Optimization of sub-100 nm InP HEMT technology

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Introduction
At high mm-wave frequencies, the InP HEMT amplifier technology provides the lowest noise and highest power. The technology is critical both for ground-based ultra-low noise receivers (IF amplifiers in radio astronomy) and in several scientific missions probing outer space. The InP HEMT technology, however, is not wide-spread and detailed data on device performance are scare, in particular for scaled HEMT devices below 100 nm. We here report results from a 50/70 nm InP HEMT technology.

Results
An InP pseudomorphic HEMT technology with 70 nm gate length has been developed. The epitaxial HEMT structure was grown using an in-house InGaAs-InAlAs-InP MBE. Dc and rf performance as a function of epitaxial parameters has been studied, in particular gate-to-channel distance. This has resulted in devices with $f_{\text{max}} > 400$ GHz and $g_m > 1500$ mS/mm, see Fig. 1 for $g_m(V_g)$ as a function of gate-to-channel distance. The extrinsic cut-off frequency $f_T$ was 180 GHz.

Dedicated modeling and experimental studies for the InP HEMT process have also been performed for thin-film TaN resistors, dry etching of via holes and MIM capacitance models. MMIC demonstrators have been fabricated in a microstrip process using 50 nm InP HEMTs. See Fig. 2 for a photograph of a one-stage broadband feedback amplifier exhibiting a gain of more than 8 dB from 0 to 42 GHz.

Fig. 1. Transconductance vs. gate voltage for $V_{\text{ds}}=1.5$ V.

Fig. 2. A MMIC broadband amplifier based on 50 nm InP HEMT technology.