Boron-doped diamond MOSFETs with high output current and extrinsic transconductance

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Wide-bandgap semiconductor diamond has excellent intrinsic properties over other semiconductors, such as high critical breakdown field, large thermal conductivity, and high hole mobility. Diamond-based electronic devices are considered promising as they operate well with low power loss, high power-frequency, and high thermal limitation. Recently, *p*-type hydrogen-terminated diamond (H-diamond) and boron-doped diamond (B-diamond) metal–oxide–semiconductor field-effect transistors (MOSFETs) have been developed greatly. However, with increase of annealing temperature, the H-diamond surface channel was damaged gradually and electrical properties of the H-diamond MOSFETs were degraded greatly. The B-diamond-based MOSFETs are considered to be operating well at high temperature. However, due to the high activation energy for boron dopants (370 meV) at room temperature, hole density in the B-diamond was quite low and the B-diamond-based MOSFETs operated with low output current and extrinsic transconductance [1, 2].

In our recent studies [3, 4], a relatively flat (surface roughness of 0.15 nm) and a high boron doping level B-diamond epitaxial layer was used for fabricating the B-diamond metal-semiconductor FETs (MESFETs). The flat B-diamond surface is considered to be good to suppress carrier surface scattering and to improve the quality of the gate metal/B-diamond interface. Boron concentration for our B-diamond was confirmed by secondary ion mass spectrometry to be an order of 10^{17} cm^{-3}. The high doping level was important to enhance the electrical properties of the B-diamond MESFETs. Their output current and extrinsic transconductance were confirmed to be -0.55 mA/mm and 14.4 μS/mm, respectively, which were much higher than those of the previously reported MESFETs.

In this work, we will employ this B-diamond epitaxial layer for fabricating Al_2O_3/B-diamond MOS capacitors and MOSFETs. It is believed that the interfacial quality of Al_2O_3/B-diamond and the electrical properties of the B-diamond MOSFETs can be improved. Additionally, their thermal stabilities after annealing at 500 ºC will be confirmed [5].

Reference

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