

DC and RF Characteristics of Double Pulse Doped In($\text{Al}_{0.85}\text{Ga}_{0.15}$)As/ $\text{In}_{0.7}\text{Ga}_{0.3}\text{As}$ / InP HEMTs Recessed by CH_4/H_2 Inductively Coupled Plasma Etching

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InP-based HEMTs are increasingly becoming important for the fabrication of millimeter wave-MMICs with high speed and low noise applications[1]. One of the major drawbacks of these HEMTs for high power applications has been a low gate breakdown. Dry recess etching process in HEMT devices is also required to obtain uniform device characteristics[2]. In this paper, we report double pulse doped $\text{In}_{0.7}\text{Ga}_{0.3}\text{As}/\text{In}(\text{Al}_{0.85}\text{Ga}_{0.15})\text{As}/\text{InP}$ pseudomorphic HEMTs (PHEMT) with high breakdown voltage fabricated using the selective dry gate recess process of a CH_4/H_2 inductively coupled plasma (ICP).

The InGaAs/InAlAs PHEMT structure grown by MBE consists of a 10nm heavily doped InGaAs cap, a 25nm undoped $\text{In}(\text{Al}_{0.85}\text{Ga}_{0.15})\text{As}$ Schottky, a Si pulse doping, 3nm $\text{In}(\text{Al}_{0.85}\text{Ga}_{0.15})\text{As}$ spacer, a 15nm undoped $\text{In}_{0.7}\text{Ga}_{0.3}\text{As}$ channel, 3nm $\text{In}(\text{Al}_{0.85}\text{Ga}_{0.15})\text{As}$ spacer, a second Si pulse doping, and a 300nm undoped $\text{In}(\text{Al}_{0.85}\text{Ga}_{0.15})\text{As}$ buffer layer on InP substrate. A typical sheet density of $3.4 \times 10^{12}/\text{cm}^2$ and a Hall mobility of $8900 \text{ cm}^2/\text{Vs}$ for PHEMT have been measured at 300K. In HEMT device, $0.2\mu\text{m}$ T-gate was defined in a PMMA/co-polymer resist system by electron beam lithography. We used dry gate recess process using ICP system with CH_4/H_2 gas mixture to selectively etch the heavily doped InGaAs ohmic layer over InAlAs Schottky layer. RF power of 18W and ICP power of 300W were used at a pressure of 27 mTorr giving a DC bias of -185V for dry gate recess process.

The reverse gate-to-drain breakdown measured at $1\text{mA}/\text{mm}$ for the dry etched PHEMT is as high as 8.7V. The dry etched HEMT shows good pinch-off characteristics and does not exhibit any kink effect. The saturation drain current measured at $V_{\text{gs}} = 0\text{V}$ is 50mA for the $0.2\mu\text{m} \times 100\mu\text{m}$ HEMT device. The dry etched HEMT device shows the uniform DC output characteristics having an extrinsic transconductance of 750 mS/mm and a threshold voltage of -0.9V . The f_{T} and f_{max} obtained for the $0.2\mu\text{m} \times 100\mu\text{m}$ PHEMT device were 110 GHz and 200 GHz, respectively.

Reference

- [1] T. Hwang, P. Chye, and P. Gregory, IEE Electronics Letters 29, 10(1993).
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