# Dependence of LeTID on brick height for different wafer suppliers with several resistivities and dopants

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High values for Light and elevated Temperature Induced Degradation (LeTID) for Passivated Emitter and Rear Cells (PERC) made from multicrystalline silicon (mc-Si) wafers were reported a few years ago [1]. During the last years, Hanwha Q CELLS has developed a solar cell production process that controls LeTID to values below 1% using the Q.ANTUM technology [2]. Despite big R&D efforts done on industry and institute side, only a few investigations on the influence of wafers parameters on LeTID exist [3]. In this paper we report on an investigation using two different groups of wafers

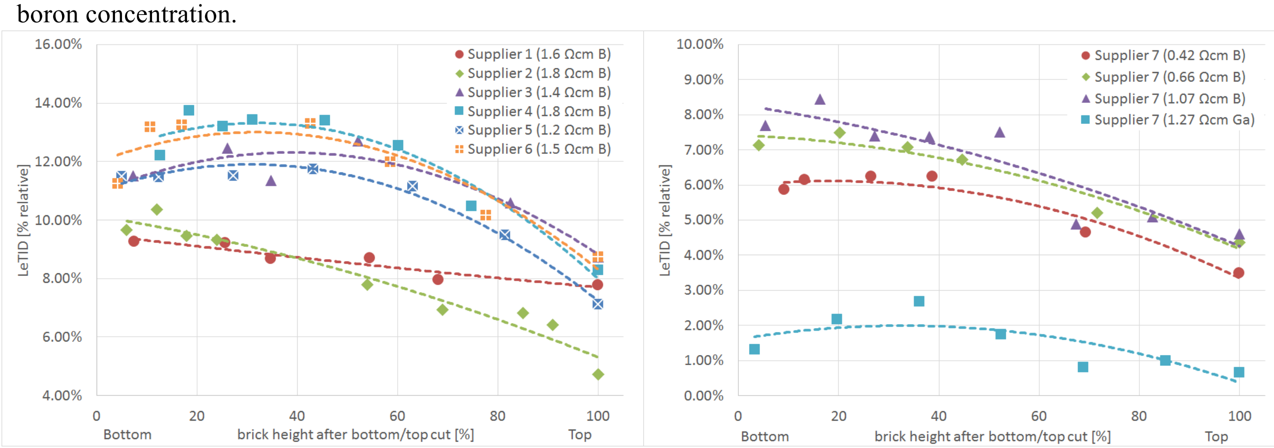
a) Commercially available boron doped “high-performance mc-Si” (HPM) wafers from six different suppliers with average brick resistivities between 1.2 and 1.8 Ωcm
b) Older “standard” mc-Si wafers from a seventh supplier with gallium doping and higher boron dopant concentrations with average brick resistivities between 0.4 and 1.3 Ωcm

It has to be noted that, in order to have a severe degradation “signal” for these investigations, we intentionally increased LeTID to a very high value by using an adapted LeTID sensitive solar cell production process and that all solar cells were processed in one experiment run with the same process conditions.

Fig. 1. shows the relative reduction of solar cell efficiency (after LeTID treatment with 1 sun illumination at 75°C for 24 hours) for wafer groups a) and b). Please note that the x-axis refers to the relative brick height after bottom and top cut done at the wafer supplier. The following observations are made:

- For all bricks the same tendency can be observed: higher LeTID for bottom and middle of bricks and a reduction towards the top
- All Boron doped HPM bricks degrade between 8% and 12% on average, differences between bricks cannot be related to resistivity
- All Boron doped standard mc-Si bricks degrade between 5% and 7% on average. No increase of LeTID can be observed when increasing boron concentration by a factor of ~ 3 (1.07 to 0.42 Ωcm average resistivity)
- Gallium doping reduces LeTID by a factor of ~ 4 to an average value of ~ 1,5%

In summary, the results indicate that LeTID can hardly be mitigated to an acceptable level simply by choosing a so-called “right” wafer manufacturer on the market because all wafers used in this investigation show high values of LeTID unless the cell process is appropriately designed and used. The results also show that LeTID can be significantly reduced by using gallium instead of boron as a dopant, however, LeTID does not seem to depend on the boron concentration.




(a) (b)

**Fig. 1.** Dependence of relative efficiency degradation after LeTID treatment (75°C, 1 sun, 24h) on relative brick height (after bottom / top cut) for (a) HPM wafers from different wafer suppliers (“1” to “6”) and (b) standard mc-Si wafers from another supplier “7” with different boron doping levels and gallium doping.

[1] K. Ramspeck et. al., “Light induced degradation of rear passivated mc-Si solar cells”, Proceedings of the 27th EUPVSEC, Frankfurt, Germany 2012, pp.861–865

[2] F. Kersten,et. al., “Degradation of multicrystalline silicon solar cells and modules after illumination at elevated temperature”, Solar Energy Materials and Solar Cells (2015), Volume 142, November 2015, Pages 83-86

[3] K. Nakayashiki, et al., “Engineering Solutions and Root-Cause Analysis for Light-Induced Degradation in p-Type Multicrystalline Silicon PERC Modules”, IEEE Journal of Photovoltaics Vol. 6, Issue 4, July 2016, Pages 860-868