MPHYCC-7 ELECTRONICS I

Unit 1: SEMICONDUCTOR

Dr. Kumar Balwant Singh

Department of Physics, L. S. College, Muzaffarpur,

B. R. A. Bihar University, Muzaffarpur-842001

Email: kbsphysics@yahoo.co.in

Whatsapp: 9835033155

Continue……….

SEMICONDUCTOR TECHNOLOGY DRIVERS IN 20th CENTURY

Since the invention of the transistor in 1947 followed by the commercial introduction of integrated circuits (IC) some twenty years later, progress in semiconductor technology has been driven primarily by the need to process information faster and more efficiently. Processing information is all dependent upon devices which can be turned "on" and "off" fast enough so that corresponding sequence of "1"s and "0"s can be executed billions of times per second. Since the Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET) is the most effective device in carrying out these functions the progress in IC engineering was driven primarily by the improvements in MOS technology.

To be exact, it is not a MOSFET either n-channel or p-channel (Fig.4a and b), but the combination of these two in the Complimentary MOS (CMOS) structure shown in Fig, 4c that is the focus of attention. CMOS shows superior characteristics in switching applications including very low energy needed to switch it from “on” to “off” state, and hence, very limited power dissipation, as well as essentially no current in the “off” state. In more general terms, digital applications involving logic and memory ICs were driving forces behind the dramatic progress in semiconductor science and engineering over the last fifty years.

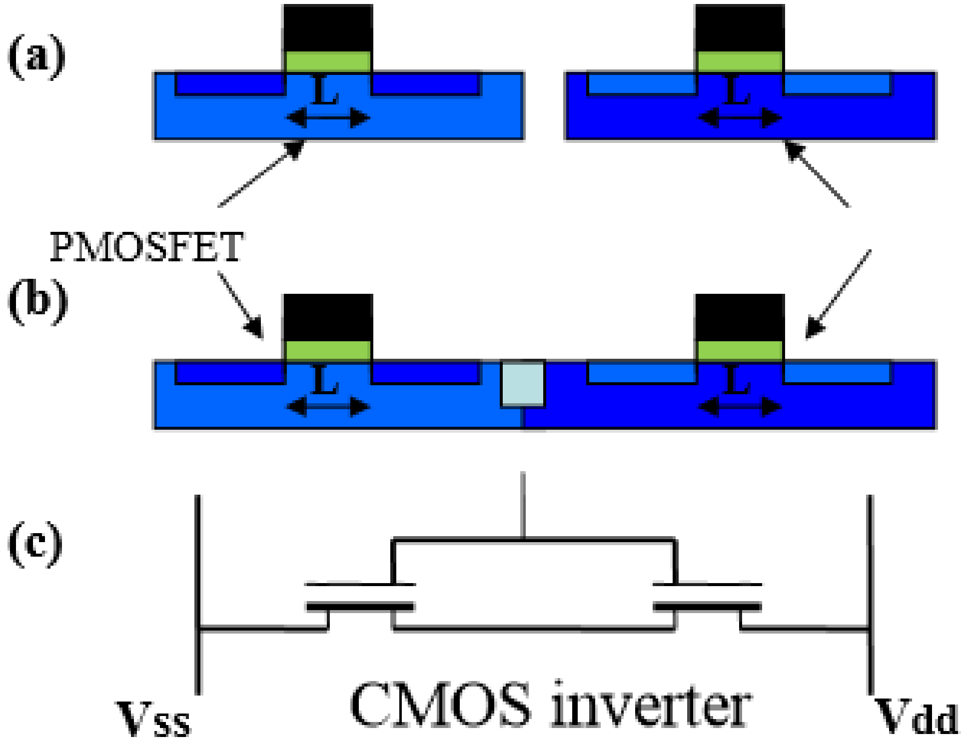

Fig. 4 *PMOSFET and NMOSFET (a) are combined into a complimentary pair (CMOS) (b) which operates in the digital systems as a CMOS inverter (c).*

- During those years, progress in IC technology expressed in terms of the number of transistors per chip by Moore's law (Fig. 5) was dependant primarily on the continued reduction of transistor's geometry in CMOS cells with scaling down of the channel length L (Fig. 4) being a lead target. Technically, the reduction of transistor geometry was possible because we had ways to keep on reducing wavelengths λ of radiation used for photoresist exposure in the photolithographic processes defining transistor geometry. That was until λ was reduced to the 193 nm emission wavelengths possible with ArF excimer laser. As further reduction of λ was not feasible without overcoming significant technical and cost-related barriers, the 193 nm exposure length remained unchanged (Fig. 5) and alternative ways of improving the performance of the CMOS were pursued. While all this was happening not much was changing in terms of materials used to fabricate advanced ICs (with the exception of copper replacing aluminum as an interconnect material, Fig. 5) and device configuration. It was all based on silicon and its derivatives (single-crystal Si, poly-Si, SiO_2, Si_3N_4, SiON) while planar CMOS remained a benchmark in terms of device layout.
- In parallel to the rapid growth of the electronic component of semiconductor device technology, impressive progress has also been accomplished at the photonic end of the semiconductor device spectrum. Over several years the driving force in this domain was an effort to develop blue light emitting diodes needed in addition to the longer wavelength LEDs developed earlier. This effort was punctuated by the successful development of blue LEDs formed on InGaN.