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A Study on Power Semiconductor Devices

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***Abstract*: Power semiconductor devices constitute the heart of power electronic system. Modern power electronics era started with the introduction of power semiconductor devices in the 1950's, particularly with the commercial introduction of thyristor in 1958. Since then, many power semiconductor devices, such as TRIAC, gate turn-off thyristor (GTO), bipolar power transistor (BPT or BJT), power MOSFET, insulated gate bipolar transistor (IGBT), static induction transistor (SIT), static induction thyristor (SITH) and MOS-controlled thyristor (MTC) have appeared. These power switching devices along with the microelectronic circuits are recently ushering a new era in power electronics and motion control systems. Power electronics and motion control are expected to have an increasing influence on a nation's industrial productivity, energy conservation and urban pollution problems in the coming decades. This chapter will give a comprehensive state-of-the-art technology review of power semiconductor devices.**

***Keywords*: Power Semiconductors, Diode, Power Transistor, Power MOSFET, IGBT.**

1. Introduction

Semiconductor materials are useful because their behavior can be easily manipulated by the deliberate addition of impurities, known as doping. Semiconductor conductivity can be controlled by the introduction of an electric or magnetic field, by exposure to light or heat, or by the mechanical deformation of a doped monocrystalline silicon grid; thus, semiconductors can make excellent sensors. Current conduction in a semiconductor occurs due to mobile or "free" electrons and electron holes, collectively known as charge carriers. Doping a semiconductor with a small proportion of an atomic impurity, such as phosphorus or boron, greatly increases the number of free electrons or holes within the semiconductor. Power semiconductors are found in systems delivering as little as a few tens of milliwatts for a headphone amplifier, up to around a gigawatt in a high voltage direct current transmission line. Exposing a semiconductor to light can generate electron–hole pairs, which increases the number of free carriers and thereby the conductivity. Diodes optimized to take advantage of this phenomenon are known as photodiodes. Compound semiconductor diodes can also be used to generate light, as in light-emitting diodes and laser diodes. Operation of a MOSFET and its Id-Vg curve. At first, when no gate voltage is applied. There is no inversion electron in the channel, the device is OFF. As gate voltage increase, inversion electron density in the channel increase, current increase, the device turns on.

2. Semiconductor devices

In between conductors and insulators, there is a third classification of atoms (material) known as semiconductors. Generally, the conductivity of a semiconductor lies in between the conductivities of metals and insulators. However, at absolute zero temperature, the semiconductor also acts like a perfect insulator.

A. Power semiconductors

A power semiconductor device is a semiconductor device used as a switch or rectifier in power electronics (for example in a switch-mode power supply). Such a device is also called a power device or, when used in an integrated circuit, a power IC.

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B. Diode

Diodes and Rectifiers include all TVS/ESD Diodes, Zener Diodes, Schottky Diodes, Silicon Carbide (SiC) Schottky Diodes, Diode and Rectifier Bridges, PIN Diodes, and Hi-Rel Diodes. Diode Arrays are also available for multi-line applications. TTI has world-class suppliers of Standard, Automotive, and Hi-Rel Diodes and rectifiers.

C. Power transistor

A transistor is a semiconductor device commonly used as an amplifier or an electrically controlled switch. The transistor is used in a wide variety of digital and analog functions, including amplification, switching, voltage regulation, signal modulation, and oscillators because of its fast response and accuracy. Modern transistors are divided into two main categories: bipolar transistors and field effect transistors (FETs).

D. Power MOSFET

A MOSFET (Metal Oxide Semiconductor Field Effect Transistor) is an electronic device used to amplify or switch electronic signals. MOSFET's are the most common field effect transistor (FET) in both digital and analog circuits. MOSFET's are an enhancement on bipolar technology and are the most popular semiconductor-type transistor. A MOSFET provides both an output current and voltage gain into an external load that exceeds the input current and voltage. In basic terms MOSFET's amplify their input signals. N-Channel & P-

Channel MOSFETs are specific types of MOSFETs. Silicon is “doped” by adding a slight impurity to the silicon to result in an extra electron or a reduction of one electron. N-channel devices have an extra electron in their base structure while the P-channel devices are missing electrons.

E. IGBT

An insulated-gate bipolar transistor (IGBT) is a three-terminal power semiconductor device primarily used as an electronic switch which, as it was developed, came to combine high efficiency and fast switching. It consists of four alternating layers (P-N-P-N) that are controlled by a metal-oxide-semiconductor (MOS) gate structure without regenerative action. Although the structure of the IGBT is topologically the same as a thyristor with a 'MOS' gate (MOS gate thyristor), the thyristor action is completely suppressed and only the transistor action is permitted in the entire device operation range. It is used in switching power supplies in high power applications: variable-frequency drives (VFDs), electric cars, trains, variable speed refrigerators, lamp ballasts, and air-conditioners.

3. Applications

They are used in the designing of logic gates and digital circuits. These are used in microprocessors. They are used in analog circuits such as oscillators and amplifiers. Used in high voltage applications.

4. Results

Semiconductor fabrication technology using a combination of n- and p-doped semiconductor material to achieve low power dissipation. Any path through a gate through which current can flow includes both n and p type transistors. Only one type is turned on in any stable state so there is no static power dissipation and current only flows when a gate switches in order to charge the parasitic capacitance.

5. Conclusion and discussion

Semiconductor is a material whose electrical conductivity is between that of a conductor and an insulator. The elements most commonly used in semiconducting devices are silicon and germanium.

A transistor with a region of donor material with two terminals called the "source" and the "drain", and an adjoining region of acceptor material between, called the "gate". The voltage between the gate and the substrate controls the current flow between source and drain by depleting the donor region of its charge carriers to greater or lesser extent. Because no current (except a minute leakage current) flows through the gate, FETs can be used to make circuits with low power consumption.

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