高温度安定ノーマリーオフ動作シリコン終端 2DHG ダイヤモンド MOSFET

The Si-terminated 2DHG Diamond MOSFETs with the Normally-off operation and Wide Temperature Range Stability

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Diamond exhibits excellent electrical properties such as high thermal conductivity about 22 kW $m^{-1}K^{-1}$, high breakdown field over 10^7 V/cm, and high bulk hole mobility of 2000 cm^2 Vs^{-1}. We have developed the H-terminated (C-H) diamond MOSFETs by using the two-dimensional hole gas (2DHG) [1-2].On the other hand, the electronegativity of Si is 0.7 Pauling unit lower than that of C, the different electronegativity (C: 2.5, Si: 1.8) C-Si dipole could more holes accumulate on the silicon termination diamond than the C-H(C: 2.5, H: 2.1) [3], the spontaneous polarization of C-Si dipole expects to induce the 2DHG which can used as the p-channel to fabricate the MOSFETs, and the SiO_2 also is advantageous for power devices in terms of chemical stability and wide band gap. The SiO_2 can be used as the gate insulator in the diamond power devices [4]. In this work, Si-terminated (C-Si) diamond MOSFETs has been fabricated with the boron-doped p+ diamond selective growth by using the SiO_2 as the mask for source and drain formation and the gate insulator and the C-Si diamond MOSFET achieved Normally-off operations and wide temperature range stability.

High-pressure high-temperature (HPHT) Ib (001) diamond substrate has been used to fabricate the Si-terminated MOSFET (Fig.1) in this work, 260 nm SiO_2 layers was formed by utilizing TEOS-CVD, the conformation of the C-Si diamond surface was formed during the Boron-doped diamond selective growth by the MPCVD with the high temperature 727°C and hydrogen plasma (microwave output power 360W). The Ti/Pt/Au metal electrodes for source/drain and 100nm ALD Al_2O_3 layer for passivation was deposited, and the 100nm Al overlapping gate has been formed in this MOSFET. The electrical characteristics of this C-Si diamond MOSFET in the room temperature (300 K) and the high temperature (673 K) were shown in Fig.2. The obtained maximum drain current density of the C-Si diamond MOSFET (normalized by gate width 25um) is -118mA/mm at V_{DS} = -30V and V_{GS} = -40 V, the maximum gm is 2.43 mS/mm at V_{DS} = -10 V, the field effect mobility (μ_{EF}) is 111$cm^2V^{-1}s^{-1}$, and the threshold voltage is V_{TH}=-4.0V (achieving normally-off operation in the room temperature). For the high temperature operation, the maximum drain current density is increased to -125mA/mm, μ_{EF} reaches up to 190$cm^2V^{-1}s^{-1}$ and the threshold voltage still keeps the normally-off operation (V_{TH}=-2.8V). As a result, The C-Si MOSFET shows the excellent temperature stability and normally-off operation which will contribute significantly to the diamond p-FET for the complementary inverter circuits combined with GaN or SiC n-FETs.

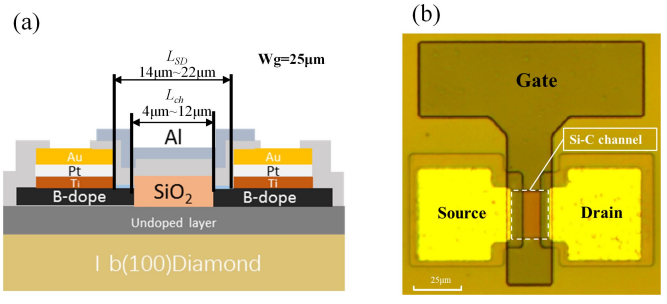

Fig.1 (a) A sectional model of Si-terminated 2DHG diamond MOSFET(b) The optical microscope top views of the Si-terminated diamond p-MOSFET

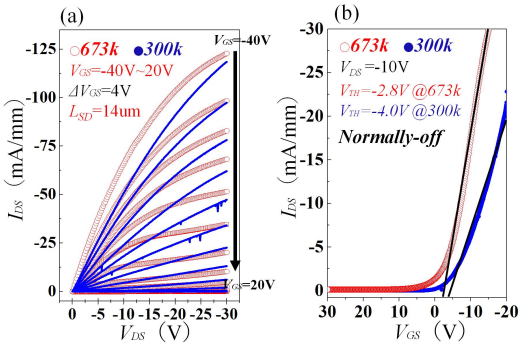

Fig.2 (a)The V_{DS}-I_{DS} and (b)The V_{GS}-I_{DS} characteristics of Si-terminated 2DHG diamond MOSFET in 273k and 673k.

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