Molecular Quantum-dot Cellular Automata

Craig S. Lent, Gregory L. Snider
Dept. of Electrical Engineering, University of Notre Dame, Notre Dame, IN, 46556 USA

S. Alex Kandel, Rebecca Quardokus, Kenneth Henderson
Department of Chemistry and Biochemistry, University of Notre Dame, Notre Dame, IN, 46556 USA

Claude Lapinte
Sciences Chimiques de Rennes, University of Rennes 1, UMR CNRS 6226, Campus de Beaulieu, F-35042 Rennes, France

lent@nd.edu

Molecular quantum-dot cellular automata (QCA) is an approach to electronic computing at the single molecule level which encodes binary information using the molecular charge configuration. This approach differs fundamentally from efforts to reproduce conventional transistors and wires using molecules. A QCA molecular cell has multiple redox centers which act as quantum dots. The arrangement of mobile charge among these dots represents the bit. The interaction from one molecule to the next is through the Coulomb coupling—no charge flows from cell to cell. Prototype single-electron QCA devices have been built using small metal dots and tunnel junctions. Logic gates and shift registers have been demonstrated, though at cryogenic temperatures. Molecular QCA will work at room temperature. Molecular implementations have been explored and the basic switching mechanism confirmed. Clocked control of QCA device arrays is possible and requires creative rethinking of computer architecture paradigms. By not using molecules as current switches, the QCA paradigm may offer a solution to the fundamental problem of excess heat dissipation in computation. The most promising candidate QCA molecules use transition metal centers to form dots. STM imaging of recently-synthesized molecular double-dots and triple-dots, support the feasibility of exploiting localization in mixed-valence species as QCA devices.

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