MESFET
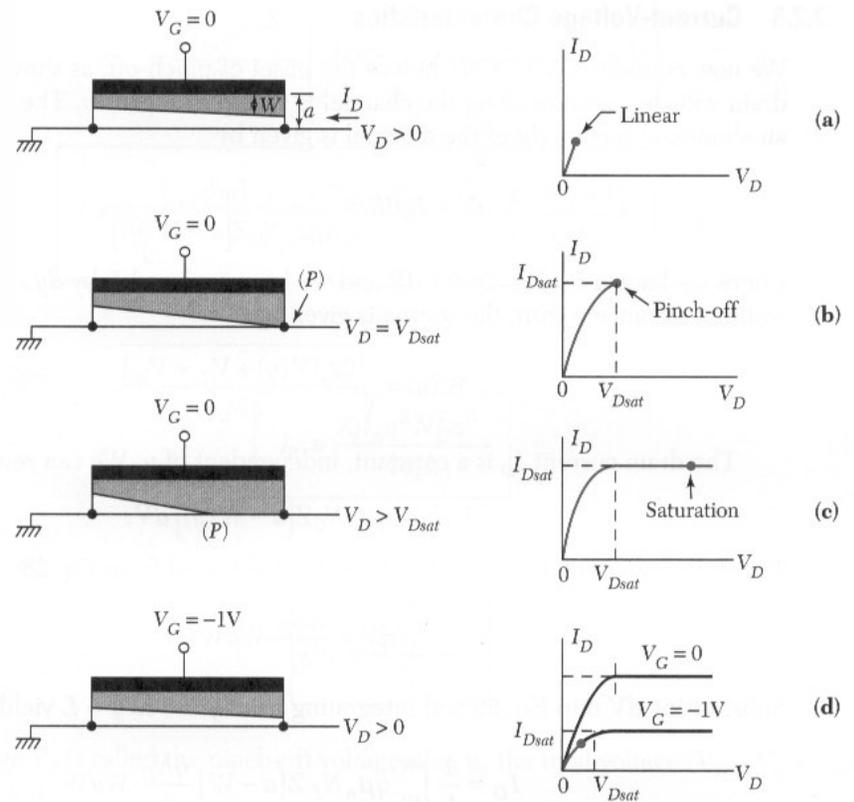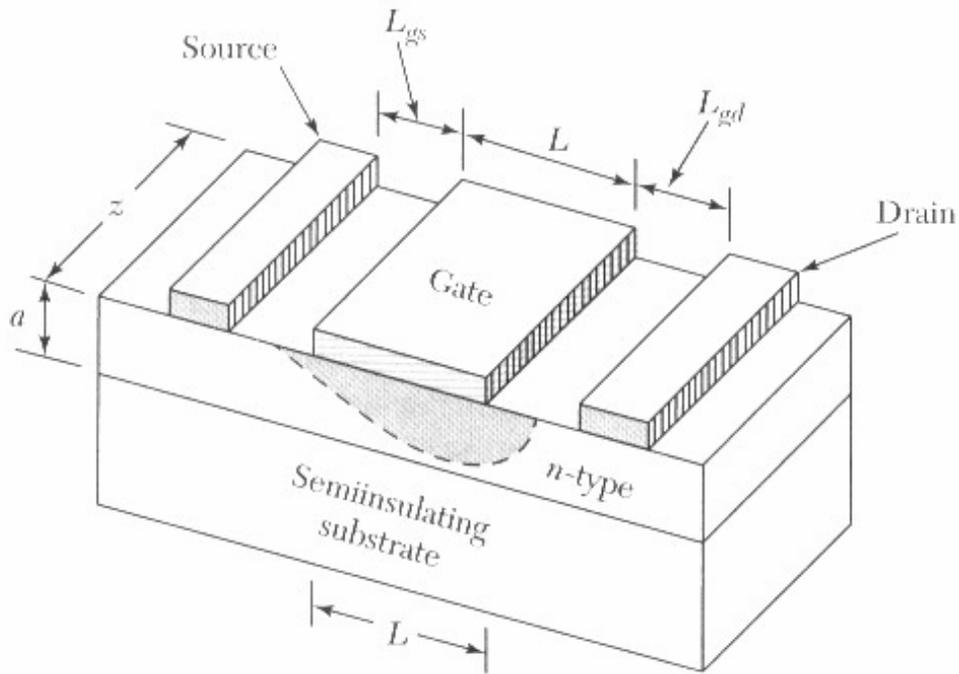
Fig. 11 Variation of the depletion-layer width and output characteristics of a MESFET under various biasing conditions. (a) $V_G = 0$ and a small V_D. (b) $V_G = 0$ and at pinch-off. (c) $V_G = 0$ at post pinch-off ($V_D > V_{Dsat}$). (d) $V_G = -1V$ and a small V_D.
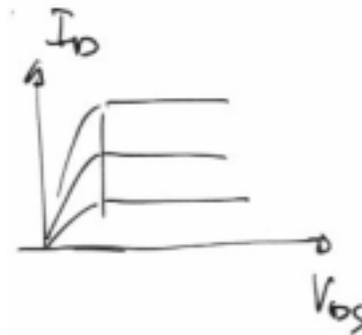
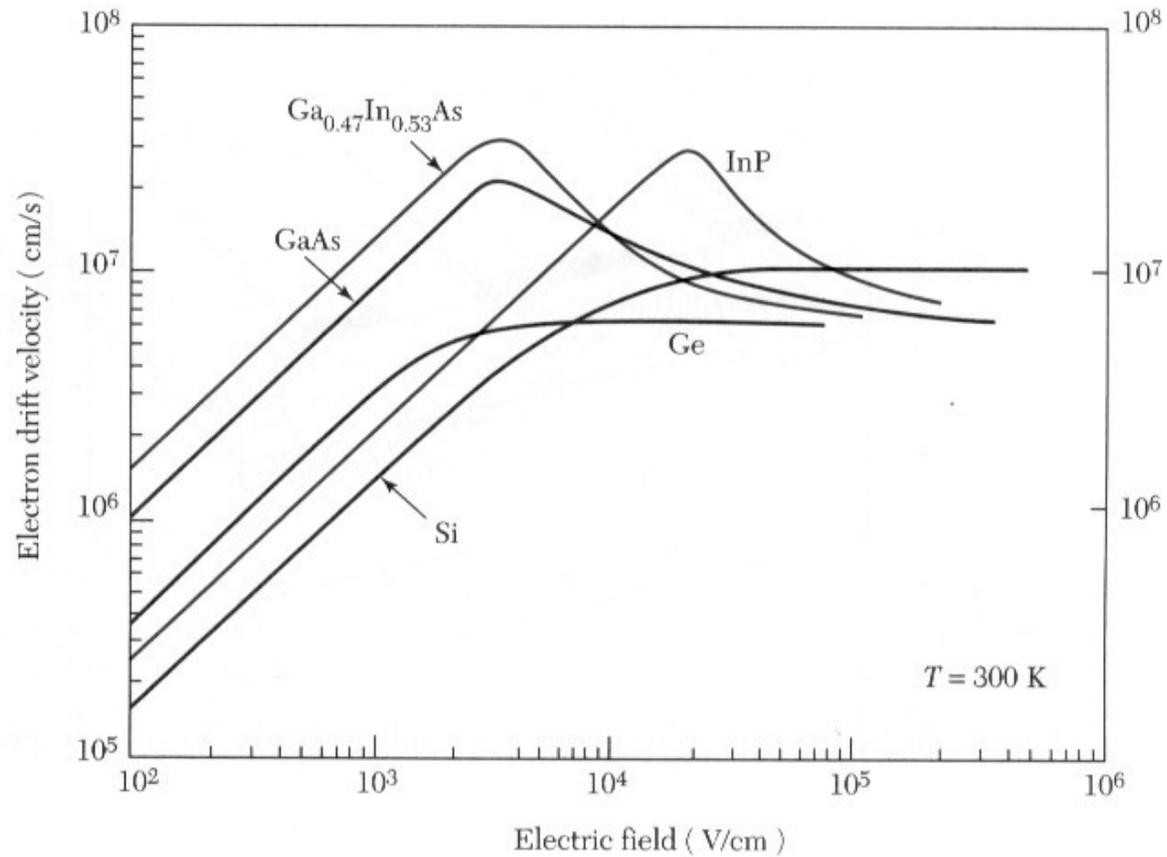Care must be given to velocity saturation effects, which already appear at 3 kV/cm (~ 10 kV/cm in silicon) E.g., L=0.25 um, V_{DS}=0.1 V give

$$e = \frac{V}{d} = \frac{0.1}{0.25 \cdot 10^{-3}} = 0.4 \cdot 10^{4} = 5 \, KV/cm.$$

so that the transistor saturates not when pinch-off is reached close to the drain, but when v_{sat} is reached by the electrons.

We get an almost linear dependence of I_D on V_{GS} (instead of quadratic)

Fig. 15 The drift velocity versus the electric field for electrons in various semiconductor materials.[8]