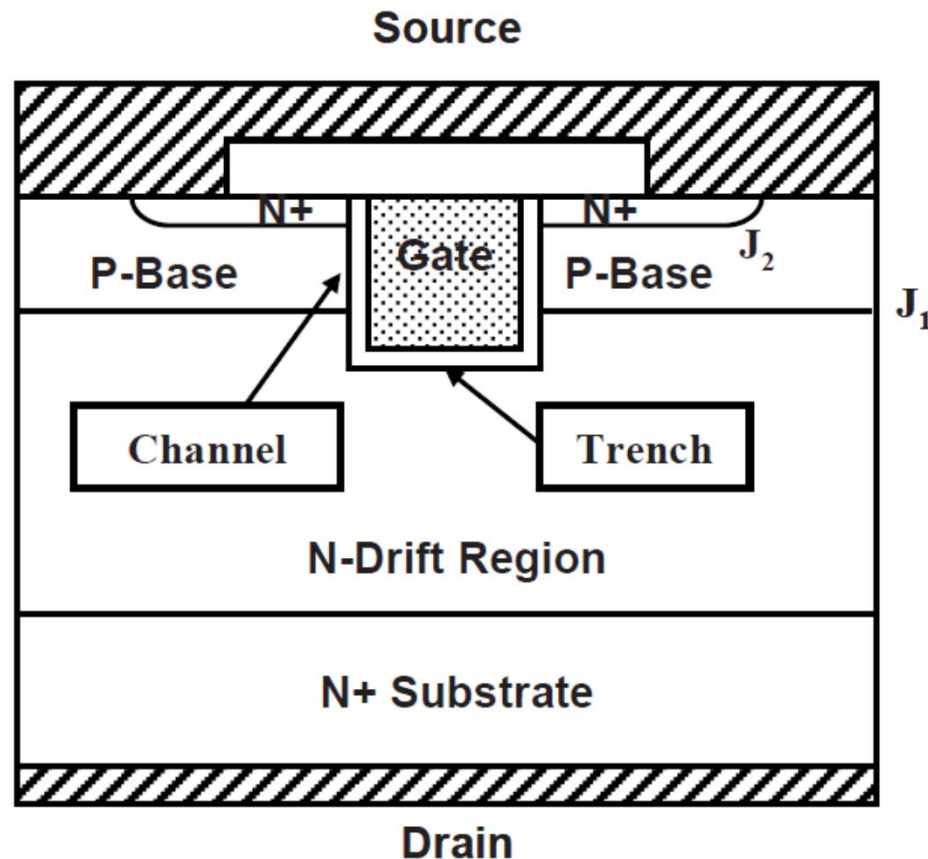
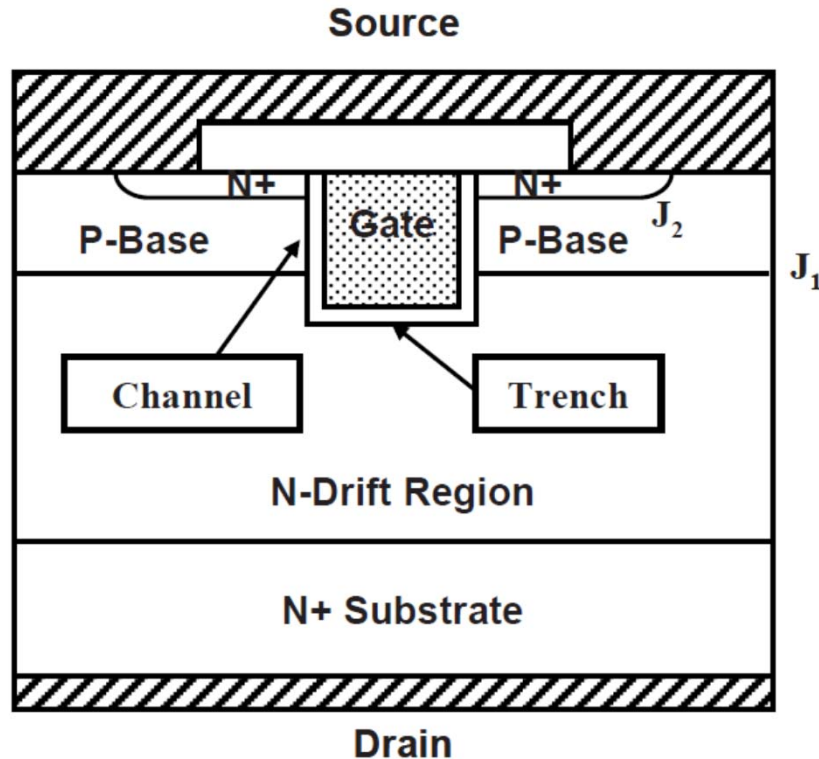


U-MOSFET (or trench-gate MOSFET) Structure



During the late 1980s, the technology for etching trenches in silicon became available due to its application for making charge storage capacitors within DRAM chips. This process was adapted by the power semiconductor industry to develop the trench-gate or U-MOSFET structure. As shown in figure above, the trench extends from the upper surface of the structure through the N+ source and P-base regions into the N-drift region. The gate electrode is placed within the trench after the formation of the gate oxide by thermal oxidation of the bottom and sidewalls.

How a U-MOSFET works?



Without the application of a gate bias, a high voltage can be supported in the U-MOSFET structure when a positive bias is applied to the drain. In this case, junction J_1 formed between the P-base region and the N-drift region becomes reverse biased. The voltage is supported mainly within the thick lightly doped N-drift region. Since the gate is at zero potential during the blocking mode of operation, a high electric field is also developed across the gate oxide. To avoid reliability problems arising from the enhanced electric field in the gate oxide at the trench corners, it is customary to round the bottom of the trench.

Drain current flow in the U-MOSFET structure is induced by the application of a positive bias to the gate electrode. This produces an inversion layer channel at the surface of the P-base region along the vertical sidewalls of the trench. This inversion layer channel provides a path for transport of electrons from the source to the drain when a positive drain voltage is applied. After transport from the source region through the channel, the electrons enter the N-drift region at the bottom of the trenches. The current then spreads to the entire width of the cell cross section. Consequently, **there is no JFET region in the U-MOSFET structure, enabling a significant reduction of the internal resistance when compared with the D-MOSFET structure.** The reduced internal resistance for the U-MOSFET structure provided motivation for the development of these devices in the 1990s.