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Enclosure 1

Final Progress Report
Investigation of High-Frequency Charge Dynamics in Nanoscale Structures

The purpose of this research was to develop techniques for detection of the motion of individual electrons on very short time scales (about $1\ \mu\text{s}$). This was to be accomplished by fabrication and operation of a fast and sensitive electrometer, the radio-frequency single electron transistor (RF-SET). By coupling the RF-SET to a semiconductor-based nanostructure such as a quantum dot (QD), we planned to develop a system capable of rapidly detecting the motion of single electrons.

We have succeeded in the above goals, procuding a strongly coupled RF-SET/QD system that allowed detection of individual electron tunneling events in a time scale as short as $1\ \mu\text{s}$. In addition, we have made significant progress in developing techinques for improved operation of the RF-SET, by means of reducing its junction resistance, thereby improving its impedance to our microwave circuitry. This reduction in junction resistance brings the added benefit of improved linearity as well. Finally, we have extended these charge detection techniques to more complex nanostructures such as double quantum dots (DQDs). We are currently in the process of using a DQD to make frequency-resolved measurements of the RF-SET backaction. Finally, we are in the process of developing on-chip impedance matching networks that should significantly increase the operating bandwidth of the RF-SET.

- Peer Reviewed Publications

1. “Real-time detection of electron tunneling in a quantum dot,” W. Lu, Z. Ji, L. N. Pfeiffer, K. W. West and A. J. Rimberg, *Nature* **423**, 422 (2003).
2. “Sensitivity and linearity of superconducting radio-frequency single-electron transistors: Effects of quantum charge fluctuations,” M. Thalakulam, Z. Ji, and A. J. Rimberg, *Phys. Rev. Lett.* **93**, 066804 (2004).

- Conference Proceedings

1. “Real-time electron counting in semiconductor nanostructures,” A. J. Rimberg, M. Thalakulam, W. Lu, Z. Ji, L. N. Pfeiffer and K. W. West, to appear in the proceedings of the SPIE.

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