

This paper presents IXYS Corporation’s power MOSFET products and their typical application information. Power MOSFETs are widely used in power switching applications due to their features of easy control, fast switching speed, wide safe operating area and high gain. Typical applications include Switched-Mode Power Supply (SMPS), DC-DC Converters and DC-AC Inverters for Motor Controls, High-Frequency Pulse Power Supplies (commonly called Pulsers) for laser and flash lamps, Audio Amplifiers (Class D Amplifiers), Computer and Telecommunication Equipment, etc. There are many types of power MOSFETs available but among them, the “DMOSFET” or vertical double-diffused MOSFET using the Planar-gate process and the “UMOSFET” or the “Trench MOSFET” using the Trench-gate process are very popular in both high and low-power applications.

Planar-gate Power MOSFET

The Planar-gate MOSFET is defined as “DMOSFET” or double diffused power MOSFET in which the MOS channel is formed on the surface by the double-diffusion process and the channel length is controlled by the relative diffusion depth of the P-base and N⁺ source regions. A typical DMOSFET structure is shown in Figure 1(a). Current can flow from drain to source by the application of a positive gate bias to create a channel at the surface of the P-base region.

Trench-gate Power MOSFET

The Trench-gate technology has been introduced to reduce the on-resistance ($R_{DS(on)}$) of the device. The structure shown in Figure 1(b) is commonly referred as UMOSFET structure where the channel is formed on the vertical sidewalls of a trench etched into the silicon surface. The name UMOSFET is derived from the U-shaped groove formed in the gate region by using reactive ion etching. These Power MOSFETs reduce the conduction losses and improve the efficiency of the system [3].

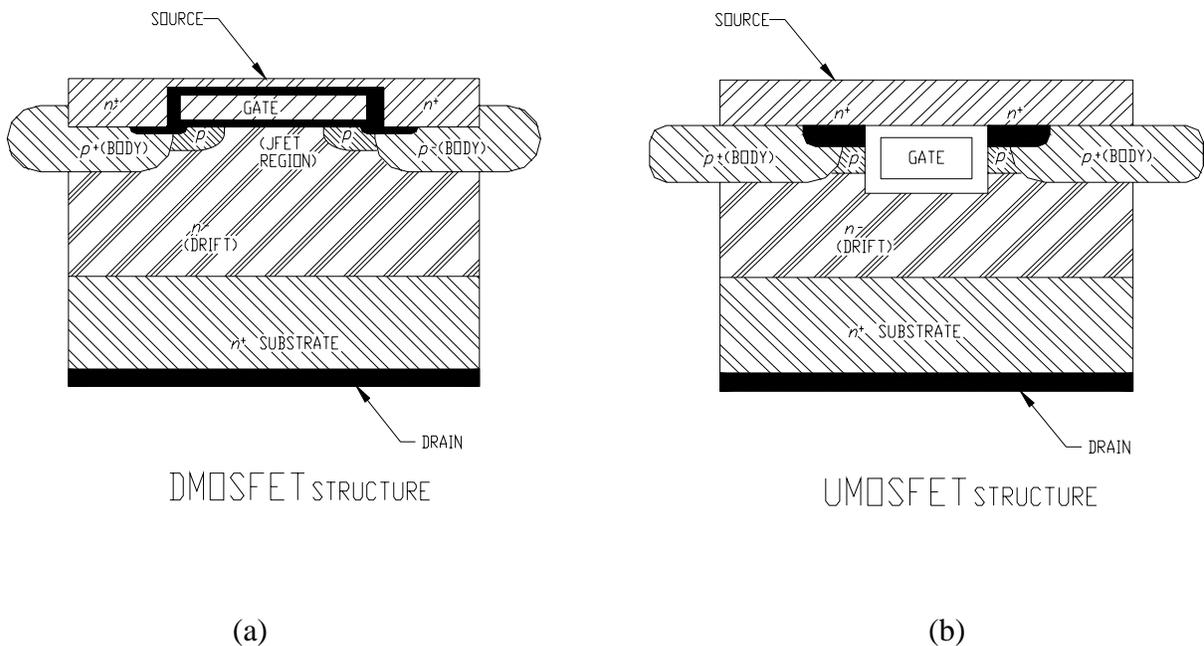


Figure 1: (a) DMOSFET and (b) UMOSFET Structures [2]

Power MOSFETs Categories

IXYS Corporation offers the following families of Power MOSFETs:

1. Standard N-channel and P-channel Power MOSFETs
2. HiPerFET™ Power MOSFETs
3. Q-Class HiPerFET™ Power MOSFETs
4. Q2-Class HiPerFET™ Power MOSFETs
5. PolatHT/HV™ Power MOSFETs
6. Trench Gate Power MOSFETs
7. Power MOSFETs with extended FBSOA
8. Superjunction Power MOSFETs
9. Depletion-mode Power MOSFETs
10. F-Class HiPerRF™ Power MOSFETs

