AlGaN/GaN Metal Oxide Semiconductor Field Effect Transistors using Titanium Dioxide

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Minimizing gate leakage in field effect transistors used in microwave power electronics is desirable both for low noise and reliability. An SiO_2 layer under the gate has been shown to reduce gate leakage current by six orders of magnitude compared to that of a conventional HFET[1,2]. Ideally the gate leakage current should be suppressed without affecting the transconductance or threshold voltage of the device. A high K dielectric should allow for a thin equivalent oxide thickness while reducing gate leakage.

Titanium dioxide (TiO_2, with the rutile structure) was grown epitaxially on AlGaN/GaN HFET structures by molecular beam epitaxy (MBE). Growth was first performed on GaN templates to establish epitaxial growth conditions. X-ray diffraction showed [001] TiO_2 || $[10\bar{1}0]$ GaN and (100) TiO_2 || (0001) GaN. The full width at half max (FWHM) of the TiO_2 (200) peak was 0.31° in the θ -2θ scan and the 2ω FWHM was 0.86°. Growth conditions established for the oxide on GaN were then used to grow TiO_2 on AlGaN/GaN structures.

Metal Oxide HFETs were processed with TiO_2 under the gate in the following manner. HFETs were partially processed prior to TiO_2 deposition. First, source and drain ohmic contacts were defined and deposited. The devices were then isolated using a reactive ion etch. Gate metals were deposited on some of the die on the wafer and the devices in these die were measured as standards. 30 nm of TiO_2 was then blanket deposited over the wafer. Gate metals were deposited on the remaining die.

The gate leakage current of this structure is approximately four of magnitude lower than that of a conventional FET, at $\sim 4*10^{-6}$ mA/mm at 50V. A maximum device current of approximately 1A/mm was measured at a positive gate bias of +1V, with a pinch off voltage of approximately –7.5V. The transconductance was 140 mS/mm, approximately 20% less than for devices with no dielecric. The dielectric constant of the TiO_2 was ~43.

These results indicate that TiO_2 is an excellent candidate as a gate dielectric on AlGaN/GaN HFETs. The high dielectric constant of the oxide allows for a low impact on the transconductance and threshold voltage of the device while reducing gate leakage. Further investigation of growth and processing conditions is required for device optimization.

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