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An Investigation on the Effect of Aluminium Back-Contacts on LeTID During Firing

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Introduction

The phenomena of light- and elevated temperature-induced degradation (LeTID) was first coined by Kersten *et al.* to describe a degradation mechism observed in multicrystalline silicon passivated emitter and rear cell (PERC) solar cell structures by Ramspeck *et al.* [1,2]. Although the exact root cause and mechanics behind the degradation is still a topic of heavy debate, there has been increasing evidence to suggest the involvement of hydrogen [3,4]. One peculiar behaviour pertaining to LeTID is that such phenomena was not observed in historical devices such as the aluminium back-surface field (Al-BSF) solar cell. Although it has been postulated that the reason for such degradation in PERC structures is the increase in hydrogen introduced from the additional rear-side aluminium oxide (AlOx:H) and silicon nitride (SiN_x:H) films [5], little effort has been put into understanding the impact of the aluminium rear-contact. Aluminium is well known for its ability to getter and segregate defects and bulk impurities [6] and should, in a similar fashion facilitate the removal of interstitial hydrogen from the bulk. Terry *et al.* in [7] showed a segregation of hydrogen into aluminium crystallized silicon through the use of SIMS measurements. In this work, we investigate the impact of the aluminium rear-contact in PERC structures during metallization fast-firing on subsequent formation of LeTID. We observe a direct correlation between the rear-aluminium contact area, as facilitated through dielectric openings, with the LeTID extent. Samples containing a higher density of PERC contact openings were observed to show reduced LeTID related defect concentrations.

Methodology

To investigate the impact of aluminium on the formation of LeTID, passivated lifetime test structures were fabricated on commercial bought p-type mc-Si wafers. These wafers were diffused with a front-side phosphorus diffusion and passivated on the front and the rear-sides with PECVD deposited SiN_x:H and AlO_x:H/SiN_x:H dielectric films, respectively. Using a continuous wave laser, a series of laser openings were made through the rear-side passivation layers with a pitch (distance between laser openings) ranging between 0.1 mm and 8 mm.

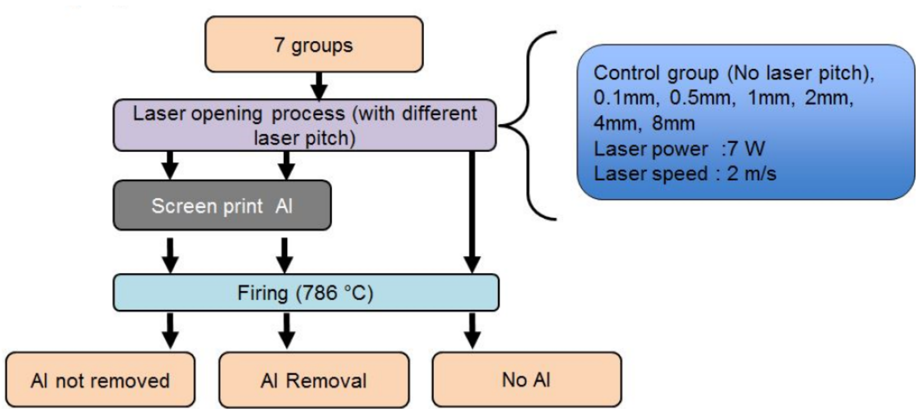

Figure 1. Experimental process flow for testing the impact of Al on LeTID formation.

Screen printed aluminium is applied on some wafers and others are left bare (controls) to isolate the impact of the laser process itself. All wafers were then fired at high temperature to facilitate contact formation and to provide the conditions required to induce LeTID. Once fired, the aluminium metal was removed from the rear-side using a concentrated solution of hydrochloric acid (HCl) in order to allow for lifetime measurements using quasi-steady-state photoconductance (QSSPC). The process flow is depicted in Figure. 1. LeTID was induced in the dark at a temperature of 205 ± 5°C as proposed by [5].

Results and Discusion

Our results show that the density of Al contact significantly affects the severity of LeTID. The normalised defect concentration measured on samples with aluminium printed is reduced in comparison to samples without aluminium present during the firing process (see Figure 2 (left)). A comparison between samples containing laser openings of various pitch but without Al during firing showed no disparity in the defect concentration, thus isolating the effect of the laser process itself as the reason behind the reduction in defects. Lastly, a comparison between Al printed samples with different laser openings (0.5 mm and 4 mm as seen in Figure 2) demonstrated a lower defect concentration when the density of laser openings is increased.

