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Normally-off HfO_2/diamond field effect transistors fabrication

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Diamond is regarded as a promising material for optoelectronic devices. It has wide band gap, a high melting point, a large thermal conductivity, a high breakdown field, large saturation velocity, and high carrier mobility. These characteristics make it possible to fabricate high power and high frequency metal-oxide-semiconductor field effect transistors (MOSFETs). Most of studies for successful FETs have used the *p*-type conduction layer in the hydrogenated diamond (H-diamond) surface as the channel layer, which accumulate holes on the surface with high hole mobility. In order to fabricate high performance H-diamond-based MOSFETs, it is necessary to search a suitable gate oxide insulator. Since the insulator with a higher-dielectric constant (higher-*k*) can provide a larger charge response at a small electrical field, we will focus on the fabrication of the high-*k* material on the H-diamond. HfO_2 has an excellent dielectric property and a high breakdown field. In this study, the electrical properties of the HfO_2/H-diamond MOSFETs will be discussed.

Figure 1 shows (a) leakage current density (J) and (b) C-V curve for the SD-HfO_2/ALD-HfO_2/H-diamond MOS structure. The J value of the MOS diode is smaller than 1.1×10^{-4} A·cm^{-2} at gate bias from -9.0 to 2.0 V. The C-V curve [Fig. 1 (b)] shows sharp dependence and small hysteresis shift voltage of 0.1 V, which indicates the low trapped charge densities in the bulk HfO_2 or at the ALD-HfO_2/H-diamond interface. Figure 2 shows the drain current versus drain voltage (I_{DS}-V_{DS}) characteristic for the SD-HfO_2/ALD-HfO_2/H-diamond FET with L_G of 4 μm. The maximum value of I_{DS} (I_{DSmax}) is -37.6 mA·mm^{-1}. The threshold voltage (V_{TH}) value was determined to be -1.3 ±0.1 V at the V_{DS} of -12.0 V. Thus, the SD-HfO_2/ALD-HfO_2/H-diamond FET operates in the enhancement-mode with complete normally-off characteristics.

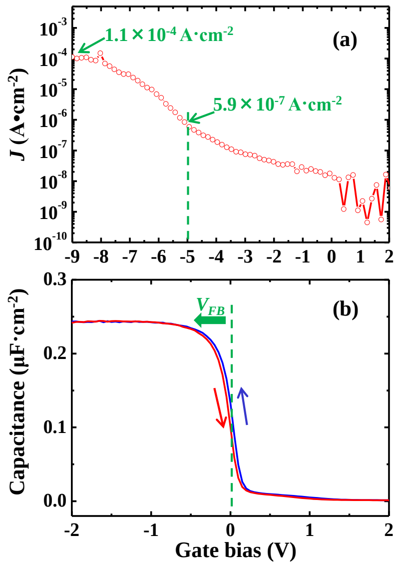

Fig. 1 (a) Leakage current density and (b) C-V curve for the MOS structure.

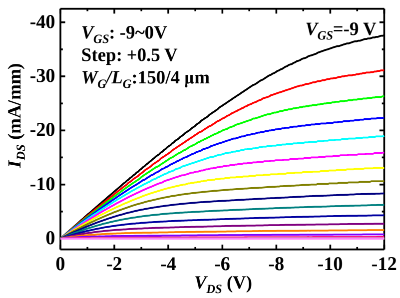

Fig. 2 The I_{DS}-V_{DS} characteristic of the SD-HfO_2/ALD-HfO_2/H-diamond FET

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