DESIGN AND ANALYSIS OF MULTIGATE MOSFETS

The semiconductor industry has advanced primarily through the continuous scaling of Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs). Miniaturization has enabled higher device density, improved performance, and reduced cost per function, driving the success of integrated circuits. However, as device dimensions have approached the nanometer regime, traditional planar MOSFETs have faced severe challenges. Short-channel effects (SCEs), increased leakage currents, mobility degradation, and the fundamental limit of the 60 mV/dec subthreshold slope have made further scaling extremely difficult. These limitations threaten the viability of conventional CMOS technology for future generations of ultra-low-power and high-speed applications.

According to the International Roadmap for Devices and Systems (IRDS), many new device architectures will require **co-design across device, circuit, and system levels** to fully exploit their capabilities. To take complete advantage of these advanced devices, new types of circuit designs, functional module structures, and even new software frameworks will be needed. These emerging devices are not simply intended to be “drop-in” replacements for conventional CMOS transistors; instead, they demand a more integrated design approach to achieve optimal performance.

To support this transition, the **analytical modeling of devices** becomes critically important. Analytical models help provide mathematical insight into device physics, enabling designers to understand how structural, material, and electrostatic parameters influence device behavior. The development of compact and physically consistent analytical models is essential for accurate circuit-level simulation and seamless integration into electronic design automation (EDA) tools. Furthermore, such models play a key role in guiding the design of low-power systems by predicting leakage characteristics, energy–delay trade-offs, and short-channel effects.

Thus, as the industry moves beyond traditional CMOS scaling limits, **multigate MOSFETs**—supported by robust analytical modeling techniques—form the foundation for future nanoelectronic technologies. Their superior electrostatic control, reduced leakage, and scalability make them indispensable for sustaining progress in advanced technology nodes and enabling the next generation of high-performance, energy-efficient integrated circuit