The Body Effect

The Body Effect

- From the qualitative discussion in the previous section, it is clear that increasing V_{CB} decreases the level of inversion, unless we also increase V_{GB} by an appropriate amount.
- It turns out that, if we want to keep the level of inversion the same, the increase in V_{GB} must be *larger* than the increase in V_{CB}. This effect is called **body effect** or **substrate effect**.
- Body effect really refers to the fact that, if V_{CB} in the connection shown is raised while V_{GC} is kept constant then the level of inversion will decrease, although $V_{GB} = V_{CB} + V_{GC}$ is increased, and that, if we want to restore the original level of inversion, we will have to *increase* V_{GC}.
  - If we set V_{GC} such that an strong inversion take place. In this case the strongly inverted surface, containing an abundance of electrons, is sometimes likened to an n^+p region → *field-induced n^+p junction* → Similar behavior with common n^+p junctions
  - The role of the reverse bias V_R there is played here by V_{CB} → *effective reverse bias*
    - Therefore increasing V_{CB} will widen the depletion region under the strongly inverted surface

The Body Effect

- …
  - By increasing V_{CB} while V_{GC} is remain unchanged (made strong inversion in first place), V_{CB} increment leads to increasing the depletion region width. As the positive gate charge density remains constant due to V_{GC}, therefore for the sake of charge neutrality electron density in inversion layer should decrease because (now more negative ion uncovered).
  - Therefore in this case for restoring the inversion layer density V_{GC} is also should be increased.
  - Effect of body doping and oxide thickness:
    - Body doping: The larger the body doping, the larger the change in the depletion region charge for a given change in V_{CB} → this means that a larger increase in the gate voltage will be needed then to restore the original level of inversion. **The body effect is more pronounced for heavily doped substrates.**
    - Oxide thickness: The thicker the oxide, the weaker the influence of the gate on the inversion layer charge, and the larger the gate voltage needed to influence that charge to a given degree.

The Body Effect

- These arguments (likening the inversion layer-substrate structure to a n^+p junction, viewing V_{CB} as its "effective reverse bias," and considering the inversion layer as the bottom plate of a capacitor) are only valid in **strong inversion**.
- As a result of the preceding effects, an increase in V_{CB} will result in increases in the values of V_L, V_M, and V_H.
- The quantity V_T shown there, which is simply the "extrapolated threshold voltage" (in analogy to V_{T0} for the two-terminal structure), is also found to increase. In fact, the term *body effect* is commonly taken to mean just the increase of V_T with V_{CB}.