Opportunities for Revolutionary Nanoelectronic Devices and Processes

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As the magnitude of technical challenges built up as we approach scaling limit of Si CMOS, a number of approaches have been explored to find a pathway to go beyond the limit. This talk will start with closely looking into recent progress made for non-silicon channel MISFETS with high k/metal gate stack and the source/drain engineering as well as nanowire/nanopillar structured vertical devices for possible improved performance and density with sustainable power consumptions.

These efforts consist of several different factors inside, i.e. metal gate and high k dielectrics as a fundamental building block for the gate structure applicable to 2-D, 3-D device structures, and a number of approaches to possibly improve transport properties of channel carriers, carrier injection efficiency improvement from the source to the channel, while minimizing such adverse side effects as the short channel effects, DIBL, GIDL, the source to drain tunneling, the band to band tunneling at the drain edge of MOSFETs.Metal gate with work function engineering coupled with an adequate choice of high k dielectrics has provided big challenges for materials and devices community, because this kind of gate stack would be one of the fundamental building blocks for nanoelectronic devices.

A large variety of mobility enhancement possibilities have been pursued everywhere, which can be categorized as: (1) staying with silicon channel with band engineering by applying strains to the channel, i.e. uniaxial tensile strain to nMOSFETs, while compressive strain to pMOSFETs, (2) utilization of quantum confinement which results in reduced conductivity effective mass of electrons for nMOSFETs by using a ultra thin body SOI substrate, (3) introduction of high mobility materials such as Ge, binary III-V compounds, ternary III-V compounds, coupled with those in (2), and (4) further revolutionary nanoelectronics devices such as nanotubes, nanowires, graphene nano-ribbons add more opportunities due to significantly improved transport properties. As possible new possible opportunities, introduction of spins as an additional degree of freedom by which signal transmission would change from traditionally used charging/based scheme, and combination of nanoelectronics and nano-electro-mechanical-systems would open up a new horizon. Fusion of electronics and other disciplines such as medical/biological and energy have become significant trends, in which there may be several low hanging fruits could be recognized soon.