820 MW/cm^2 3326 V 0.42 A/mm 選択ドープダイヤモンド MOSFET

820 MW/cm^2 3326 V 0.42 A/mm Modulation Doped Diamond MOSFETs

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1. Introduction

Diamond is a promising semiconductor material for high power and high-frequency operation as it possesses a very high breakdown field and thermal conductivity. The hole sheet concentration of H-diamond can be increased by using NO_2 doping up to ~1 × 10^{14} cm^{-2} [1] and can be passivated by using the Al_2O_3 layer [2]. Recently, we demonstrated p-channel modulation-doped diamond MOSFETs with NO_2-delta doping in the Al_2O_3 layer for spatial separation of acceptor layer to improve mobility [3]. This study reports a very high voltage (3326 V) operation of modulation-doped diamond MOSFETs.

2. Growth and Fabrication

Diamond MOSFETs were fabricated on (001) high-quality heteroepitaxial diamond (Kenzan diamond®). An Al_2O_3 layer was deposited on the H-diamond as the spacer layer. Then, NO_2 delta doping was performed on the spacer layer. Finally, an Al_2O_3 /NO_2/ Al_2O_3 was formed on the H-diamond sample.

3. Results and Discussion

Figure 1 (a) shows the maximum drain current ($I_{D,max}$) of 417 mA/mm and on-resistance of 82.2 Ω·mm of modulation-doped diamond MOSFETs. From the capacitance characterization, a maximum sheet concentration (p_s) of 1.66 × 10^{13} cm^{-2} was obtained. By eliminating the access resistance, p_s dependent effective mobility (μ_{eff}) characteristic is shown in Fig. 1(b). μ_{eff} at the high current region was almost constant (~150 cm^2/Vs) and near the threshold maximum, μ_{eff} becomes 497 cm^2/Vs. A high breakdown voltage of 3326 V was measured as shown in Fig. 2. The specific on-resistance was 13.48 mΩ·cm^2 and consequently, Baliga's figure-of-merit (BFOM) was determined as 820 MW/cm^2.

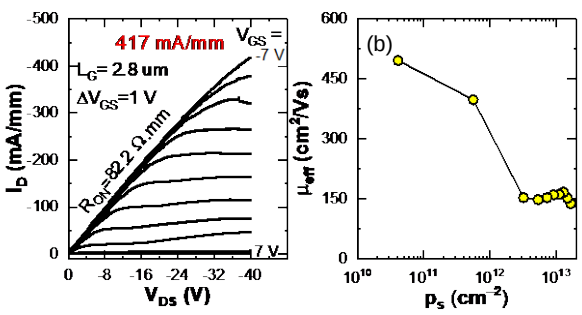

Fig 1. (a) DC output characteristics of modulation doped diamond MOSFET and (b) sheet-carrier density dependent effective mobility characteristics.

4. Conclusion

In conclusion, by using NO_2-delta doping in the Al_2O_3 layer technique, we have demonstrated the high voltage (3326 V) operation and high BFOM (820 MW/cm^2) of modulation-doped diamond MOSFETs.

Acknowledgements

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References

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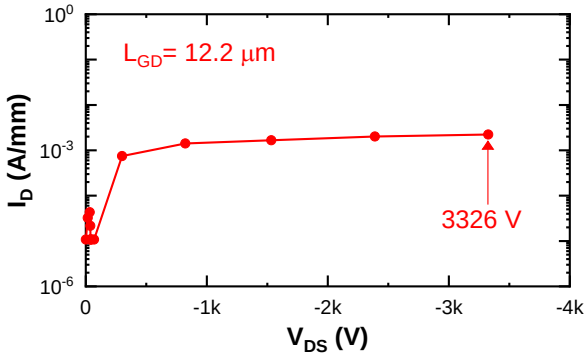

Fig. 2. Off-state breakdown voltages of modulation doped diamond MOSFET.