Toward atom scale ultra low power electronic circuitry

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Decades of academic study of silicon with scanned probe and related techniques have made it possible to now envisage a silicon-based, atom-scale, ultra-low power circuitry that merges with and enhances CMOS electronics technology.

A key step was made in 2008 when single silicon dangling bonds on an otherwise H-terminated surface were shown to behave as ultimate small quantum dots[1]. Because all such dots are identical, and spacing between dots can be identical, and dots can be placed very closely to achieve strong interaction, and because many, many dots can be printed easily there appears to be prospects for interesting circuitry. The same dots can be deployed to make “passive” elements like wires and to make active elements of diverse kinds including quantum cellular automata with the prospect of room temperature operation, and single electron transistors (SETs) of extremely narrow device to device variation.

Among most recently published work I will describe are single-electron, single-atom transport dynamics[2] and the use of multi-probe STM to show surface conduction among collectives of DBs[3]. Just published STM spectral studies of silicon atoms will be shown and the remarkable roles of controlled single atom charge state change and of near surface dopants will be identified[4].

The preparation and characteristics of a robust, readily repairable, single atom tip and its varied applications to imaging and fabrication will be described also.

[1] M. Baseer Haider, Jason L. Pitters, Gino A. DiLabio, Lucian Livadaru, Josh Y. Mutus, and Robert A. Wolkow, Phys.Rev.Lett., **102**, 046805 (2009), and patent issued recently.
[2] Marco Taucer, Lucian Livadaru, Paul G. Piva, Roshan Achal, Hatem Labidi,
Jason L. Pitters, and Robert A. Wolkow, Phys. Rev. Lett., **112**, 256801 (2014)
[3] Bruno V. C. Martins, Manuel Smeu, Lucian Livadaru, Hong Guo, and Robert A. Wolkow, Phys. Rev. Lett., **112**, 246802 (2014)
[4] H. Labidi, M.Taucer, M.Rashidi, M.Koleini, L.Livadaru, J.Pitters, M.Cloutier, M.Salomons and Robert A Wolkow, New J. Phys., 17, 073023 (2015)