Investigation of $Al_{1-x}In_xN$ barrier ISFET structures with GaN capping on silicon substrates for pH detection

T. Brazzini*, A. Bengoechea-Encabo, M.A. Sánchez-García, F. Calle
Dpto. Ingeniería Electrónica and Instituto de Sistemas Optoelectrónicos y Microtecnología
ETSI Telecomunicación, Universidad Politécnica de Madrid, 28040 Madrid, Spain
*E-mail: tbrazzini@isom.upm.es

In the last decade the interest in nitride-based sensors (gas, ions...) and bio-sensors is increased. In the case of ion sensitive FET (ISFET), gate voltages induced by ions adsorbed onto the gate region modulate the source-drain currents. Devices with high electron mobility transistor (HEMT) hetero-structures, typically $Al_{1-x}Ga_xN$/GaN, have been frequently used in pH detection. In such a structure, the conductivity of the two dimensional electron gas (2DEG) located at the interface between the barrier ($Al_{1-x}Ga_xN$) and the GaN is affected by surface potential modifications. Recently AlInN barrier HEMT is substituting the AlGaN technology basically due to the advantages of lattice matching for indium composition of 17%, reducing in this way the strain present in the conventional AlGaN-based HFET. Furthermore, due to polarization, high carrier concentrations can be achived with a smaller thickness of the AlInN barrier, increasing the transconductance of the device. Thus, improved sensitivity of the device can be achieved as the 2DEG is more influenced by environmental changes with this an ultrathin barrier layer [1].

In this work we investigate in detail the possibility to use InAlN barrier HEMT structures for pH sensing applications. Samples used in this work are $Al_{1-x}In_xN$/AlN/GaN HEMT structures with different barrier thickenesses, in all cases GaN capped, grown by MOCVD on silicon (111) substrates (Figure 1.a). The devices have a length and width of 1.2 mm and 0.5 mm, respectively, and showed a high transconductance up to 83 μS when biased at V_{ds} = 0.2 V (fig.1.b) and V_{gs} = 0.9 V.

The variation of GaN surface potential with pH of the solution gave values comparable with literature, close to the Nerstian limit (58 mV/ph) [2], as shown in fig. 2.a. The variations on the source-drain current (I_{ds}) are shown in fig. 2.b .

References

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2. G. Steinhoff and M. Hermann, W. J. Schaff and L. F. Eastman, M. Stutzmann and M. Eickhoff, Appl. Phys. Lett. **83**, 177 (2003)

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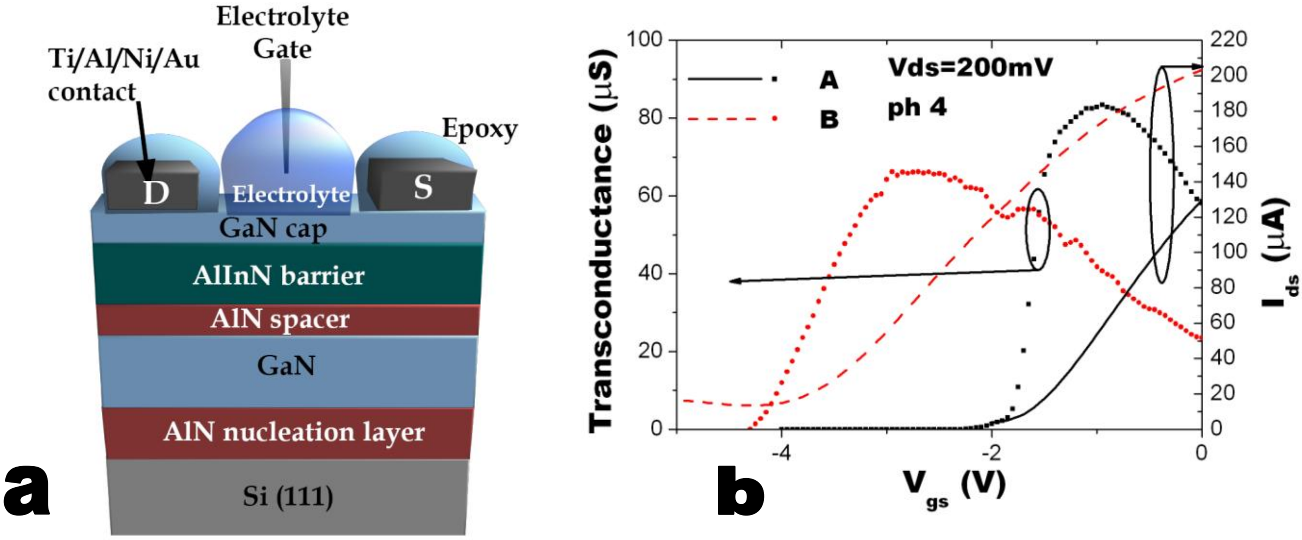

