

## Surface Reactivity of InSb Studied by Cyclic Voltammetry Coupled to XPS

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A necessary step in device technology is the preparation of a reproducible semiconductor surface, undamaged and with a well-determined chemical composition. Among the III-V compounds, InSb has a particularly high chemical reactivity when wet chemical treatments are used. For example, an oxide-free surface is almost impossible to reach. Here, we present a fundamental study of the surface reactivity. The surface chemical composition of InSb is transformed by anodic and cathodic treatments, and the surface layers are analyzed by XPS-profiling (X-ray Photoelectron Spectroscopy).

Cyclic voltammetry gives a first indication of how different the surface composition is after anodic oxidation at low pH or at neutral or high pH. The steady state anodic currents are large at low pH and much smaller at neutral or high pH, by orders of magnitude. The latter means that the surface is passivated. XPS analysis confirms the presence of a thin (mixed) oxide layer at neutral or high pH. After anodization at low pH, XPS-profiling reveals the presence of a thick, porous Sb oxide. The  $Sb_{3d_{3/2}}$  signal clearly consists of three contributions: Sb from the InSb crystal, the Sb oxide, and a significant amount of elemental Sb ( $Sb^0$ ). The  $Sb^0$  concentration is almost constant across the thickness of the film (see Fig. 1a). After a subsequent cathodic treatment, even more  $Sb^0$  is obtained, due to reduction of the Sb oxide (see Fig. 1b).

The presence of  $Sb^0$  in the anodic oxides of InSb is one of the reasons why they are of insufficient electrical quality for technological applications (poor breakdown characteristics, high surface state and interface trap densities). The presence of  $Sb^0$  is usually discussed from a thermodynamic point of view. However, work on other semiconductor materials has shown that the reaction mechanism is crucial in determining the composition and thickness of surface layers on compound semiconductors after (electro)chemical treatment. Our results indicate that  $Sb^0$  is formed as an intermediate species in the anodic oxidation of InSb, much in the same way as  $Te^0$  is obtained in oxidation layers on HgCdTe or CdTe.

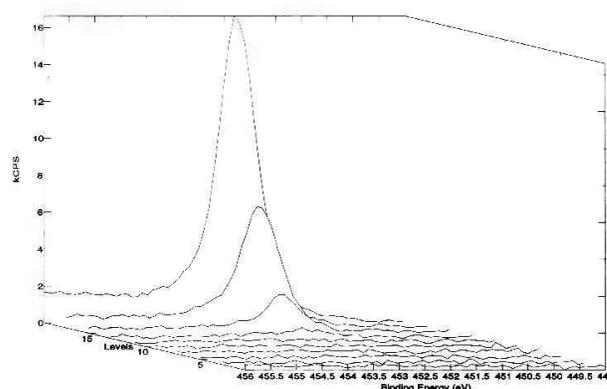


Fig. 1a : In<sub>3d3/2</sub>

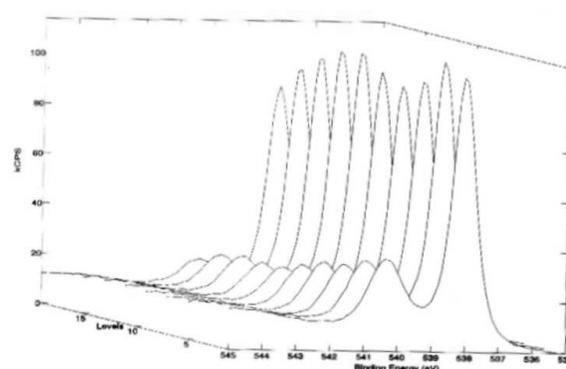


Fig. 1b : Sb<sub>3d3/2</sub>

Figure 1. XPS-profiles of the interfacial region on p-InSb(100) after electrochemical treatments at pH 0 (1.2 M HCl): (a) interface after an anodic potential scan from  $-0.6$  V (the open circuit potential) to  $0.0$  V and back to  $-0.6$  V, and (b) after a subsequent cathodic scan to  $-1.05$  V (scans at  $10$   $mV s^{-1}$ , potentials with respect to Hg/HgSO<sub>4</sub>). A thick layer of Sb oxide containing  $Sb^0$  is obtained during the anodic treatment (about  $200$  nm thick), and much of the oxidic Sb is converted to  $Sb^0$  during the cathodic treatment.