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Indium Phosphide

Methyl hydroxide

Most of our efforts during the past contract period were focused on elucidation of the properties of InP semiconductor/liquid interfaces. Our interest in InP is primarily due to its potential for use in the next generation of high speed electronic devices. We have performed detailed studies of the properties of stable, nonaqueous-based $n\text{-InP}$ /liquid contacts with a variety of redox couples.¹ Measurements of the current-voltage behavior of $n\text{-InP}/\text{MeOH}$ based junctions confirm that charge transfer within this system can be extremely responsive to the electrochemical potential of the contacting phase. This behavior contrasts with the predicted, and observed, behavior for III-V based semiconductor/metal Schottky barrier systems. A full kinetic analysis of the $n\text{-InP}/\text{dimethyl-ferrocene}^{+0}\text{-CH}_3\text{OH}$ interface demonstrated that the deviation between theoretical prediction and actual experiment is not due merely to an artifact of the lower density of states in the liquid, but instead arises from a difference in surface potential between the liquid and metal contacts. This implies that restrictions on interface performance predicted by the unified defect model, and other models that postulate intrinsic limitations on the output properties of InP junctions, can be experimentally avoided with proper choice of redox couple and electrolyte. This work has possible implications with regard to techniques for surface passivities of InP devices and with respect to fabrication of improved Schottky barrier systems based in InP . (10)

During the last year of our ONR contract period we initiated scanning tunneling microscopy studies of the electrode/electrolyte interface.² This work was motivated by the apparent lack of available techniques for the in situ investigation of electrode surface geometric and electronic structure. It is desirable to perform such investigations in electrochemical environments that contain electroactive redox species. We have developed STM tip preparation schemes³ and a microscope⁴ that have enabled us to image, on an atomic scale, highly ordered pyrolytic graphite (HOPG) surfaces which were in contact with aqueous 1 M NaCl solutions containing 0.1 M $\text{K}_3\text{Fe}(\text{CN})_6$ and 0.1 M $\text{K}_4\text{Fe}(\text{CN})_6$. These results suggest that

solution species are sterically hindered from entering the tunneling gap and do not participate in electron transfer reactions. This advance should allow us to perform several unique experiments of electrochemical interest.

References

- 1) M.J. Heben, A. Kumar, C. Zheng, and N.S. Lewis, Evidence for an Unpinned Surface Fermi Level at n-InP/ Liquid Junctions, Submitted to *Applied Physics Letters*.
- 2) M.M. Dovek, M.J. Heben, N.S. Lewis, R.M. Penner, and C.F. Quate, in "Molecular Phenomena at Electrode Surfaces", *ACS Symposium Series*, M.P. Soriaga, Ed., in press.
- 3) M.J. Heben, M.M. Dovek, N.S. Lewis, R.M. Penner, and C.F. Quate, Preparation of STM Tips for the *In Situ* Investigation of Electrode Surfaces, to appear in the *Journal of Microscopy*.
- 4) M.M. Dovek, M.J. Heben, C.A. Lang, N.S. Lewis, and C.F. Quate, Design of a Scanning Tunneling Microscope for Electrochemical Applications, to appear in *Review of Scientific Instruments*.

Personnel Funded by Contract N00014-85-K-0805, mod/amend: P00001

Michael J. Heben, Graduate Student
Amit Kumar, Graduate Student
Nathan S. Lewis, Associate Professor of Chemistry
Reginald M. Penner, Postdoctoral Fellow
Chong Zheng, Postdoctoral Fellow



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