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Analytical Modeling of InSb/AlInSb Heterostructure Dual gate High Electron Mobility Transistors

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***Abstract*— This paper presents an approximate solution of a 2D Poisson's equation within the channel region for Double-Gate AlInSb/InSb High Electron Mobility Transistors (DGHEMTs), using variable separation technique. The proposed model is used to obtain the surface potential, electric field, threshold voltage and drain current of both tied and separated gate bias conditions for Double-Gate AlInSb/InSb HEMTs. The surface potential and electric field are derived for both effective conduction paths of front and back heterointerface by a simple analytical expression and an analytical solution is verified with sentarus TCAD device simulator.**

***Index Terms*— Double Gate; Heterostructure; InSb/AlInSb; Variable Separation Technique**

I. INTRODUCTION

MOSFETs are the most promising devices for many digital and analog circuits. When dimensions are scaled down the short channel effects (SCEs) will disorganize the device performance [1-5]. It is the most needed one to reduce the device dimension in both vertical and horizontal directions without affecting the device performance. Many researchers have been performing their research to overcome such short channel problems by gate engineering (double material gate, triple material gate), channel engineering (dual channel technologies) and source-drain engineering [6-8].

The dual channel technology, which was invented in 1984, gives better output current and transconductance. The double gate MOSFETs technology provides better charge control in the channel and reduction in short channel effects in the nanometer regions and its solution is used for further reduction in the gate length [9-10]. In the same way, Wichmann used transferred substrate technology to reveal the short channel effects of high electron mobility transistor with different gate lengths. It shows that SCEs are less significant with very small gate length than the single gate HEMTs [11].The channel thickness, which is in the vertical direction, can be reduced without short channel effect using the back gate technology with particular gate length for both quasi-enhancement and depletion mode operation of double gate HEMTs [12].

Nowadays, many research groups are concentrating on higher frequencies and ultra-low power devices with increasing lattice constant (greater than 6.0A). The first high electron mobility transistor was fabricated using component semiconductor AlGaAs barriers and the GaAs channels are known as Modulation-Doped Field-Effect Transistors (MODFETs) [13]. In order to change the MODFETs to higher frequency operation with high electron mobility and velocity, the indium (In) has been added to GaAs channel. The modified structure with $In_xGa_{1-x}As$ channel is known as Pseudomorphic HEMTs (PHEMTs). Further to improve the performance of the high electron mobility transistor additionally indium (In) has been added to the barrier and also with the channel. The trend towards the logical evolution, undoped InAs layer is used as a channel with a lattice matched InAlSb layer for confining the electrons [14-17].