Education on CMOS IC Design and Reliability

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Abstract

Today's electronics products in wireless communications require low power dissipation and longer lifetime of battery. Silicon CMOS is the key semiconductor technology to produce high-density integrated circuits with low power dissipation for portable electronics. High speed and high frequency operation of electronic systems and circuits are essential for data/voice transmission for the information age.

When CMOS device sizes are minimized to achieve high density, the channel electric field of MOS transistors becomes higher. This enhances hot carrier (HC) effects. Furthermore, the scaling of oxide thickness could trigger the gate oxide soft breakdown (SBD). As a result, reliability issues in CMOS devices and circuits become very important. Degradation of the DC device parameters has received widespread attention, but the degradation of RF circuit performance has not been studied systematically.

Traditional textbooks do not cover CMOS reliability for the design of RF circuits using today's nanoelectronics technology. For effective learning, students first need to know how hot electrons and gate gate oxide breakdown occur. The experimental data of stressed devices are then demonstrated for further understanding. Using stressed transistors data and RF device model, RF circuit performances subject to stress are examined. Hot carrier effect and gate oxide breakdown increase noise figure and decrease power gain of MOS transistor circuits. From physical insight into RF circuit degradation, one can design RF circuits to reduce hot electron and oxide breakdown effects on circuit performance. This flow provides a robust circuit design and is essential in today's wireless integrated circuit design and education.

In summary, a systematic study of RF circuit performance degradations due to HC and SBD effects is reported. The experimental facts of DC stress on the RF properties of MOSFETs are given. The methodology to study the HC and SBD effects on RF circuits is proposed. The performance degradations of a low noise amplifier are examined using the methodology developed. Furthermore, this talk stresses the importance of RF circuit education and design in reliability for other circuits such as oscillators and mixers.