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Organic Quantum Computing Systems for Eletronic Brain

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ABSTRACT

The authors propose organic quantum computing system models. The systems are based on novel organic quantum dots device architectures and multiple valued cellular automata(CA) dynamics. In the systems, the MOSFET vertical quantum device architecture is considered, which is composed of massively paralleled quantum dots structure applying organic molecular crystal superlattices multiple layers and inherent tunneling modes.

INTRODUCTION

The downscaling capability of the semiconductor VLSI technology will eventually be brought to an end by the problems of scaling limits, interconnection saturation and multiplicity of more complex functions. Thus, the implementation of a revolutionary approach should consider both device and architecture issues aiming at synthesis post-VLSI technologies and human brain functions.

ORGANIC QUANTUM DOT STRUCTURE

As shown in Fig. 1 organic molecular column, which is composed of bridged stacks of metal phthalocyanine rings, forms one dimensional electron gas system. The wave packet of carriers flow along the conjugated intermolecular π electron orbits of the one dimensional gas system.

Semiconductive quantum band structure, shown in Fig. 2, is observed in the unit column of organic molecular materials such as phthalocyanines. Figure 3 shows organic quantum dots structure with phthalocyanine superlattices crystalline system. The wave packet tunnels along the one dimensional column and through heterostructured polymerized crystal layer, which acts as a barrier.

The superlattice quantum structure, as illustrated in Fig. 4, can be fabricated with state-of-the-art techniques, for example, with modulation doping method in organic molecular beam epitaxy (OMBE). The period of the superlattices is typically 30 - 100 angstroms, whereas the period of the crystal lattice is only a few angstroms. Therefore the energy band of the superlattice, which arises from the coupling between the energy band levels of the quantum dots, is able to form subbands structure. The current-voltage characteristics has multiple states, which is analogous to the optical bistability in a non-linear Fabry-Perot interferometer, due to modulating both the difference between the energy levels of the subbands in quantum dots and the energy of the incident electrons.

Therefore, the logic with multiple on and off states has been considerable subject theoretically and practically in the information dynamics of cellular automata structure. In this quantum device, not only are the states caused by quantum size effects, but the fundamental carrier transport mechanism is tunneling phenomena, which suppress the parasitic tunneling channels that are available for the one dimensional organic molecular crystal above. This advantage may be preferable for multiple valued digital logic devices even at room temperature.

QUANTUM DEVICE ARCHITECTURE

The quantum devices have characteristics of mesoscopic, multistates caused by strong local coupling unlike conventional VLSI devices. We think nearest-neighbor connection architecture can not only utilize the limited local coupling, which is physically natural for quantum devices, but solve the interconnection dilemma in conventional GaAs/AlxGa1-xAs quantum devices.

A type of the nearest-neighbor connection architectures is cellular automata (CA), where multiple valued logical nodes are located on a regular uniform lattice with a discrete variable at each site (cell), and the value of each cell are evolved in discrete time steps according to well defined nearest-neighbour rules.

In our devices, quantum dot acts as the cell and heterolayer as the lattice. Information carrier (the wave packet) localized in each quantum dot is transferred along the conjugated π electron intermolecular orbits of the one dimensional phthalocyanine columns, perpendicular to the heterolayers in stead of not along them by external applied electrostatic force.

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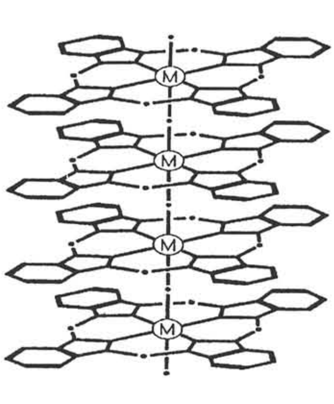

Figure 1.
One dimensional organic molecular column, which is composed of bridged stack of metal phthalocyanine rings.

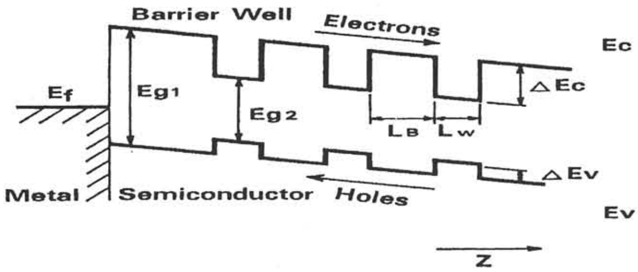

Figure 2.
Energy Band of a Multiquantum Well Schottky Junction

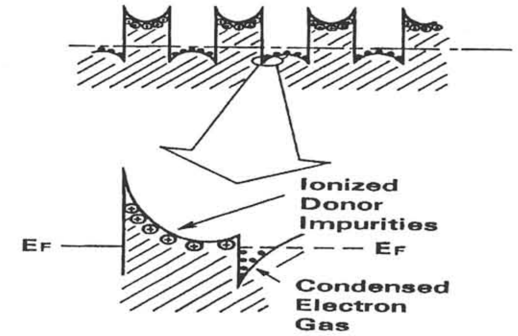

Figure 4.
Modulation Doping in a Superlattice Heterostructure with Schottky Junction

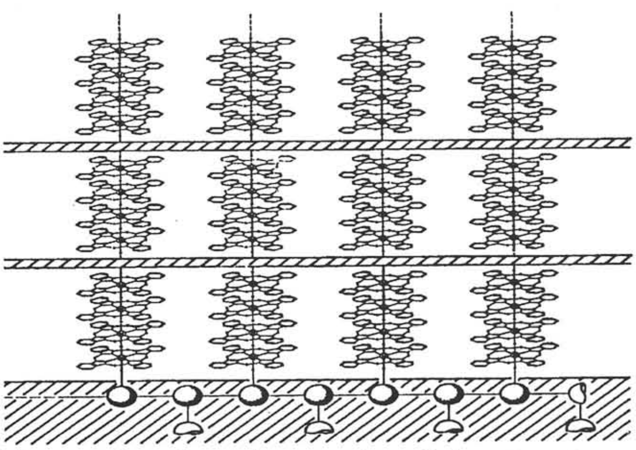

Figure 3. Organic quantum dots structure with phthalocyanine superlattices crystalline system.

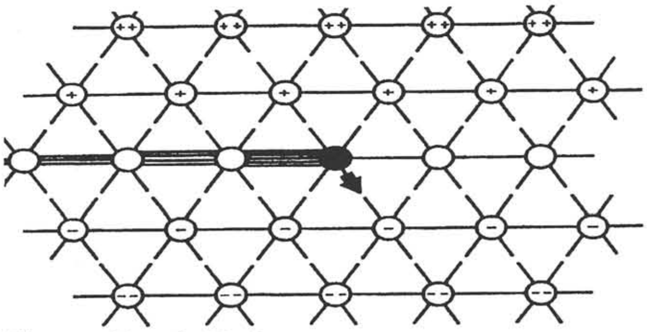

Figure 5. Cellular automaton dynamics in phthalocyanine superlattices.