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On the Road to Low Power Circuitry: Analysis of Si Dangling Bond Charging Dynamics

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Undesired circuit heating results from the billions of electrons flowing through our devices every second. Heating wastes energy (leading to shorter battery life), and also puts a limit on computational speeds. The solution to excess heat generation is of huge commercial interest and has led to a large push towards nanoscale electronics which are smaller and more energy efficient. Proposed hybrid atom-scale schemes have already been formed to reduce power consumption of Complementary Metal Oxide Semiconductor (CMOS) chips commonly used in many consumer electronics including digital cameras and computers. At the heart of these schemes are atomic silicon dangling bonds (DBs) which can theoretically be used to form ultra-low power nanowires. In order to move towards the realization of these practical schemes, however, fundamental physical properties of DBs must first be characterized and studied. One of the properties inherent to DBs is their ability to store electrons. They can exist in a positive, neutral, or negative charge state when storing zero, one, or two electrons respectively. When imaging a DB with a scanning tunneling microscope (STM), fluctuations of the DB charge state can be observed that are driven by influence of the STM tip. A correlation analysis method adapted from biophysics was utilized to study these fluctuations in charge state to help uncover intrinsic transition rates between states for a given DB. Analysis such as this also opens the doors to study more complex systems of interacting DBs as well, which is another important step towards making practical devices.

Author: ACHAL, Roshan (University of Alberta)

Co-authors: Mr TAUCER, Marco (University of Alberta); Dr RASHIDI, Mohammad (University of Alberta); Dr WOLKOW, Robert (University of Alberta)

Presenter: ACHAL, Roshan (University of Alberta)

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