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MANIPULATION AND CHARGING OF SILICON NANOCRYSTALS BY ATOM IC-FORCE M ICROSCOPY*

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As silicon-based devices shrink, interest in fast, low-power devices sensitive to small numbers of electrons is increasing. Recent work suggests that MOS structures with large arrays of Si nanocrystals comprising a floating gate are already extremely fast, reliable and nonvolatile relative to conventional floating gate memories, in these structures approximately one electron is stored per silicon. Despite promising initial results, devices have a distribution of charge transit times during writing of nanocrystal ensembles, which limits speed. This behavior is not understood, but could be related to a dispersion in oxide thicknesses, nanocrystals interface states, or possibly shifts in the electronic bound states due to size variations. To address these limitations, we have developed an aerosol vapor deposition technique for silicon nanocrystal synthesis with active size classification, enabling narrow size distributions in ensembles size variation (- 10-1 5°/0 of particle in the 2-10 nm size range). The first goal of these experiments has been to use scanning probe techniques to perform particle manipulation and to characterize particle electronic properties and charging on a single particle basis. Si nanocrystal structures (lines, arrows and other objects) have been formed by contact-mode operation and subsequently imaged in noncontact mode without additional particle motion. Further, single nanocrystal charging by a conducting AFM tip has been observed, indicated as an electrostatic force by apparent height change, followed by a slow relaxation as the stored charge dissipates. Future efforts will also be briefly discussed, including reduction of nanocrystal size distributions, control of oxide thickness on substrate and particles, and measurements of electron transport through particles and ensembles,

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