SUSTAINABLE SEMICONDUCTOR FOR PERSONAL SATELLITE AND DEEP SPACE EXPLORATION

JIN-WOO HAN
NASA AMES RESEARCH CENTER, MOFFETT FIELD, CA 94035

AS silicon devices scaling advances, a long-term operation becomes increasingly less sustainable due to several device aging mechanisms. A failure rate of the device tends to increase with miniaturization and new space applications by various wear out mechanisms including stress induced leakage current (SILC), hot-carrier injection (HCI), and bias temperature instability (BTI). In addition to those reliability concerns, total ionizing dose (TID) degradation caused by ionizing radiation appears as important measure in ultralight weight vehicle along with long term (> 20 years) space exploration such as wafer scale satellite, nano-spacecraft and satellite-on-chip. These wear out mechanisms collectively limits the stability and lifetime of circuit. If the device degradation can be recovered in a controllable manner akin to the human immune system, the reliability and lifetime for personal satellites and deep space vehicles can be improved. Regardless of the type of degradation mechanisms, the results of SILK, HCI, BTI, and TID appear as bulk trapped charge and interface states in the gate dielectrics and the field oxide. The recoveries of SILK, HCI, BTI, and TID through thermal annealing are respectively demonstrated from many literatures. It has long been known that the process induced defects including missing atoms in the lattice, charge traps, and dangling bonds are recovered by thermal treatment. In this respect, the space semiconductor immunity system that is capable of detecting and recovering to any number of possible assaults is attractive in order to keep the chip working optimally on-the-fly. In this talk, a heating element in different forms are embedded in different silicon circuits and the on-demand recovery will be introduced. Also, the self-healing system that is applicable for generic devices will be demonstrated.