Elastic Modulus Dependence on Surface Volume Ratio in Micro Silicon Resonators

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Abstract

Silicon resonators exhibit excellent mechanical property and have been used in many modern applications such as navigation, mass sensing, and recently in timing modules, posing to replace quartz as the electronic clock. More and more silicon resonator applications are predicted. One area of special interest is space applications where ionizing radiation may affect the integrity or general performance of the device. This research reports the interesting transformation of silicon's mechanical property, i.e. elastic modulus, using ionizing ultraviolet (UV) light radiation. The UV light used is a powered LED (LED255J - OPTAN®) with a center wavelength at 255 nm (4.9 eV). We designed a custom silicon MEMS test resonator to investigate the UV effects on its mechanical and electrical properties by measuring its resonant frequency and resistance during radiation exposure. We compensated for any environmental changes (temperature, etc), by mounting a protected reference device in the same DIP package along with the device under test. Resonators with 3 different widths were radiated and we observed that devices with smaller widths showed a larger resonant frequency shift. In other words, the larger surface volume ratio resulted in a larger change in the elastic constant. With UV radiation, carrier concentration changes drastically near the surface region (≈10nm) because of its absorption depth. Previous theories showed that silicon's elastic modulus and carrier concentration are correlated. Based on that, we have developed a model relating the surface volume ratio to the elastic modulus change. Our experimental data agrees well with the prediction of the model.

Biography of Presenter Ji-Tzuoh Lin, Ph.D. is a research scientist in the department of Electrical Engineering at University of Louisville. His research fields has been in the MEMS devices and energy harvesting areas. He is specifically interested in low power MEMS solutions for internet of things (IoT). Dr. Lin has one issue patent, two book chapters and more than 20 Journal publications. He has started his companies and received an SBIR award. He is currently working on subjects related to UV effects on silicon and GaN resonator and their low power applications.