AlSb/InAs HEMTs with a TiW/Au Gate Metalization

J. B. Boos, B. R. Bennett, W. Kruppa, and D. Park
Naval Research Laboratory
Washington, DC 20375-5320

Low-voltage, low-power-consumption electronics will be critical in future microwave/mm-wave analog and digital applications that require light-weight power supplies, long battery lifetimes, improved efficiency, or high component density. AlSb/InAs HEMTs are potential candidates for these applications due to the attractive material properties of this heterojunction system which include high mobility, high channel conductivity, and high peak electron velocity at low electric field. For example, intrinsic f_T values of 250 GHz have been obtained at V_{DS}=600 mV[1], an f_T of 90GHz has been measured at V_{DS}=100 mV[2], and simulations of MOBILE circuits biased at 0.4V show a power dissipation of 0.3 mW/gate at 20GB/s[3]. The potential payoffs associated with this material system are, however, dependent on further improvements in the technology. One key issue is the reduction of the gate leakage current, which impacts LNA performance by compromising the noise figure and presents design issues for the designer of MOBILE-based logic circuits. In this paper, we identify gate metal-semiconductor reaction as one cause of increased leakage current and demonstrate the use of a TiW/Au metalization scheme to reduce the problem. When compared to previous devices of similar design, HEMTs with the TiW/Au gate exhibit reduced leakage current in the low drain bias region as well as improved thermal stability.

The metamorphic HEMT material was grown on a GaAs substrate at 510 ^{o}C by MBE with a thick buffer layer to accommodate the 7% lattice mismatch. A cross section of the material layer design is shown in Fig. 1. The room temperature Hall mobility and sheet charge density are 20,000 cm^2/V-s and $1.9x10^{12}$ cm^{-2}. Details related to the HEMT design and fabrication process have been previously reported[1,2]. The drain characteristics obtained for a 0.2 µm gate length HEMT with a TiW/Au gate metalization are shown in Fig 2. The maximum transconductance at V_{DS}=500 mV is 750 mS/mm. These characteristics are similar to those obtained using the earlier Cr/Au gates. However, the gate leakage current at low drain bias was reduced by more than an order of magnitude. The gate current characteristics are shown in Fig. 3. At higher drain bias the leakage current increases due to additional holes generated by impact ionization in the channel.

Whereas previous HEMTs with a Cr/Au metalization typically degraded at a temperature near 90°C, minimal degradation in the gate leakage current was observed in the TiW/Au gate HEMT when heat treated up to a temperature of 180°C (unpassivated in a N_2/H_2 atmosphere). Moreover, in special diodes fabricated using the contact, no degradation of the TiW/Au diode was observed with heat treatment up to 270°C (unpassivated in a N_2/H_2 atmosphere). The TiW/Au gate-drain diode characteristic was also measured at low temperature and is shown in Fig. 4. At 77K, the leakage current was reduced by an order of magnitude compared to the 300K characteristic. The HEMT microwave performance will also be presented and discussed.

[1] J. B. Boos et al., *Electron. Lett.*, **34** (15), pp. 1525-1526, 1998.
[2] J. B. Boos et al., *J. Vac. Sci. Technol. B*, **17** (3), pp. 1022-1027, 1999
[3] M. G. Ancona et al., *12th IPRM Proceedings*, pp. 130-133, 2000.

