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C—1—3 Plasma-Grown Oxide Gate GaAs Deep Depletion MOSFET

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GaAs MOSFET's using a chemical anodization technique for forming native oxides as gate insulators have already been reported.[1, 2] In this paper, we present the first GaAs MOSFET using a low-temperature plasma-oxidation technique as a new native oxidation process of GaAs. Because of a simple one-step dry process, a plasma oxidation technique is more favorable to a device fabrication than a chemical anodization technique. The plasma oxidation was made in the following manner. An oxygen plasma in a quartz chamber was excited at a pressure of about 0.1 Torr with a 150 W, 10 MHz power generator by making a capacitive coupling between an Al substrate holder and a Cu electrode attached to the outside of the chamber. The magnetic confinement of the plasma thus formed was made to increase an oxidation rate and to avoid contamination from the chamber walls. The wafer of a l.p.e.-grown layer($n \simeq 1.2 \times 10^{17}$ cm^{-3}) on a Cr-doped substrate was immersed in the oxygen plasma for about three minutes to grow a 900 Å-thick oxide film. The thickness of the film was determined by interference color which could be observed through the chamber wall during oxidation. Under a typical oxidation condition, a thermocouple attached to the oxidizing sample read ~290 °C. The oxide films grown by this technique are shown to have good dielectric and interface properties so that the successful fabrication of GaAs MOSFET can be reported now. A preliminary analysis has shown that the films have an oxygen-to-GaAs ratio of 4; on the other hand, an oxygen-to-GaAs ratio of the oxide films grown by the linear plasma device has recently been reported to be 1.5.[3]

Figs. 1a and b show the output characteristics of the device(gate length: 400 µm, gate width: 50 µm) measured with a 100-Hz curve-tracer. The device shows a good saturation characteristic in both the depletion and enhancement modes of operation. The value of the zero-gate-bias drain saturation current I_{dso} in the enhancement mode is smaller than that of I_{dso} in the depletion mode; I_{dso} in the enhancement mode decreases with increasing gate bias. This is presumably due to electron trapping at the interface states; consequently, the flatband voltage increases in the positive direction as gate bias increases. Therefore, in the enhancement mode, the device does not exhibit square-law behavior of the transconductance against gate bias.

In the depletion mode, the field-effect mobility of the device is measured at a low drain voltage($V_D = 0.3$ V) and plotted against gate bias(Fig. 2).

Values of the field-effect mobility obtained are comparable to the value of the Hall mobility($\mu_H \approx 4000\ cm^2/Vs$) of the starting epitaxial n-layer.

In conclusion, we described the fabrication and performance of an n-channel GaAs deep depletion MOSFET with high-quality gate oxides grown using a low-temperature plasma-oxidation technique. In addition to the high field-effect mobility, simple and reproducible fabrication indicates that the plasma-grown oxide gate GaAs MOSFET promise to become useful devices for GaAs high-speed integrated circuits.

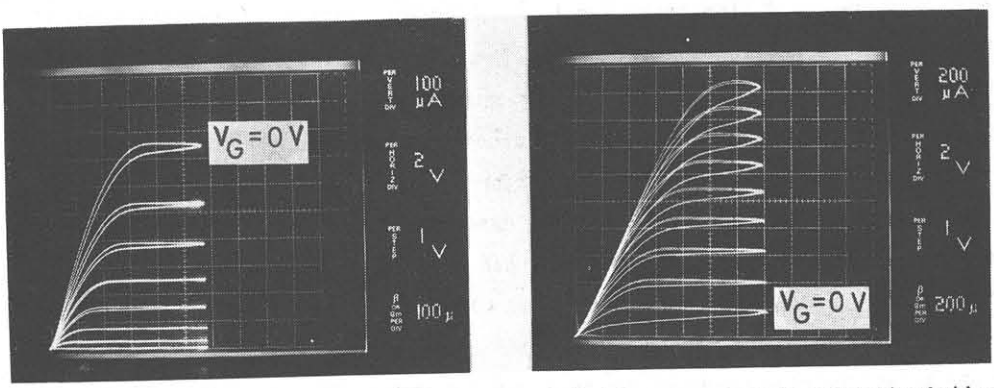

Fig. 1(a) Depletion-mode characteristics, Drain current: 0.1 mA/div.; Drain voltage: 2 V/div.; Gate bias: 1 V/step.

(b) Enhancement-mode characteristics Drain current: 0.2 mA/div.; Drain voltage: 2 V/div.; Gate bias; 1 V/step.

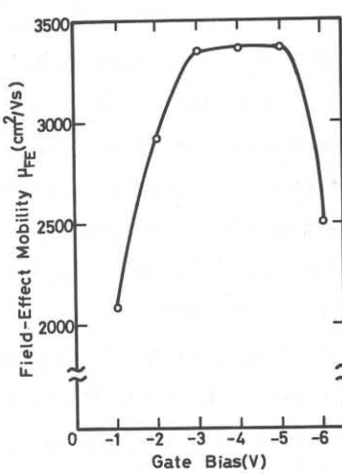

Fig. 2 Variation of field-effect mobility with gate bias at a low drain voltage.

References

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