Cz silicon wafer characterization by photoconductive decay technique (PCD)

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Cz silicon wafers have been widely used for microelectronic devices manufacturing in an industrial scale, such as diodes, solar cells and sensors due to the cost reduction that their usage can provide. In this work, the silicon wafers are characterized by using the photoconductive decay, which is a contactless technique able to measure the effective minority carrier lifetime as function of the excess carrier density (from $1 \times 10^{13}$ to $1 \times 10^{17}$ cm$^{-3}$)), generated by optical excitation. The measured effective lifetime becomes dependent on the surface recombination velocity and on bulk lifetime. Besides being a non-destructive technique, the PCD has become an important tool for starting material characterization and for monitoring fabrication processes as well. In order to characterize the behavior of the minority carrier lifetime after thermal treatments in silicon, samples were analyzed after each thermal step of a solar cell fabrication, generally required for processing rear passivated solar cells with high efficiency. The p-type Cz silicon samples with 3cm x 3cm area and 2.5Ohm.cm resistivity were initially oxidized using chloride additives, achieving an effective lifetime of about 0.130ms for excess carrier concentration equal to $3.1 \times 10^{14}$ cm$^{-3}$. Then they were submitted to a photolithographic step, resulting in a 4cm$^2$ useful frontal area. The emitters were obtained by phosphorus diffusion followed by the PSG dropping out and re-oxidation with chloride additives, obtaining a rear passivated n+p structure with a 55ohm/square emitter sheet resistance. The benefits of a hydrogenation technique (anneal) have also been showed by the effective lifetimes measured before, 0.103ms and after, 0.222ms[1]. Meanwhile, the excellent implied open-circuit voltage, about 652.4mV associated to the device after the anneal is in agreement to other works[2], representing an important minimization of carrier recombination after each thermal step. If a typical low cost frontal anti-reflection system (SiO2 film over random pyramids) were considered, efficiency predictions would be about 19.4-19.7 percent, being of great interest for solar cell applications.

References