. WU, Y.J. LEE, M. HONG, Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu, Taiwan — Inelastic electron tunneling spectroscopy was applied to characterize the microstructure, interface, and trap-related states in silicon MOS diodes made of high κ gate dielectrics HfO$_2$, Y$_2$O$_3$, and stacked HfO$_2$/Y$_2$O$_3$ bilayers by molecular beam epitaxy and atomic layer deposition under various heat treatments. Reproducible vibrational modes of monoclinic HfO$_2$ and cubic Y$_2$O$_3$ were identified from IETS spectra. The gate bias dependence of the spectrum enables to ascribe the phonon modes adjacent to the lower or upper interface. A simple modeling was employed to analyze the trap related features in the spectra of stacked HfO$_2$/Y$_2$O$_3$ bilayers, and showed that most traps are located near the HfO$_2$/Y$_2$O$_3$ interface due to dissimilar charge distributions of two ionic oxides of different cation valences, and the interfacial strains of dissimilar structures. Work is now extended to Y-doped HfO$_2$ films in cubic phase with an enhanced κ over 30.

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