Long-Term Viability of DNA-Based Bionanoelectronics: Studies in Transient Effects on Electrical Property of DNA Molecular Wires

Sam Kassegne, PhD, PE
Associate Professor,
Department of Mechanical Engineering
San Diego State University, San Diego, CA 92182
Email: kassegne@mail.sdsu.edu

In this talk, we present recent data from our Lab in the investigation of the long-term electrical characteristics of DNA in new carbon-based bionanoelectronics platform comprising of DNA molecular wires and interconnects attached to carbon microelectrodes where the 3D structure enables suspension of DNA wires away from the substrate eliminating its effect. Key results in the electrical characterization of this 3D carbon electrode-based bionanoelectronics architecture and accelerated testing for exploring long-term viability and stability of this platform are presented.

This study is part of our ongoing research program in the use of DNA-based nanomanufacturing of more complex 3D nanoelectronics components in an environment of constantly varying and extended localized environmental conditions such as salinity, pH, ionic concentrations, current-levels, temperature, hysteresis, and the like. Such electrochemical variations are expected during the self-assembly process (as well as post-fabrication operation) of DNA wires and interconnects. The systematic electrical characterization of such DNA wires/interconnects by varying such external variables coupled with eliminating the effect of the substrate itself could help the understanding of the fundamental mechanism of charge transport in DNA under various experimental conditions.

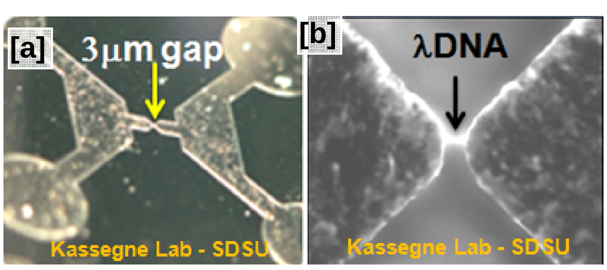

Figure 1. (a) Microfabricated electrodes with 3μm gap and thickness of 50 μm (using soft-lithography) (b) SEM image of 3D electrodes with fluorescent-tagged λ-DNA attachment through Oligos.

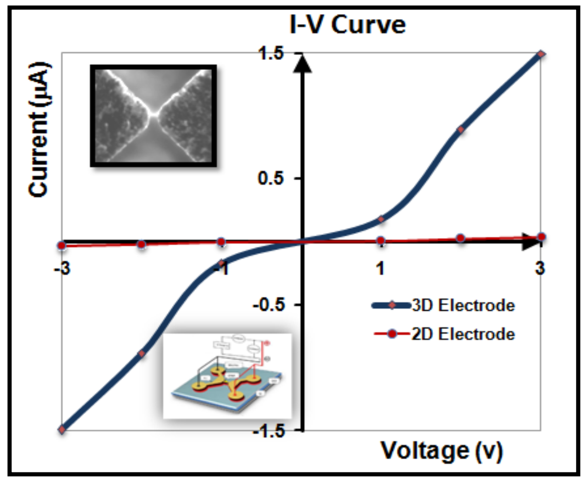

Figure 2. I-V curve for 3D bio-nanoelectronics platform After DNA attachment. Current levels of 1μA is obtained after some tunneling effect at V < 0.25V.

References

1. Berlin Y.A., Burin A.L., and Ratner M.A., *'DNA as a Molecular Wire, Super Lattices and Microstructures'*, Volume 28, Number 4, October 2000 , pp. 241-252(12).
2. Braun, E., Sivan, U., Ben-Yoseph, G.B., "*DNA-templated Assembly and Electrode Attachment of a Conducting Silver Wire*", *Nature*, 391 775-778, 1998.
3. Csaki, A., G. Maubach, D. Born, W. Fritzsche, Institute for Physical High Technology, Jena, Germany *'DNA-Based Construction for Nanoelectronics'.*
4. Mirkin *et al* 1996 *Nature* 382 607.
5. Kassegne, S.K., Reese, H., Hodko, D., Yang, JM., Sarkar, K., Smolko, S., Swanson, P., Raymond, D., Heller, M.J., and Madou, M.J., "*Numerical Modeling of Transport and Accumulation of DNA on Electronically Active Biochips*," *Journal of Sensors and Actuators B: Chemical,* 94 (2003) 81–98, Elsevier Science B.V, 2003.
6. Kassegne, S.K., Arya, B., and Yadav, N., "*Numerical Modeling of the Effect of Histidine Protonation on DNA Hybridization and pH Distribution in Electronically Active Microarrays*," Sensors and Actuators B, Vol-143, pp:470-481 (2010).
7. Eichen, Y., Braun, E., Sivan, U., and Yoseph, G.B., Acta Polym. 49, 663 (1998).
8. Alivisatos, A.P., Johnsson, K.P., Peng, X., Wilson, T.E., Loweth, C.J., Bruchez, M.P., and Shultz, P.G., *Nature (London),* **382** (1996), p. 609.
9. Wang, C., Taherabadi, L., Jia., G., Kassegne, S.K., Zoval, J., and Madou, M., "*Carbon-MEMS Architectures for 3D Microbatteries*," Proceedings of the SPIE, 2004, Vol. 5455, p: 295-302.
10. Hirabayashi, M., Mehta, B., Khosla, A., and Kassegne, S, "*Functionalization of Pyrolyzed Carbon Structures for Bio-nano-electronics Platforms*", 2012, ECS Proceedings, Honolulu, Hawaii.