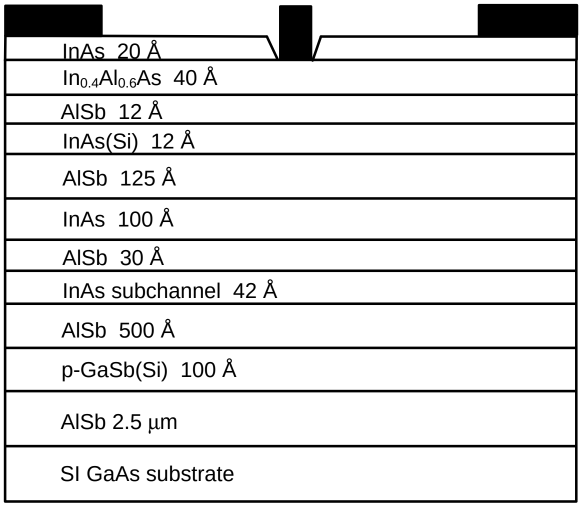

Fig. 1. HEMT cross section.
μ=20,000 cm^2/V-s, n_s=1.9x10^{12} cm^{-2}

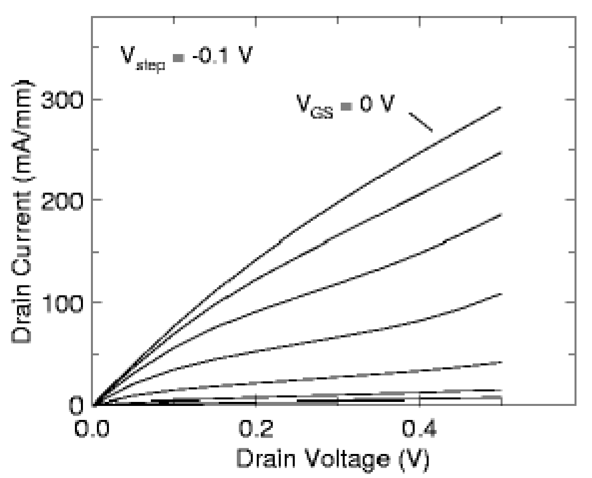

Fig. 2. HEMT drain characteristics.
L_G=0.2 μm, L_{DS}=2.0 μm, W_G=50 μm.

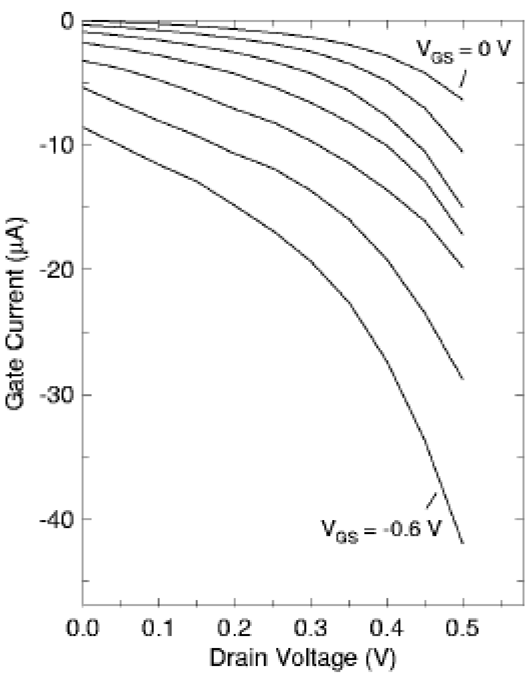

Fig. 3. HEMT gate current.

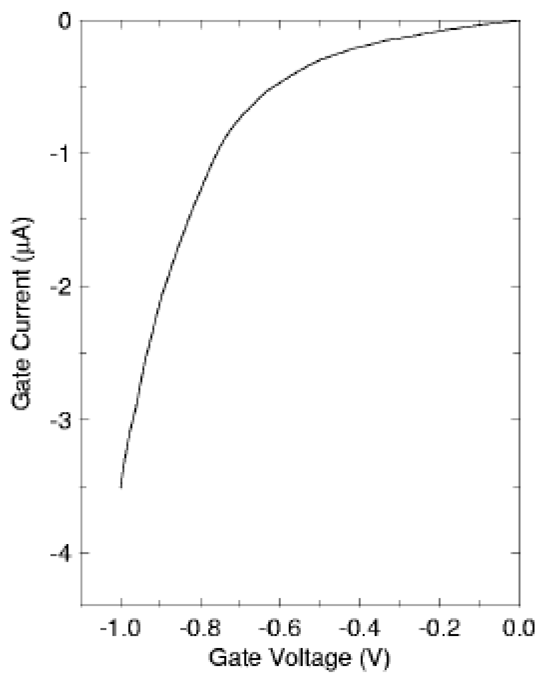

Fig. 4. Reverse gate-drain diode characteristic at 77K.