Fig.1: (a) Schematic diagram of the structure and device analyzed and (b) transconductance and source-drain current (I_{ds}) versus gate voltage (V_{gs}) for a pH= 4 solution. DESCRIPCION DE LA BARRERA PARA AMBAS MUESTRAS, POR EJ.: The InAlN barrier has x=X and a width of Y nm for sample A, and XY for sample B.

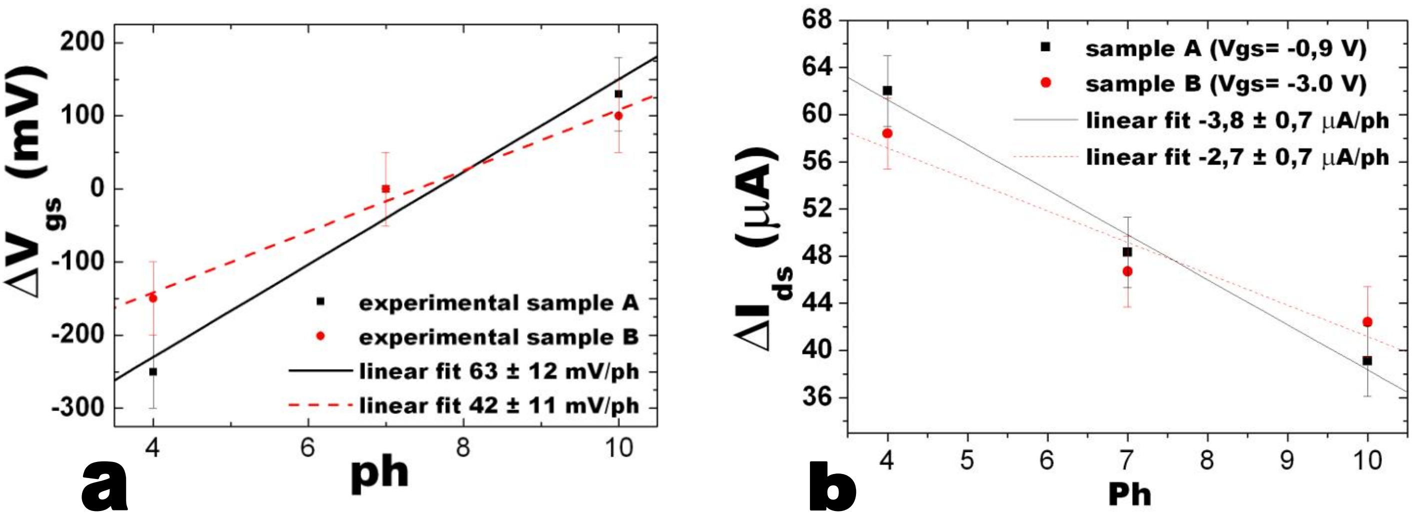

Fig. 2: Variation of the surface potential (a) and source-drain current (b) versus pH for the samples in Fig. 1. investigated. The lines are a linear fit of the experimental values. MODIFICAR LAS LEGENDAS DESCRIBIEBDO LAS MUESTRAS