Studies of Field Ionization Using PECVD-grown CNT Tips

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The Micro Gas Analyzer project aims to develop the technology for portable, real-time sensors intended for chemical warfare and civilian air-purity control. For the analyzer, we are developing a field ionizer array based on gated CNTs. We plan to use arrays of CNTs because their small tip radii and high aspect ratio yield high fields at low voltage. One possible configuration for the device is to bias the CNTs to the highest potential and the collecting anode to the lowest potential. The electrons in the outer shell of the molecules tunnel out due to the ambient high electric fields, which serve to lower the unperturbed potential barrier seen by the electrons (Figure 1). The tunneling effect is a purely quantum-mechanical process whose probability of occurrence is strongly dependent on the applied electric fields [1]. We optimize the electron current by varying structural parameters in our device. The most relevant parameters include the radius of curvature, height, base radius and base angle of the grown tip; height and thickness of the tip; and the gate aperture. Varying the gate (or oxide) height without updating the height of the CNT yields the derivable result that the electric field is maximized with the tip peaks at about the same height as the gate. When the tip height is varied in sync with the height of the gate (or oxide), we see that an independent optimum height exists (Figure 2). The value of this height will depend, among other variables, on the electrostatic properties of the insulating material and the actual dimensions of the rest of the structure. These simulation results are being verified by experiment.

Figure 1: Representative picture of potential barrier faced by electron in a single molecule when the molecule is close to a tip biased at a high potential.

Figure 2: Field factor $\beta$ for various heights of gate. Tip height was varied in sync with gate height so that the tip remained within the range of the gate width. A field ionization configuration was used. (CNT) : $\text{roc} = 5.01 \text{ nm}$
| Base: angle=85 , radius=101 nm | (GATE) : Aperture=1.01 $\mu$m $\text{Thickness}=0.301 \mu$m $V_{\text{CNT}} = 10 \text{V}$, $V_{\text{GATE}} = 0 \text{V}$, $V_{\text{ANODE}} = -150 \text{V}$

REFERENCES