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Emerging Materials
Room On Demand - Session EM3

Atomic Layer Epitaxy and Doping

EM3-1 Low-Temperature Dopant-Assisted Crystallization of HfO_2 Thin Films, ***Theodosia Gougousi,*** Department of Physics, UMBC

We have studied the thermal ALD of HfO_2 on native and chemical oxide GaAs(100) surfaces using various aklylamide precursors. Bright field and HRTEM data for ***as-prepared*** 12 -36 nm HfO_2 films deposited on native oxide GaAs(100) at 250°C from tetrakis ethymethylamino hafnium (TEMAHf) and H_2O shows that the films are polycrystalline. These films contain several large grains of the order of the film thickness and numerous small crystallites (Figure 1). To clarify the role of the GaAs(100) substrate in the observed HfO_2 film structure an additional set of films was grown on GaAs(100) surfaces that were chemically oxidized. The chemical oxide layer thickness was measured at ~4.6 nm more than twice the thickness of the native oxides. GaAs chemical oxides are similar in composition to the native oxides. HfO_2 films with thickness ~6 nm deposited on the chemical oxide GaAs(100) surfaces are also polycrystalline while ~2 nm of the chemical oxide layer is still detectable at the interface (Figure 2). The presence of the chemical oxide at the interface precludes the direct contact of the HfO_2 layer with the GaAs substrate. Normally, HfO_2 films of such low thickness remain amorphous even after they are subjected to thermal treatment. One of the highlights of alkylamide HfO_2 ALD processes on III-V substrates is the so-called interface cleaning reaction that leads to the gradual consumption of the surface native oxides and results in the formation of a sharp HfO_2/III-V semiconductor interface. We have shown that this interface cleaning reaction is accomplished because the surface native oxides transport to the surface of the growing ALD oxide layer where they react with the precursor to form volatile byproducts that are removed. So, at any point during the ALD process there is mixing of the various III-V oxides in the film but because of the removal mechanism the final ALD film has very low impurity content. We hypothesize that the native oxides lead to the stabilization of the various HfO_2 polymorphs during low temperature thermal atomic layer deposition allowing control of the film microstructure via the deposition process.

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