45nm gate length HEMT-InP with f_{max} of 540GHz and f_T 430 GHz using a composite channel InGaAs/InAs/InGaAs

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Abstract

High-electron-mobility transistors (HEMTs) with a composite channel InGaAs/InAs/InGaAs are very promising for millimeter and terahertz applications, especially in radio communication systems[1], imagers, radio astronomy[2], and telecommunication[3]. The telecommunication is the main focus of our project, because of their superior high-frequency characteristics and low-noise properties[4]. In fact, for the last 10 years, InP based transistors have held the record in frequency response as assessed by the current-gain cutoff frequency f_T and the maximum oscillation frequency f_{max}. The Current record for f_T is 688 GHz in pseudomorphic InGaAs/InP HEMTs [5], and that of f_{max} is 1.5 THz [6].The objective of this thesis is to develop a generic technology for the development of integrated circuits for THz frequency and low power applications. HEMT is one candidate for THz applications especially for communication reception. Indeed, it permits the best low noise and amplification of high frequency signal. Furthermore, we intend to explore the capabilities of ultra high frequency transistor for low power consumption in the millimeter band frequency. IEMN is involved in these activities and the characteristics frequency obtained several years ago were cutoff frequency fT =450GHz and the maximum oscillation frequency fmax=500GHz [7].

In this work, we developed a device (Fig1) in which the resistance and capacitance parasitic were minimized. To achieve this, we reduced Drain-Source distance from 2µm to 1.5µm and the gate width from 50 µm to 24 µm. Schottky barrier layer is also reduced from 6nm to 2nm, with InAs composite channel with a total thickness of 95Å, consisting of an InAs layer inserted between two lattice matched In0.53Ga0.47As layers on InP substrate. With all this modifications the result of HEMT-InP based pseudomorphic with 45nm gate length are low contact resistance Rc=13 Ω.µm, Rsheet =56Ω, with a cap layer, high current IDS 1500mA/mm and 2000mS/mm extrinsic peak transconductance Gm achieved at VDS=0.8V. The current-gain cutoff frequency (fT) achieved is 430GHz and the maximum oscillation frequency (fmax) is 540GHz.

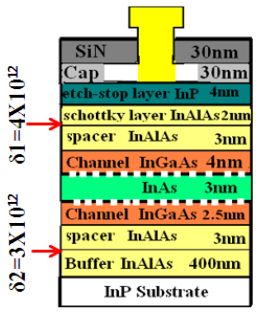

Figure1: Cross-sectional schematic of epitaxial layer structure Fabricated.

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