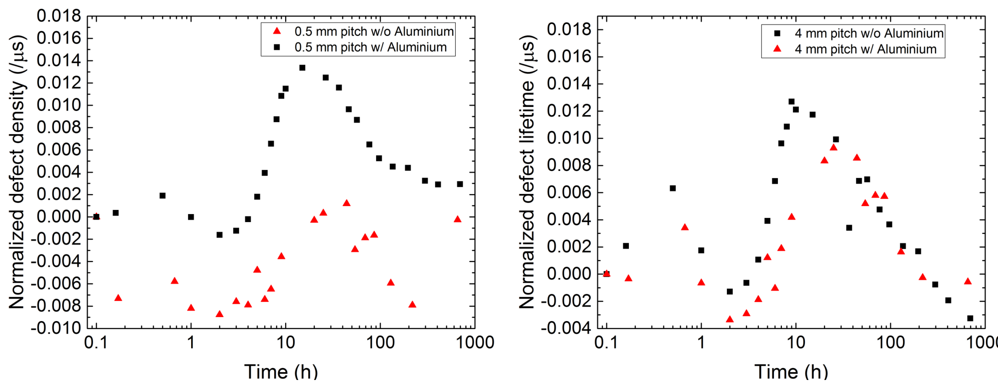

Figure 2. Evolution in defect concentration of samples fired with 0.5 mm and 4 mm rear-side laser openings and with and without Al during firing.

Conclusion

Our results in this are consistent with the hypothesis that impurity segregation, in this case hydrogen into the Al contact may be the reason why Al-BSF solar cells did not experience severe LeTID observed in PERC solar cells. If this is indeed correct, our results may have huge implications on the fabrication of commercially made PERC cells, where additional thermal treatments may be used to segradate hydrogen and mitigate LeTID. In our final paper, we will also discuss further findings of a secondary degradation after the initial recovery of LeTID.

[1] K. Ramspeck, S. Zimmermann, H. Nagel, A. Metz, Y. Gassenbauer, B. Brikmann, A. Seidl, Light induced degradation of Rear Passivated mc- Si solar cells, in: Proc. 27th Eur. Photovolt. Sol. Energy Conf., 2012: pp. 861–865. doi:10.4229/27THEUPVSEC2012-2DO.3.4.

[2] F. Kersten, P. Engelhart, H.C. Ploigt, A. Stekolnikov, T. Lindner, F. Stenzel, M. Bartzsch, A. Szpeth, K. Petter, J. Heitmann, J.W. Muller, A new mc-Si degradation effect called LeTID, 2015 IEEE 42nd Photovolt. Spec. Conf. PVSC 2015. (2015). doi:10.1109/PVSC.2015.7355684.

[3] A. Ciesla, S. Wenham, R. Chen, C. Chan, D. Chen, B. Hallam, D. Payne, T. Fung, M. Kim, S. Liu, S. Wang, K. Kim, A. Samadi, C. Sen, C. Vargas, U. Varshney, B.V. Stefani, P. Hamer, N. Nampalli, Z. Hameiri, C. Chong, M. Abbott, Hydrogen-Induced Degradation, (2012). doi:10.1109/PVSC.2018.8548100.

[4] D. Chen, P.G. Hamer, M. Kim, T.H. Fung, G. Bourret-Sicotte, S. Liu, C.E. Chan, A. Ciesla, R. Chen, M.D. Abbott, B.J. Hallam, S.R. Wenham, Hydrogen induced degradation: A possible mechanism for light- and elevated temperature- induced degradation in n-type silicon, Sol. Energy Mater. Sol. Cells. 185 (2018) 174–182. doi:10.1016/j.solmat.2018.05.034.

[5] D. Chen, M. Kim, B. V. Stefani, B.J. Hallam, M.D. Abbott, C.E. Chan, R. Chen, D.N.R. Payne, N. Nampalli, A. Ciesla, T.H. Fung, K. Kim, S.R. Wenham, Evidence of an identical firing-activated carrier-induced defect in monocrystalline and multicrystalline silicon, Sol. Energy Mater. Sol. Cells. 172 (2017) 293–300. doi:10.1016/j.solmat.2017.08.003.

[6] S. Martinuzzi, O. Porre, I. Périchaud, M. Pasquinelli, Aluminium Gettering in Silicon Wafers, J. Phys. III. 5 (1995) 1337–1343. doi:10.1051/jp3:1995100.

[7] M.L. Terry, D. Inns, A.G. Aberle, Rapid thermal annealing and hydrogen passivation of polycrystalline silicon thin-film solar cells on low-temperature glass, Adv. Optoelectron. 2007 (2007). doi:10.1155/2007/83657.