Atomic-layer-deposited HfO$_2$ on In$_{0.53}$Ga$_{0.47}$As – passivation and energy-band parameters

Y.C. CHANG, K.Y. LEE, M.L. HUANG, Y.J. LEE, T.D. LIN, M. HONG, Dept. of Materials Science and Engineering, Natl Tsing Hua Univ., Taiwan, J. KWO, Dept. of Physics, Natl Tsing Hua Univ., Taiwan — High κ dielectric HfO$_2$ films were deposited by atomic layer deposition on air-exposed In$_{0.53}$Ga$_{0.47}$As/InP (100), and found to exhibit an atomically sharp interface free of arsenic oxides, an important aspect for Fermi level un-pinning. Angular-resolved x-ray photoelectron spectroscopy (XPS) using synchrotron radiation, however, observed the existence of Ga$_2$O$_3$, In$_2$O$_3$, and In(OH)$_3$ at the interface. The I-V of the MOS diode for an HfO$_2$ 7.8 nm thick follows the Fowler-Nordheim tunneling mechanism with a low leakage $\sim 10^{-8}$A/cm$^2$ at $V_{FB}+1$V, and an interfacial density of states $D_{it}$ of $2 \times 10^{12}$cm$^{-2}$eV$^{-1}$. A conduction-band offset of $\sim 1.8$ eV, and a valence-band offset of $\sim 2.9$ eV were derived from the transport, and XPS data, respectively. For another HfO$_2$ film 4.5nm thick we achieved a CET value as small as 1.0nm, and a leakage of $3.8 \times 10^{-4}$A/cm$^2$ at $V_{FB}+1$V. The good scalability of ALD grown HfO$_2$ film with low leakage makes it very promising for III-V MOSFET applications.

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