Al_2O_3/ダイヤモンドヘテロ接合の結合エネルギーの校正と界面バンドベンディングの解明

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Diamond-based electronic devices are considered for the future applications due to their promising operations with low power loss, high power, high-frequency, and high thermal limitation. Recently, there has been significant progress in the development of *p*-type hydrogen-terminated diamond (H-diamond) and boron-doped diamond (B-diamond) based metal–oxide–semiconductor field-effect transistors (MOSFETs). Cutoff frequency and breakdown voltage for the H-diamond-based MOSFETs were reported to be as high as 70 GHz and 3326 V, respectively [1, 2]. The B-diamond-based MOSFETs could also operate well at temperature of 300 ℃ with on/off ratios larger than 10^9 [3].

For fabricating high-performance diamond-based MOS capacitors and MOSFETs, understanding the band configuration at the oxide/diamond interface is crucial. It can help in optimizing the capacitance and charge storage properties for the diamond MOS capacitors. It can also help to understand the threshold voltage, charge injection and extraction, leakage current density, and device stability for the diamond MOSFETs. Thus, clarification the band configuration for the oxide/diamond interface is important for designing and fabricating more efficient and reliable diamond-based MOS electronics.

Experimental techniques like X-ray Photoelectron Spectroscopy (XPS) are often used to analyze and characterize the band alignment at oxide/semiconductor interfaces. In the previous study, the band alignment for the Al_2O_3/diamond heterojunction such as valence/conduction band offsets has been clarified [4]. However, interfacial band bending for the diamond is difficult to be confirmed. This is attributed to the charge up effect for the diamond and Al_2O_3/diamond during the XPS measurement and the presence of the intrinsic C 1*s* peak in diamond makes it impossible to calibrate the binding energy using the adventitious C 1*s* peak (284.8 eV).

In this study, we have formed an Au-mask on the Al_2O_3/B-diamond sample [Fig. 1(a)]. The Au-mask can not only suppress the charge up effect but also be used to calibrate the binding energy positions for the XPS peaks with the Au 4*f* (83.96 eV). The band bending for the B-diamond at the Al_2O_3/B-diamond interface is clarified [Fig. 1(c)].

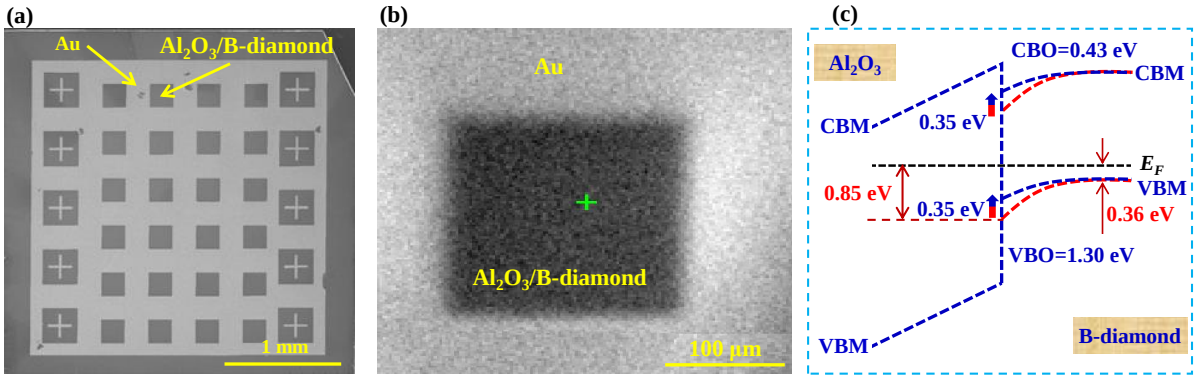

Fig. 1 Scanning electron microscopy image of the Al_2O_3/diamond with net-patterned Au-mask. (b) Image of the XPS measurement. and (c) Band bending for the B-diamond at the Al_2O_3/B-diamond interface. The CBM, VBM, CBO, and VBO are conduction band minimum, valence band maximum, conduction band offset, and valence band offset, respectively.

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