Study of phosphazene like film formation on InP in Liquid Ammonia (218 K) by electrochemistry and XPS analyses.

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High electron saturation velocity and high thermal conductivity make InP a relevant semiconductor for metal–inslator–semiconductor Field Effect Transistors (MISFET) [1]. However, the instability of devices based on InP or other III-V is generally associated to the evolution of electrical and chemical parameters of the interfaces. Therefore, the surface passivation of semiconductor (SC) in aqueous solvent obtained by anodic treatments has been explored in order to minimize those instability and increase device performances [2]. For example, the sulfur passivation $(NH_4)_2S$ in aqueous media, provide also the formation of stable In-S onto InP surface [3].

Another promising way to modify and perhaps improve the electrical properties of III-V semiconductor surface is to perform anodic treatments in non aqueous solvent in order to obtain original passivating films resulting from a new interfacial chemistry. The use of non aqueous solvents provides a large potential window to the electrochemical response of semiconductors. According to the nature of the solvent (physical and chemical properties), anodic treatments should strongly differ from aqueous media. In past decades, many electrochemical processes have been studied in non aqueous solvents but electrochemical reactions are ruled by moisture, i. e. water chemistry (see e. g. [4]). As a solvent, liquid ammonia (NH_3 liq) has found a distinguished place in electrochemical studies of semiconductors since experiments occur in real water free condition avoiding the formation of oxides surface. In NH_3 liq the formation of a monolayer phosphazene like film on InP was recently published [5,6].
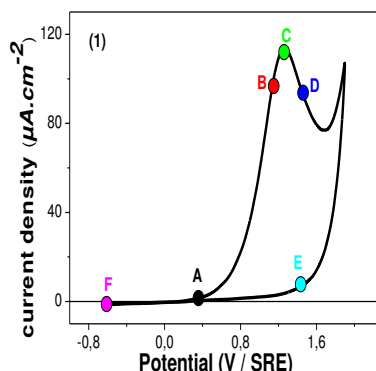

Fig. 1 Electrochemical anodic wave at different steps on InP-n under illumination in liquid ammonia (218 K), [NH4Br] = 0.1M, scan rate: 20mV/s.

In this paper, the study of this protective film on InP is described in NH_3 liq. using cyclic voltammetry and interfacial capacitance. The anodic treatment is characterized by a reproducible anodic wave obtained during the first scan (Fig. 1). A passivation step of the surface occurs just after the first positive scan since the anodic wave did not emerge again after the following scans. To study the electrochemical formation of the phosphazene like film, the potential scan is stopped for six determinant positions on the anodic wave (A to F).
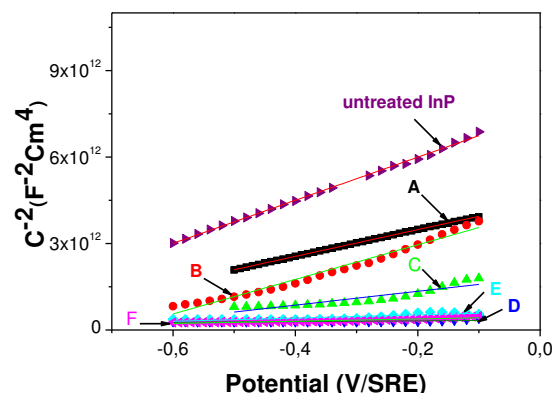

Fig. 2 Evolution of Mott-Schottky according the different stopped scans of the anodic wave (A to F) on InP-n in liquid ammonia (218 K), [NH4Br] = 0.1M, scan rate: 20mV/s.

From the start of the wave (A) to the end of the wave which is given by the position (F). The description of the wave is associated to the evolution of the interfacial capacity. Mott-Schottky plots are reported in the figure 2. A drastic evolution is observed. Mott-Schottky plots become rapidly nearly flat. The applied potential ends up to not wholly dropping in the space charge layer of InP.

Due to the large change of temperature, from very low value (218 K) to the room condition, a gently and suitable extraction of InP, from NH_3 liq. to the analyzer (XPS) was set-up. The same way as for capacitance measurements, surface analyses are performed by XPS for each position (A to F). A gradual evolution of the chemical transformation of InP surface has been clearly demonstrated (Fig.3A-B). The coupling of XPS analyses and electrochemical is a successful approach to understand the gradual evolution of the interface during the phosphazene like film formation on InP.
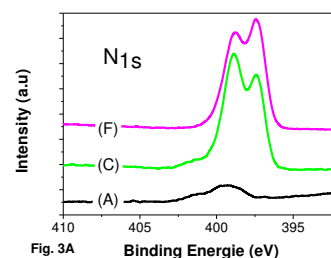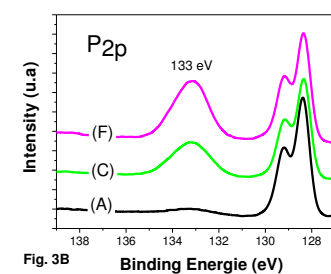

Fig. 3 XPS spectra (**3A**: N_{1s}, **3B**: P_{2p}) obtained after the anodic wave in NH_3 liq.,for different stopped scans (A, C and F). T = 218 K, [NH4Br] = 0.1 M.

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