INTRINSIC AND EXTRINSIC POINT DEFECTS IN CARBON-IMPLANTED SiO_2

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The properties of carbon impurities in silica glasses and amorphous SiO_2 oxide layers are of interest due to applications of these materials in optical fibers or high power/ radiation resistant optics and because of an increased reliance on carbon-containing silicon-organic raw materials for industrial synthesis of SiO_2 glasses. In power electronics, carbon impurities can adversely affect the quality of SiO_2 layers in SiC-based electronic circuits. While there are numerous studies of C nanoparticles in silica and on core-shell silica-coated C nanoparticles, the state of separate C atoms in silica glass matrix is still not well-understood. The present study is aimed at obtaining their spectroscopic signatures and understanding their structural environment.

The samples of synthetic silica glass and alpha quartz crystals were studied. Carbon was introduced by implanting C^+ ions at energies 50 keV or 300 keV and fluences up to 5×10^{16} ions/cm^2. C-ion distributions and radiation damage profiles were obtained by SRIM software package. To separate the specific carbon-related effects from the general implantation-induced radiation damage, Ne^+ -implanted samples were used for comparison. Optical absorption, photoluminescence and electron paramagnetic resonance (EPR) spectra were measured.

Optical absorption spectra of implanted samples differ from the usual pattern of irradiated silica by 2 aspects: 1) by up to 10^4 times higher concentration of "ODC(II)"-centers (divalent Si atoms) as compared to gamma-irradiated or non-irradiated oxygen deficient silica; (2) by nearly complete absence of oxygen dangling bonds ("NBOHC"- centers), which are ubiquitous in irradiated silicas. Infrared spectra indicate formation of interstitial CO and CO_2 molecules, however, they account only for a minor part of the implanted C ions. Photoluminescence spectra show a new emission band at 2.20 eV (560 nm), which is specific to C-ion implantation. It has excitation peak at 5.76 eV (220 nm). The lifetime is in short ns region (to be measured exactly).

EPR spectra show carbon-related signal with g=2.0028. This is close to the g-factor (g=2.0026) of the previously reported carbon-related surface radicals $(\text{-O-Si})_3\text{-C}^\bullet$. However, the signal in ion-implanted glass is much (~5×) wider. Studies of magnetic isotope (^{13}C)-implanted samples are ongoing in order to establish the structure of this center.