Probing electronic transport in SiO$_2$ films containing Si nanocrystals by conductive atomic force microscopy

TAO FENG, HARRY ATWATER, California Institute of Technology — Understanding the mechanisms of charge injection into Si nanocrystals embedded in SiO$_2$ is the central issue governing device performance in Si nanocrystal nonvolatile memories. We use conductive atomic force microscopy (c-AFM) to study transport in partially etched SiO$_2$ films containing Si nanocrystals fabricated by Si ion-implantation into a 15 nm SiO$_2$ layer on p-Si (001). The 2~3 nm size nanocrystals were identified by scanning tunneling microscopy. In the c-AFM experiments, correlation between morphologies and tunneling current images shows dependence of tunneling currents on SiO$_2$ thickness fluctuation. Highly localized tunneling paths were recorded and attributed to localized state-assisted tunneling through nanocrystals and/or defects. The electron tunneling current changes much more rapidly with SiO$_2$ thickness than the hole tunneling current, a result explained by the combination of Fowler-Nordheim tunneling and inversion layer formation in the channel for electron tunneling. Current-voltage spectroscopy data showing resonant tunneling and itinerant single electron storage will be presented and discussed.

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