Space charge layers and hydrogen adsorption on the cleavage surfaces of III-V compound semiconductors
by Yu Chen

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Physics
Montana State University

Abstract:
High resolution electron energy loss spectroscopy and other surface analytical techniques have been used to study the cleavage and lightly sputtered (110) surfaces of III-V compound semiconductors. Two aspects of their properties are investigated.

First, the conduction-band-electron plasmon and its coupling with the optical phonon in the space charge layer near the surface are studied. In the depletion layer, as the space charge layer forms, the energy positions of these coupled modes shift. In addition, the phonon in the depletion layer is unscreened due to the absence of electrons and oscillates at the uncoupled frequency. Thus three losses are observable. A two-layer model together with local response theory is employed to interpret the data successfully. Space charge parameters are obtained from the model calculation. In an accumulation layer, the plasmon is localized in the space charge region and also couples to the optical phonon. The shifts and intensity changes of these coupled modes are systematically measured as the space charge layer forms and the data are analyzed and understood in the context of model calculations. The high density of electrons in the accumulation layer screens the uncoupled phonon beneath it; thus the bare phonon cannot be observed, in contrast to the case of the depletion layer.

The second aspect is the study of hydrogen chemisorption processes on the cleavage and lightly sputtered surfaces. The H is observed to adsorb on both surface cation and anion atoms for GaAs, GaP and InP where H forms a bond with the dangling bonds. This picture is believed to be true for GaSb, InSb and InAs although quantitative conclusions could not be made. The effective charges for the H-substrate bonds of GaAs, GaP, and InP is calculated. An argument based on electronegativities of these elements is pursued to interpret the trend in the values of the effective charges. A general model to correlate the effective charge with the material's ionicity is proposed. On sputtered surfaces, the anion-H stretch intensity is enhanced relative to that of the cation-H stretch. The strongest enhancements occur on samples containing In, where the local In clustering due to sputtering is believed to be responsible for the passivation of surface In bonds.

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APPROVAL

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Yu Chen

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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