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TTDB-Time Dependent Dielectric Breakdown:

Thin layers of silicon dioxide used as a dielectric for capacitors or as the gate oxide for a MOS semiconductor device are subject to a wearout mechanism known as time dependent dielectric breakdown (TDDB). This mechanism causes the dielectric to break down and become electrically shorted after some duration of operation. The expected lifetime of a thin oxide under normal operating conditions should be several million years. However, defects in the oxide can shorten this lifetime by many orders of magnitude. Therefore, the random defect density is the primary parameter determining the reliability of the oxide.Therefore, the random defect density is the primary parameter determining the reliability of the oxide. The interface trap density at a range of energies and the bulk electron trap density are two material properties of the oxide that affect the reliability of the oxide.

The mechanism that causes time dependent dielectric breakdown begins with an electron tunneling through the oxide, a phenomenon known as Fowler-Nordheim tunneling. Electrons in the conduction band of the conductor above or below the oxide can randomly acquire enough energy to jump the energy barrier separating the electron from the oxide. This is a rare occurrence at low electric fields, but, as the electric field increases, the frequency of this injection increases rapidly. Once an electron has sufficient energy to overcome the energy barrier keeping a conductor’s electron from the oxide, it acts as a charged ballistic particle in an electric field. As long as the electron travels in a free path (i.e., no collisions), the electron is accelerated by the electric field and its kinetic energy increases. The longer the free path is, the greater the energy of the electron will be. In addition, the greater the electric field for any free path is, the greater the energy of the electron will be.

TTDB is a stressing method used to measure the useful lifetime of thin dielectrics (oxides), yield information on failure rate during the field operation. The test is done at fixed voltage and temperature. Under stress for a period of time, time to fail for device is recorded with automated test facilities, and the date is analyzed by plotting cumulative percent failure as a function of time to failure.

Input parameters for a constant voltage TDDB test are: T_{test}(C°), V_{force}(V), T_{max}(h), I_{max}(A), EOT condition. The output parameter is I_{real} (A).Q_{bd}

Fowler-Nordheim tunneling current equation: (oxide thickness >5 nm)

$$J = A\ E^2\ \exp(-B/E)$$

Where A: 1.6 MA/$(MV)^2$; B: 222 MV/cm

A. B are constant relate to Si/SiO2 electron effective mass and the barrier height.