

Will the insulated gate transistor concept survive next decade?

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One of the most challenging problems in the present development of electronics is to find an alternative to silicon dioxide as a gate insulator for MOSFETs. As no obvious solution exists today, it may be relevant to estimate the risk that CMOS technology development is thwarted.

The need for increasing capacitive coupling between gate and channel region has brought the thickness of the presently used silicon dioxide down to a limit, where current leakage is too high to be accepted. The solution is to be found among materials with higher dielectric constant.

For the 45 nm CMOS-node, currently moving from the research to the development phase to be in production in 2010, nitrided silicon dioxide may still be a solution. On the other hand, for the coming 32 and 22 nm generations a new material is a necessity. A wide research activity in the past 10–15 years has focused an interest on HfO₂ as the next gate insulator material. However, it is questionable whether the properties of this material will fulfill the demands beyond, or even at, the 45 nm node. Beside rigorous production requirements concerning, for instance, thermal stability, HfO₂ or other high-κ materials need to fulfill other fundamental requirements. In particular, in order to limit current leakage at a high enough channel coupling, not only a high dielectric constant, but also high electron and hole barriers between the energy bands of the silicon and the insulator are necessary.

The paper presents guidelines for finding an appropriate material, points out the very limited number of possible candidates for the 22 nm low-power applications, and discusses the probability for the "CMOS-show" to stop.