EPR pētījumi ar oglekļa izotopu ^{13}C implantētā SiO_2 stiklā

Madara Leimane[1], Anders Hallén[2], Linards Skuja[1],
[1]*Latvijas Universitātes Cietvielu fizikas institūts*
[2]*KTH Royal Institute of Technology, Electrum 229, SE-164 40 Kista, Sweden*

Oglekļa piemaisījumi oksīdos var veidoties sintēzē no organiskiem izejmateriāliem vai ogleklim nepilnīgi izdaloties carbīdu oksidēšanas procesā, piem., $SiC \rightarrow SiO_2$ vai $HfC \rightarrow HfO_2$. Tos oksidējot, C pamatā izdalās kā CO_2, tas var veidot arī daļiņas/fāzes (HfO_2) vai pasliktināt kvalitāti SiO_2 kārtiņām SiC MOSFET struktūrās. Atsevišķu C – atomu apkārtne oksīdos nav labi izprasta. Mēs salīdzinājām $^{12}C^+$ un $^{13}C^+$ jonu implantācijas radītu paramagnētisku centru īpašības SiO_2 stiklā, izmantojot X-joslas EPR spektrometru. Visos spektros tika novēroti Si norauto saišu (E'-centru) signāli. ^{12}C-implantētos paraugos tika novērots ar C saistīts signāls ar g=2.0028, kurš ir vairākkārt aprakstīts literatūrā, bet tā struktūra nav zināma. ^{13}C-implantētos paraugos šī signāla vietā parādās 2 dubleti ar sašķelšanos 9.5 un 22 mT, kuri atbilst 2 dažādiem paramagnētiskiem centriem ar S=1/2, kuros elektrona spins sadarbojas tikai ar 1 oglekļa atomu. 9.5 mT dublets visticamāk atbilst oglekļa atomam, saistītam ar 3 Si atomiem SiO_2 stikla tīklā, 22 mT dublets domājams atbilst struktūrai kurā oglekļa tuvāko kaimiņu skaitā ietilpst skābeklis.

EPR study of ^{13}C carbon isotope-implanted SiO_2 glass.

Madara Leimane[1], Anders Hallén[2], Linards Skuja[1],
[1]*Institute of Solid State Physics, University of Latvia*
[2]*KTH Royal Institute of Technology, Electrum 229, SE-164 40 Kista, Sweden*

Carbon impurities can be present in oxide materials due to their sol-gel synthesis from metal-organic compounds or due to incomplete removal of carbon on oxidation of respective carbides, e.g., $SiC \rightarrow SiO_2$ or $HfC \rightarrow HfO_2$. On oxidation, most of carbon emanates as CO_2, some may form separate carbon nanoparticles/phase (in HfO_2), or may reduce the quality of amorphous SiO_2 layers in SiC MOSFETs. The structural environment of separate carbon atoms in oxides is not well-understood. To obtain information on this problem, we performed a comparison between the paramagnetic centers, introduced in synthetic SiO_2 glass by implantation of non-magnetic $^{12}C^+$ and magnetic $^{13}C^+$ (I=1/2) carbon ions. Ion energies were 50 keV and 300 keV, ion fluence 1×10^{16} ions/cm^2. Electron paramagnetic resonance (EPR) spectra were measured at room temperature with X-band spectrometer

All spectra showed signals due to silicon dangling bonds (E'- centers). ^{12}C- implanted samples revealed an additional, signal with g=2.0028 which is related to carbon and reported in C-doped SiO_2 in numerous cases, however its structure is not yet known. In samples implanted by ^{13}C, this signal disappeared and 2 doublets with splittings 9.5 mT and 22 mT emerged. Their relative intensities were different in 50 keV and 300 keV ion-implanted samples, indicating presence of two separate centers with S=1/2, each having hyperfine couplings with a single carbon ^{13}C nucleus. Based on published data on C-related centers on SiO_2 surfaces, the 9.5 mT doublet can be most likely assigned to carbon, bonded to 3 silicon atoms in glass network. The 22 mT doublet is tentatively related to carbon radical with at least one oxygen neighbor.

Supported by Latvian Science Council project lzp-2024/1-0676. M.L. thanks the support "Mikrotīkls", donation is administrated by the University of Latvia Foundation. General support by EU Horizon 2020 Framework Program H2020-WIDE-SPREAD-01–2016–2017-TeamingPhase2 under grant agreement No. 739508, project CAMART^2 is acknowledged.