NANO HIGHLIGHT
Merged CMOS/Molecular I.C. Fabrication, Analysis, and Design:
A Simplified Test Structure For Electrical Characterization Of Molecules
NSF NIRT Grant 0210585

L.R. Harriott, M. Stan, J.C. Bean, M. Neurock, L. Pu
University of Virginia, Charlottesville, VA

A test structure for electrical characterization of metal-molecule-metal junctions was built using simplified processing tools and procedures[1]. The test device consisted of nanometer scale well with a gold bottom, a self-assembled molecular monolayer on the bottom of the well, and capped with titanium/gold. The test device was similar to a device built by a group in Yale[2] but had simplifications in the area of processing tools and conditions. The device tested alkanethiol molecules that were found to tunnel electrons in metal-molecule-metal junctions. The parameters for tunneling, such as potential barrier height (ϕ_b) and barrier shape (α) were determined[3]. The values of these parameters are comparable to those found in the literature. An exponential dependence of tunneling current to the chain length was also found. The exponential decay factor calculated by experimenting with different chain length molecules agreed well with the literature values.
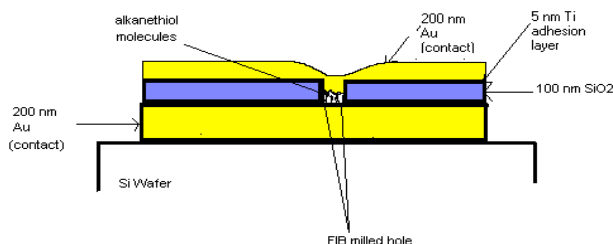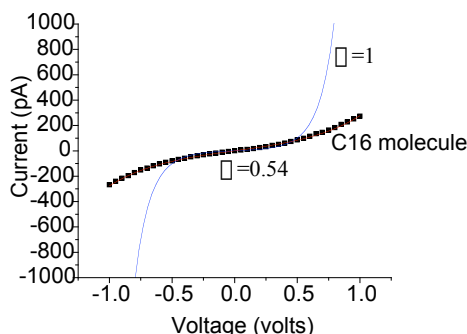

Figure 2 side view of our device..

Figure 1 I-V plot shows c16 experimental data for c16 molecule. Blue line is the plot with a=1 and the red line is the theoretical fit for C16 with α=.54 confirming a nonrectangular fit. barrier height (ϕ_b)
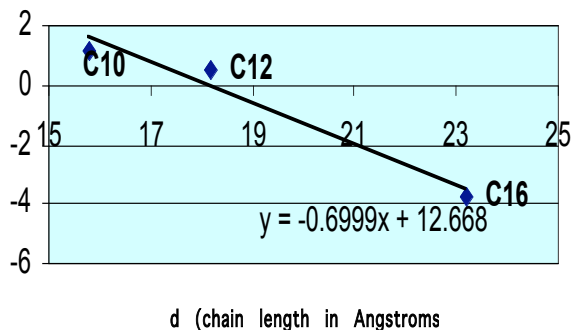
Molecule	ϕ_b (V)	α
C16	2.1±0.1	.56±.02
C14	2.1±0.1	.56±.02
C12	2.1±0.1	.55±.05
C10	2.0±0.1	.75±.02
C8	2.1±0.1	.77±.05

Table 1. α values for different chain length molecules

Figure 3 Graph shows the exponential dependence of tunneling current to the length of the molecule. The slope of this line gives $\beta = 0.7/$ Å.

Our new simplified test structure will enable us to determine I-V characteristics and other fundamental measurements for a wide variety of molecular species. Knowledge of basic transport and conduction mechanisms is critical for the advancement of molecular electronic devices. The results will enable parameter extraction for our circuit modeling effort. This will lead to circuit-based requirements on device parameters and performance in the context of real architectures including CMOS/Nano types.

References:
1. For further information on this project send e-mail to lrharriott@virginia.edu
2. C. Zhou, M. R. Deshpande, M. A. Reed, L. Jones II and J.M. Tour, Appl. Phys. Lett. **71**, 611 (1997).
3. J. G. Simmons, Journal of Appl. Phys. **34**,1793 (1963).