Amino-Acids Detection With Modulation Doped and Surface Nanoengineered GaAs Schottky Diodes

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Most current techniques for analyzing amino acids require substantial instrumentation and significant sample pre-processing. With this problem in mind, we designed, fabricated and tested scalable diode-based microdevice that allows for direct sensing and quantification of amino acids. The device is based on a modulation doped GaAs heterostructure with a Schottky contact. While relatively high mobility and small dielectric constant of GaAs are naturally helpful in this problem [1][2], we additionally present how etching procedure allows for substantial modification of the surface properties, thereby further boosting the sensing performance. Data for several qualitatively different amino acids (e.g. belonging to different classes, such as non-polar with aliphatic R-group, polar uncharged R- and charged R-group) with specific examples of Glycine, Cysteine and Histidine, respectively, are presented.

The conductance for the GaAs-amino acid interface measured using scanning tunneling microscope (STM) was previously reported to have distinct spectral features [3][4]. In this talk, we show that measuring differential conductance of GaAs diode whose surface is in a direct contact with an amino acid, can still lead to a useful (and easier to obtain) information, previously available only via effective but cumbersome STM and molecular electronics type of inquiries. We employ standard multivariate data analysis techniques to extract reliably distinct (> 97%) single amino acid specific features. We also present how sensitivity of detection can be achieved within broadly varied pH levels (pH from 4 to 9, so far). Density functional theory (DFT) was used to examine which adsorption processes were likely responsible for surface conductance modification.

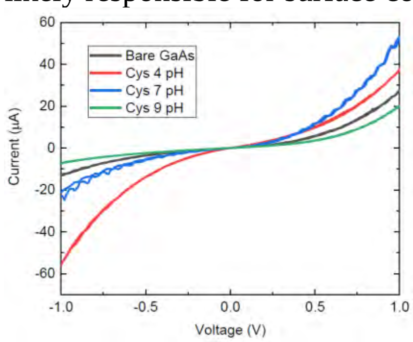

Figure 1 I-V curves of GaAs-Cystein interface for varied pH factor.

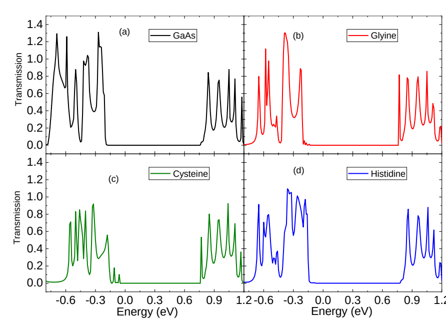

Figure 2 The simulated conductance for the different amino acids adsorbed at GaAs surface

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Supplementary Information

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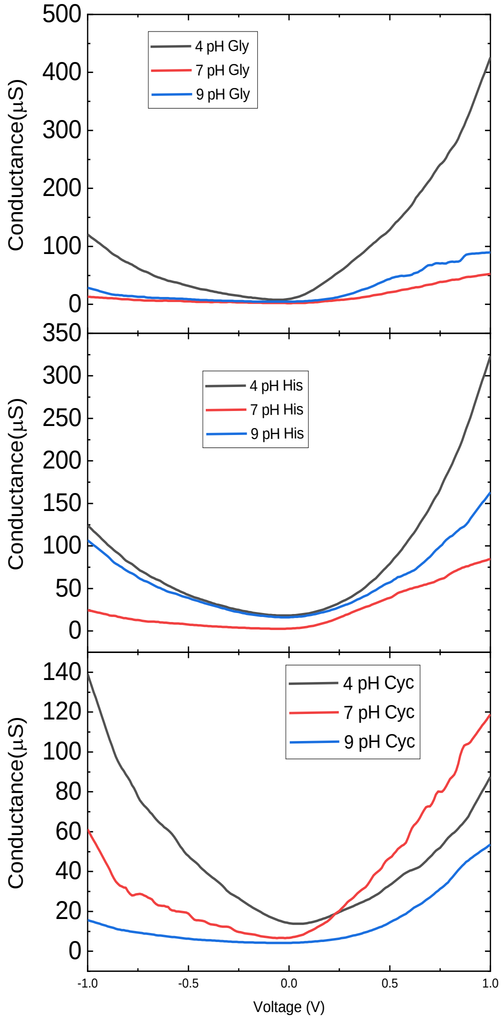

Conductance data for varied amino acids in contact with GaAs, and at varied pH levels. We build here upon work by Willet *et al.* [5], who studied peptides adhesion on inorganic surfaces.

At low pH (pH = 4), in most cases, the measured conductance shows higher values in comparison to the other pH levels except for Cysteine. This behavior can be explained by the way amino-acids bond with the GaAs. The adhesion between Histidine and GaAs decreases with the increase in the pH [5, and this work]. At low pH (<6), Histidine and Glycine bond probably with the GaAs through carboxyl group (this work). However, with the increased in the pH, side group starts to have more effect in the adhesion. At pH above 7, Histidine can bond to GaAs through the nitrogen of the imide group. For cysteine, the thiol group gets deprotonated at pH=7, resulting in strong adhesion with GaAs.

[5] R. L. Willett, K. W. Baldwin, K.W. West, L. N. Pfeiffer, PNAS **102**, 7817 (2005).