Chapter 5
A Detailed Study on Single Electron Transistors in Nano Device Technologies

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ABSTRACT

The rapid advancement of integrated circuit (IC) technology in the recent decades paved the path for miniaturization of electronic devices. Nowadays all the handheld devices are battery operated, which moves the researchers to develop the devices with low power utilization, high-speed operating capability, and low cost. The advancement in technology scaling is crucial for enhancing the effectiveness of IC in the areas of latency, power dissipation, and signal processing. The chapter provides an outline of the history of nano electronic device development and emphasizes the potential of the single electron transistor (SET) as a new nano device that will eventually replace more traditional ones.

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INTRODUCTION

Metal Oxide Semiconductor Field Effect Transistor (MOSFET) has been a fundamental component of all devices with computing platform and memory elements over the past 50 years. Continuous device geometry minimization, nowadays dipped into the range of micron, is mostly to enhance the efficiency of the device. In addition, limitations enforced by manufacturing processes and principles governing quantum physics prevent feature size decrease. The researchers are compelled by these limitations to investigate novel transistor substitutes for ultra-dense circuits. These novel technologies are referred to as nano-devices, and the science underlying them is referred to as nanotechnology (Khan, 2014; Zhang et al., 2018). The basic and fundamental element of Very Large-Scale Integration (VLSI) is MOSFET. The enhance speed, large package density of transistors and minimum power consumption are the requirements for an effective VLSI design. This can be achieved by already mentioned device geometry minimization but this leads to various shorter channel length effects in the device (Jacob et al., 2017; Krautschneider et al., 1997; Kuhn et al., 2008). Many nano-devices have been investigated to reduce these drawbacks and improve performance (Parekh, 2019). Depending on the operating concepts and fabrication methods, the devices are divided into three major types. They are carbon nanotube-based transistors, quantum solid state devices and molecular principle. Devices within the first segment resemble typical MOSFETs but differ from them in terms of size and composition because they are constructed of carbon nanotubes. The remaining categories are constructed independently but both involve quantum effects. The solid-state transistors utilize fabrication techniques comparable to, those utilized for MOSFETs. A cutting-edge strategy, molecular electronics needs new components and a novel operating concept. Quantum effects are taken advantage of by solid state quantum effect devices. A tiny island that confines the conducting charge in the sort of electrons is a crucial component shared by all of these circuits. This island is comparable to a MOSFET's channel. These electron confinement-based devices can be divided into two groups. One is quantum dots and the other single electron transistors (SET). The SET is a special kind of semiconductor switches that amplifies the current by using the process of controlled electron tunneling. The typical MOSFET works by allowing charge to move between both the drain and source electrodes under the supervision of the gate electrode. Millions of electric charge flow through the channel for current conduction in MOSFETs, which is detrimental since it results in thermal dissipation and power outages (Durrani, 2010; Mahapatra & Ionescu, 2005). The nanotechnology-based devices are divided into three major types as shown in fig.1. The solid-state mechanism utilizing quantum effects that confines the charge in the form of electrons as islands is a common essential future of this kind of nano-devices. The bifurcated device classification