COMPACT BISTABLE CNNS BASED ON RESONANT TUNNELING DIODES

James Alpha

Department of Electrical Engineering
University One
City, XX 12345
alpha@email.org

John Beta

Dept. of Electrical Eng. and Comp. Science
University Two
City, YY 98765
beta@email.edu

ABSTRACT

Resonant tunneling diodes (RTDs) have intriguing properties which make them a primary nanoelectronic device for both analog and digital applications. We propose a bistable RTD-based cell for the cellular neural network (CNN) which exhibits superior performance in terms of circuit complexity, and processing speed compared to standard cells.

1. INTRODUCTION

Nanoelectronics offers the promise of ultra-low power and ultra-high integration density. Among the different nanoelectronic devices discovered and studied so far, the *resonant tunneling diode* (RTD) [1–3] occupies a prominent position. Its intriguing properties are its extreme compactness, picosecond switching speed, and its non-monotonic voltage-current characteristic. Initially, with a low voltage across the device (point A in Fig. 1), the electrons are below the the point of resonance, and no current can flow through the device. As the voltage increases, the emitter region is warped upwards, and the collector region is warped downwards.

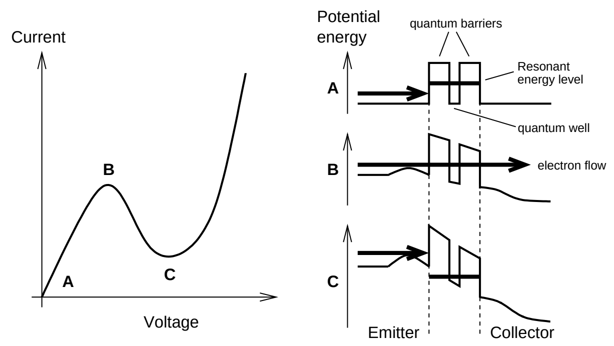

Figure 1. I–V characteristics and energy band diagrams of the resonant tunneling diode.

The *negative differential resistance* (NDR) between points B and C is the key property of RTDs. In digital applications [3], the NDR property can be exploited to design compact bistable circuits without feedback. In this paper, however, we consider the potential of RTDs for the design of cellular neural networks (CNNs).

2. THE MOBILE CNN

If a gate is added to the RTD, the effective diode area and, as a consequence, the peak and valley currents can be controlled; the resulting three-terminal device is named a *resonant tunneling transistor* (RTT). When driven by an *oscillating* bias voltage, the series connection of two RTTs forms a so-called *monostable-bistable logic element* (MOBILE).

3. CONCLUDING REMARKS

The MOBILE CNN exhibits very high-speed processing at extremely high cell densities. Networks with fixed template parameters with 10^5 or more cells become feasible. Their operation is restricted to locally regular tasks but still permits gray-scale inputs. The switched-voltage technique solves the problem of hysteresis and allows the start and termination of the dynamical process.

4. REFERENCES

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