

THE FIRST FIELD-EFFECT DEVICES:

In 1925 a patent for solid-state electric-field-controlled conductor was filed in Canada by Julius E. Lilienfeld, a physicist at the University of Leipzig, Germany. Other patent refinements followed in the United States in 1926 and 1928. Regrettably, no research papers were published. Consequently, in 1934 Oskar Heil, a German physicist working at the University of Cambridge, U.K., filed a patent on a similar idea. But all these early concepts of electric-field control of a semiconducting path languished because suitable technology was not available.

The invention of the bipolar transistor in 1947 at Bell Telephone Laboratories resulted in the speedy development of bipolar devices, a circumstance that further delayed the development of field-effect transistors. Although the field-effect device was described in a paper by William Shockley in 1952, it was not until 1960 that a patent on an insulated-gate field-effect device, the MOSFET, was filed by Dawon Kahng and Martin Atalla, also at Bell Labs. Clearly, the idea of field-effect control for amplification and switching has changed the world. With integrated-circuit chips today containing billions of MOS devices, MOS dominates the electronics world!

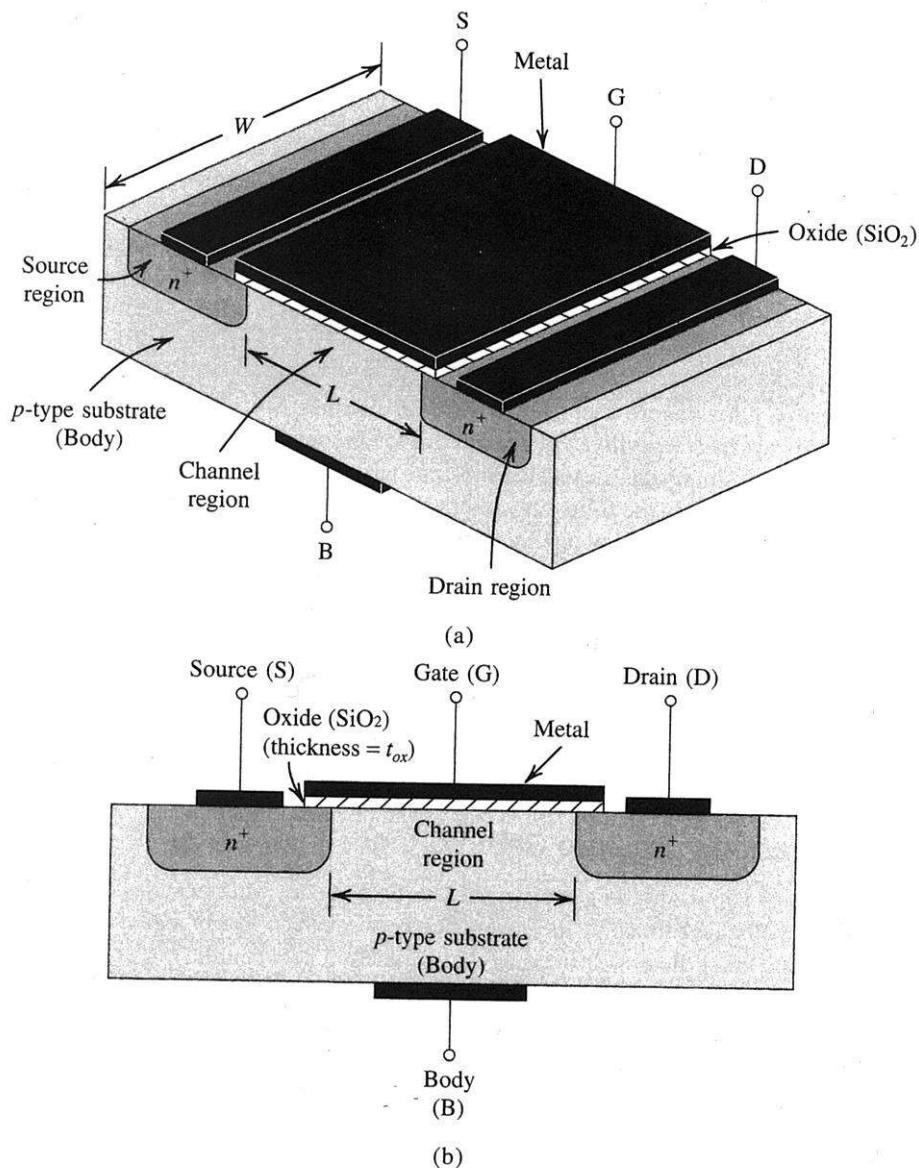


Figure 5.1 Physical structure of the enhancement-type NMOS transistor: (a) perspective view; (b) cross section. Typically $L = 0.03 \mu\text{m}$ to $1 \mu\text{m}$, $W = 0.05 \mu\text{m}$ to $100 \mu\text{m}$, and the thickness of the oxide layer (t_{ox}) is in the range of 1 to 10 nm.