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B—2—2 Investigation on the Drift of GaAs MESFET's by High Frequency Parameters

K. Ohata, H.Itoh and F.Hasegawa

Central Research Laboratories, Nippon Electric Co., Ltd.
Miyazaki, Takatsu-ku, Kawasaki, Japan

The drift of gain and noise figure during operation was one of the annoying problems of GaAs MESFET's for past few years. Although it is almost solved now in practical devices by appropriate passivations, the mechanism of the drift is not made clear yet and there are many discussions on it, that is, the drift is dominated by the surface condition[1),2)], or it is affected by the substrate[3)].

In order to make clear the mechanism furthermore, and to distinguish the effect of the surface and the substrate, the drift of the equivalent circuit parameters was measured with changing the surface condition and the substrate bias. It was found that remarkable changes in the drain conductance and the drain gate feedback capacitance occured due to the ordinary drift, and that the manner of such changes was different from that due to the substrate bias.

The s-parameters of 1- μm gate low noise GaAs MESFET's with and without a surface passivation were measured in the frequency range from 1 to 2 GHz by an automatic network analyser. The measurement was carried out with some time interval after applying a drain bias of 2.5V and an appropriate gate bias to give an initial drain current of 10 mA (normal bias condition). After about 15 minutes, the substrate bias was applied (substrate bias condition). The equivalent circuit parameters were calculated from the measured s-parameter values.

Figure 1 shows the difference in the drain current drift between a MESFET with a passivation and that without a passivation. The drift in the normal bias condition is remarkably improved by the surface passivation, however, the drift due to the substrate bias is not affected by the surface passivation at all. This fact means that the phenomena of both conditions are different. Figure 2 shows the changes of the circuit parameters and the drain current I_d of a MESFET without the surface passivation. Figure 3 shows the initial values of the equivalent circuit parameters and those of 10 minutes later. In the normal bias condition, as I_d decreases, the drain-conductance g_d, the transconductance g_m and the feedback capacitance C_{dg} decreases gradually but the gate capacitance C_{gs} do not change very much. When I_d is reset to the initial current (shown as "I_d Reset"), g_d and C_{dg} do not come back to the original values although the others recover. On the contrary, in the substrate bias condition, parameters show the different changes from those in the normal bias condition, for example, all parameters do recover when the substrate bias is removed.

In a MESFET with the surface passivation, on the other hand, all parameters scarcely change in the normal bias condition as shown in Fig.4. Although g_d and I_d are greatly affected by the substrate bias as shown in Fig.1 and Fig.2, it is noted that the g_d and I_d are also stabilized by the appropriate surface passivation for the normal bias condition.

Those results indicate that the drift phenomenon as shown in Fig.2 in the normal bias condition is almost due to the surface effects between the gate and the drain, source electrodes, and an appropriate surface passivation can stabilize all circuit parameters. The changes of circuit parameters, especially those of g_d and C_{dg} in a MESFET without the surface passivation can be explained as the result of the gradual expansion of the surface depletion region from the gate to the drain area after the gate is negatively biased.

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1)D.R.Ch'en et al.; ISSCC Dig. Tech. Papers 1976, p.160.
2)K.Ohata et al.; Record Nat. Conv. IECE Japan 1977, S6-3 (in Japanese).
3)T.Itoh and H.Yanai; Gallium Arsenide and Related Compounds 1978, p.326.

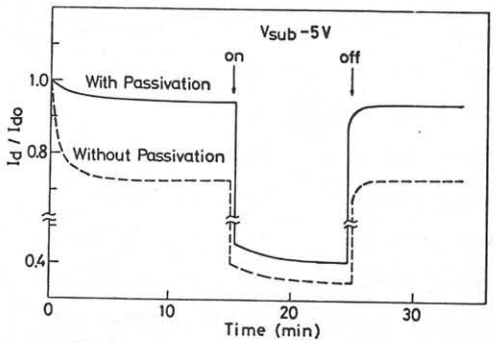

Fig.1 Drain current drift in MESFET's with and without a passivation

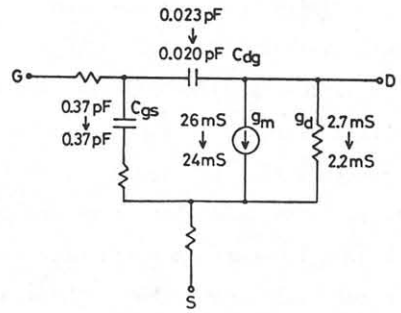

Fig.3 Equivalent circuit parameters of the MESFET in Fig.2 at t=o and 10min.

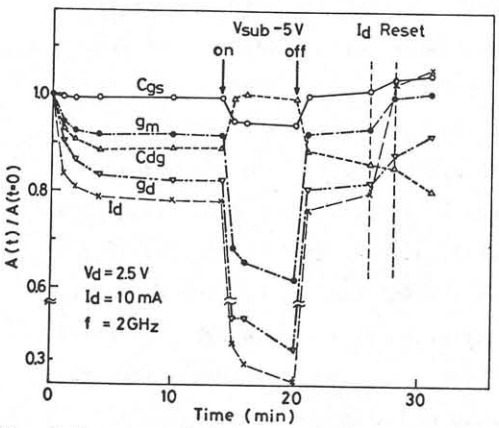

Fig.2 Changes of parameters in a MESFET without a passivation

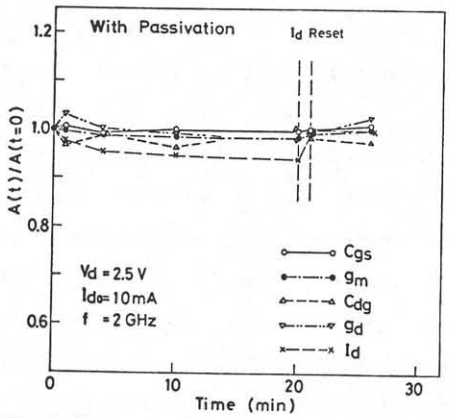

Fig.4 Changes of parameters in a MESFET with a passivation