Remote Oxygen Plasma Growth of MgO Films on SiC for Functional Oxide Integration

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Replacing silicon with wide bandgap semiconductors, such as silicon carbide (SiC), can lead to high-power, high-frequency, robust devices that cannot be made from silicon. To produce these new devices, different materials such as controlled functional oxides and metals need to be integrated as thin films with the silicon carbide. Magnesium oxide (MgO) is a potential bridging layer between SiC and complex oxides such as barium hexaferrite ($BaFe_{12}O_{19}$) and lead zirconate titanate ($Pb(Zr_xTi_{1-x})O_3$). For example, by integrating MgO on SiC and then matching the oxygen atoms in the MgO with the oxygen atoms in the $BaFe_{12}O_{19}$, the lattice mismatch of $BaFe_{12}O_{19}$ on MgO is 1.3% compared to $BaFe_{12}O_{19}$ on SiC, which is 4.5%.

Preliminary data has been collected showing that thin, crystalline MgO films can be grown on 6H-SiC surfaces using a remote oxygen plasma and a magnesium effusion cell. Chemical, structural, and morphological information was collected from *in-situ* Auger Electron Spectroscopy (AES), X-ray Photoelectron Spectroscopy (XPS), and Reflection High-Energy Electron Diffraction (RHEED). *Ex-situ* morphological information is collected from Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM). The chemical species of the oxygen plasma is currently being characterized by a quadruple mass spectrometer.

Oxygen species, oxygen flux to the surface, substrate surface temperature, and surface chemistry may each play a role in nucleation and growth mechanisms that determine the final chemistry, structure, and morphology of the films. Initial studies have focused on the influences of magnesium flux and surface temperature on the nucleation and growth mechanism of MgO on clean 6H-SiC. Preliminary data suggests that the nucleation and growth rate of the thin films is dependent on the amount of available magnesium to the substrate surface. All films were grown to a target thickness of approximately 5 nm. Samples that had higher Mg fluxes, resulted in faster growth rates. When the growth rates were faster than 20 nm/hr the resulting MgO films produced RHEED patterns indicating more crystalline films than those with slower growth rates. This decreased crystallinity may be a result of the formation of an oxide interlayer that forms at the interface between the SiC and MgO at lower Mg fluxes. If there is sufficient Mg flux to the surface, the oxygen may be incorporated into the MgO film before it bonds with the SiC. This hypothesis was tested by intentionally oxidizing a clean SiC substrate. After oxidation, MgO was deposited using a reproducible set of processing conditions that were expected to yield a single crystalline, stoichiometric film on non-oxidized surfaces. The MgO film grown on the oxidized surface was stoichiometric, but highly polycrystalline. This supports the hypothesis of oxide formation during low Mg flux conditions.

Continued studies are focusing on the nucleation mechanism at the interface and how different interfaces influence the crystal structure and morphology of the MgO films. Further processing parameters will include substrate temperature, oxygen species, oxygen flux, and different starting surface chemistries.