Standard N-channel and P-channel Power MOSFETs

Standard N-channel and P-channel Power MOSFETs are members of a series of MOS family which uses HDMOS, a planar high density process developed by IXYS. This technology, combined with a unique polysilicon gate cell structure, significantly reduces the on-resistance ($R_{DS(on)}$) while maintaining input capacitance (C_{iss}) at a low value. They are suitable for applications not requiring the use of the intrinsic body diode, which has slow reverse-recovery characteristics. They are offered in the range of 70-1200V.

HiPerFET™ Power MOSFETs

The High Performance MOSFET family is an upgraded version of the Standard Power MOSFET family. It is designed to provide superior dv/dt performance while eliminating the need for discrete, fast recovery “free wheeling diodes” in a broad range of power switching applications. They are offered in the range of 100-1200V.

Q-Class HiPerFET™ Power MOSFETs

The Q-Class HiPerFET™ MOSFETs (identified by the suffix letter Q) are upgraded versions of the HiPerFET™ Power MOSFETs family. This family significantly reduces gate charge and Miller capacitance. It improves the switching performance of the device. Therefore, these devices have the same applications as HiPerFET™ and allow higher frequency operation. They are offered in the 1000V category.

Q2-Class HiPerFET™ Power MOSFETs

The Q2-Class HiPerFET™ MOSFETs (identified by the suffix letter Q2) are the result of a revolutionary new chip design, which decreases the MOSFET’s total gate charge Q_g and the Miller capacitance C_{rss} , while maintaining the ruggedness and fast switching intrinsic diode of the company’s current HiPerFET™ product line. The result is a MOSFET with dramatically improved switching efficiencies and thus enabling higher frequency operation and smaller power supplies. They are offered in the range of 500-1000V.

Polar HT/HV™ Power MOSFETs

The Polar MOSFET is another upgraded version of the Standard Power MOSFET. The HT stands for High Temperature and the HV stands for High Voltage. It has a proprietary cell design, which reduces the on-resistance $R_{ds(on)}$ and the gate charge Q_g by 30% per unit area in comparison with the Standard Power MOSFET. The ratio of the drain-to-gate capacitance C_{dg} to gate-to-source C_{gs} capacitance is also reduced which results in faster switching and higher efficiency. IXYS also introduces the HiPerFET™ version of the Polar HT/HV™ Power MOSFETs. They are offered in the range of 55V-1200V.

Linear Power MOSFETs

The FBSOA is an important operating characteristic for power MOSFET, especially when it is operated in its “linear mode”. Linear-mode requires high power dissipation and thus needs Power MOSFETs with extended the FBSOA which defines the limits of operation of the devices. They are offered in 500V and 1000V categories.

Trench Gate Power MOSFETs

The Trench-gate reduces the on-resistance $R_{DS(on)}$ of the device drastically by incorporating a gate-cell structure. These MOSFETs are widely used in low-voltage and offered in the range of 40-100V [1].

Superjunction Power MOSFETs

The Superjunction implements a compensation structure in the vertical drift region of a MOSFET in order to improve the on-resistance, $R_{ds(on)}$. This process reduces the conduction power losses dramatically therefore improves the efficiency of the system. The Superjunction is capable to handle two to three times more output power depending on a converter type as a standard MOSFET in the same package. The main disadvantage is the large reverse recovery current of the intrinsic diode, which limits its ability to carry “free-wheeling” currents. They are offered in 600V and 800V categories.

Depletion-Mode Power MOSFETs

Unlike the regular N-channel enhancement-mode type, the depletion-mode power MOSFETs require zero gate bias to turn-on and negative gate bias to turn-off but otherwise have similar characteristics [1]. They are offered in 500V and 1000V categories.

F-Class Power MOSFETs

The F-Class Power MOSFETs are members of HiPerRF™ Power MOSFETs family that is designed with extremely low gate charge and patented double metal process for sub 0.01 ohm impedance. They are suitable for Mega Hertz switching applications [1]:

Bibliography

- [1] IXYS, “Power Semiconductors Application Notes, 2002” IXYS Corporation, 3540 Bassett Street, Santa Clara CA 95054, and Phone: 408-982-0700
- [2] Philip T. Krein, “Element of Power Electronics” Oxford University Press, 1998, ISBN: 0-19-511701-8
- [3] B. Jayant Baliga, “Power Semiconductor Devices” PWS Publishing Company, ISBN: 0-534-94098-6, 1996.