Characterization of Traps in High Resistivity Silicon Substrates and Link with Radio Frequency Performances

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An important family of silicon-based substrates used for radio frequency (RF) applications relies on the introduction of a large concentration of traps to prevent the formation of a parasitic conduction layer, detrimental to RF substrate performance. Effective resistivity and harmonic distortion (HD) measurements allow the suitability of the substrate for RF applications to be assessed, but to engineer their values, information on trap properties are required. Those properties are difficult to characterize with conventional capacitance techniques due to the combination of high resistivity and large trap density which induces a Fermi-level pinning. In this work, we used photo-induced current transient spectroscopy to generate a transient current by thermal de-trapping after light-induced trap-filling. The signal was then processed to obtain, over a temperature range, a spectrum depending on the trap energy levels and capture cross-sections. This technique was applied to gold-implanted silicon substrates and enabled the detection of four main traps. Quantitative evaluation of the defect concentration was achieved by a fitting of measured and simulated HD results. Finally, information obtained about traps was compared with secondary ion mass spectroscopy measurements and an explanation of the role of each introduced defect on RF behavior was proposed. This work opens the way to understanding trap behaviour in other RF substrates such as trap-rich silicon-on-insulator substrates.