Quantum Computing

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Abstract

A description of the general principles of quantum computing is followed by a discussion of different quantum concepts, advantages, applications and documentation describing the leading scientists and institutions at the forefront in exploiting the laws of quantum physics governing subatomic particles for building a faster and more efficient computer.

Keywords: *Superposition, quantum physics, subatomic particles, qubit, quantum dot, spintronic transistor, chemical computer.*

Introduction

Electronics are shrinking. This creates challenges on the limits of the ability to craft increasingly tiny features. These features etched with extremely high-energy laser light are processor components. Disk drives store information in ever-smaller clusters of atoms. Major inhibitions are electrical, magnetic, and quantum interferences that set limits to how many transistors can fit into a given finite volume. According to Moore's Law, the density of integrated chips should double every six months (Gershenfeld and Chuang 1998). It will become ever more difficult to maintain and detect signals such as the state of a memory bit. To circumvent these, scientists are exploring the possibility of molecular memory or information storage in chemical structures of single molecules.

The origins of quantum computing are not too far back. It was first theorized less than 30 years ago, by a physicist at the Argonne National Laboratory. Paul Benioff was the first to apply quantum theory to computers in 1981. He theorized about creating a quantum Turing machine. Most digital computers are based on the Turing Theory (Bonsor and Strickland 2009).

Molecular memory requires chemicals that can oscillate between two stable states, just like atom clusters switching magnetic states on disk drive surfaces. Most of these molecular switches involve structural changes. When changing states, large molecular chunks move relative to each other. However a flat molecule (eg. naphthalocyanine) can change states without undergoing any structural changes. Structurally identical molecules with different conformation are called tautomers. The process is called tautomerization. The memory states can be changed and read through the same technique used in electronics today: changes in electrical conduction (Timmer 2007).

A team of European researchers were able to induce the hydrogens in naphthalocyanine (shown in Fig. 1) to swap locations: single-molecule storage. A tunneling microscope pushed several naphthalocyanine molecules close enough to form linked orbitals.

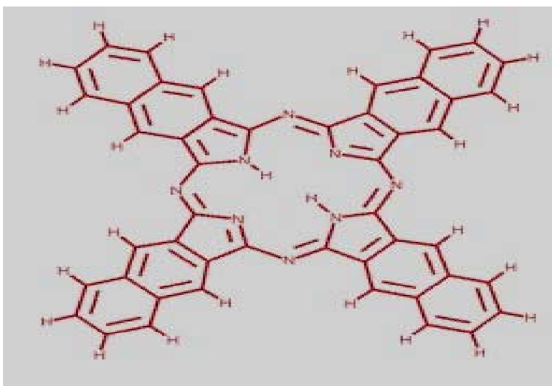

Fig. 1. Naphthalocyanine, a flat molecule. It can change states without any structural changes – tautomerism (Timmer 2007).