Separating NBTI and PBTI effects on the Degradation of Ring Oscillator Frequency

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Ring Oscillators (RO) have been a mainstay of characterizing NBTI transistor degradation with traditional SiO_2 dielectrics. With the implementation of High-k dielectrics, the traditional RO circuit suffers NBTI, PBTI, and potentially hot carrier degradation. We have designed, implanted, and verified new RO circuits that allow the separation of NBTI and PBTI effects while eliminating hot carrier degradation.

The key idea in separating the two BTI effects is to stress only NFETs or PFETs in the RO. Our circuits achieve this by cutting the RO circuit at each stage during the stress cycle. In addition, the inputs to each stage are either all high or all low. In this manner, a DC stress is applied to either all the NFETs or all the PFETs, but not both. Because the ROs are not switching during stress, hot carrier effects are eliminated. During the measurement cycle, the RO is allowed to ring and the frequency is measured.

We have successfully tested multiple RO circuit topologies for separating out NBTI and PBTI effects. This talk will describe the RO topologies stress results in detail, while discussing the considerations necessary for successful measurement and interpretation of the data.