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RECOMBINATION AND TRAPPING ACTIVITY IN HEM MULTICRYSTALLINE SILICON GETTERED BY PHOSPHORUS DIFFUSION

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Abstract:

Multicrystalline silicon (mc-Si) wafers are widely used as precursor elements in solar cells manufacturing, and constitute more than half of the overall industrial market. This is due to their low cost of manufacturing as compared to that of monocrystalline silicon (c-Si) [1].

However, the contamination of mc-Si material by metallic impurities (Fe, Cr, Mn, Cu, Ni, Co, etc...) during its elaboration and the existence of crystallographic defects are considered as its major disadvantages. The presence of such defects can, respectively, provoke a high carrier recombination and trapping activity. This may be greatly limiting the efficiency potential of solar cells.

Nevertheless, most metallic impurities dissolved in material bulk or segregated at grain boundaries, may be removed by "gettering" process. It refers to a thermal process step that activates the diffusion of interstitial impurities from the active regions of the device to less important regions created generally by phosphorus diffusion and/or aluminum-silicon alloying [2-7].

In this present contribution, we have investigated the recombination-trapping activity of minority charge carriers in p-type HEM mc-Si treated by extended phosphorus diffusion gettering (PDG). The study was made after phosphorus diffusion and according to different extended annealing temperatures.

Using quasi-steady state photoconductance (QSSPC) technique, the apparent lifetime dependent minority carrier density curves have been obtained. The results showed an increment of the bulk minority carrier lifetime for specific annealing temperatures. Appropriate calculations carried out on lifetime curves allowed us to determine the lifetime curves associated to gettered impurities. Their fitting by Shockley-Read-Hall (SRH) model [8, 9] reveal that the origin of the lifetime increment is due to the diminution of interstitial chromium (Cr_i) density in the bulk. A further analysis performed by secondary ion mass spectrometry (SIMS) technique confirms the gettering of chromium, revealing a significant accumulation of ^{52}Cr in phosphorus diffusion region.

Using Hornbeck-Haynes model [10], the modelling of apparent lifetime curves leads to estimate the electron to hole capture cross-section ratio ($k=\sigma_n/\sigma_p$) that confirmed the effectiveness of Cr_i gettering, the trapping centres concentration and the localised energy levels (E_C-E_T) of the traps in band gap.

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