PID-free c-Si PV module using novel chemically-tempered glass

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We have developed a PID free c-Si PV module using novel glass that is chemically tempered by substitution of Na ions by K ions in the surface region (AGC Leoflex™). Leoflex™ is aluminosilicate glass and chemically tempered. Chemically tempered glass is widely used for smart-phones.
It is found that the absence of Na ions in the surface region drastically suppress the PID even using the same cells which shows severe degradation with conventional soda-lime glass.
After 96 hours application of -1000 V to the cell, the module with conventional cell shows degradation in the power by more than 90% and only 10% of the power remains, while the module with chemically tempered glass shows no degradation keeping more than 99.5% of the power.
Na migration into Si wafer is suppressed by using chemically tempered glass.

Experimental

Fabrication of 4-cell modules

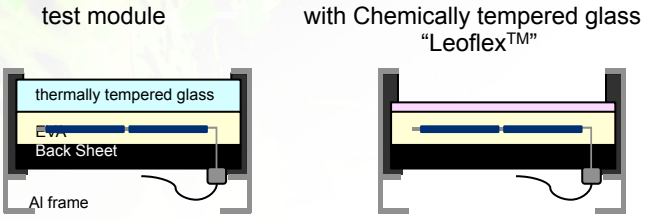


Fig. 1. Schematic diagrams of cross-section view of two kinds of 4-cell modules, with thermally tempered glass (left) and with chemically tempered glass "Leoflex™".

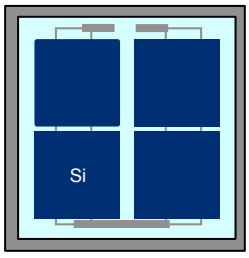


Fig. 2. Schematic diagram of top view of 4-cell modules.

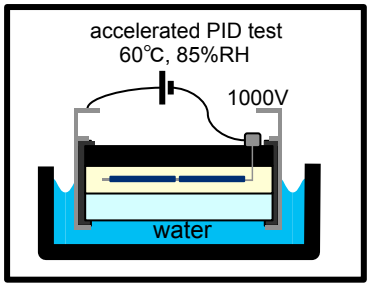


Fig. 3. Schematic diagram of accelerated PID test conditions.

Chemically tempered glass

Glass is submerged in a bath containing a potassium nitrate. Sodium ions in the glass surface are exchanged with potassium ions from the solution.

Na_2O in glass surface : >10 wt% → ~ 3 wt%
resistivity of glass : 1 → x 100

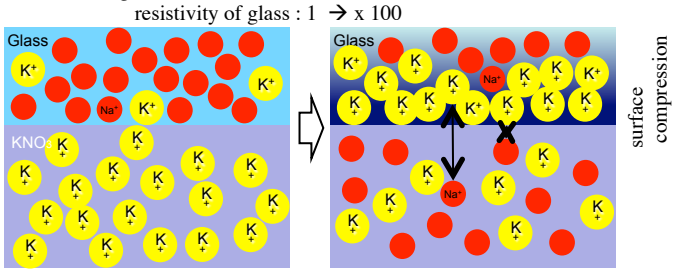
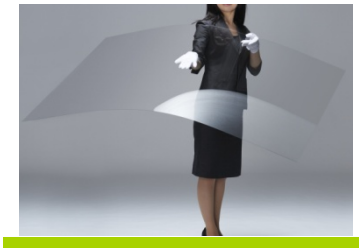


Fig. 7. Schematic diagrams of glass and potassium nitrate bath, before (left) and after (right) chemically tempering.



Chemically tempered glass as a photovoltaic module cover glass is commercially available now, as "Leoflex™" by Asahi Glass. The Leoflex™ is aluminosilicate glass and its composition is specially designed for good chemical-tempering characteristics.

Results

Modules with chemically tempered glass show no degradation keeping more than 99.5% of the power.

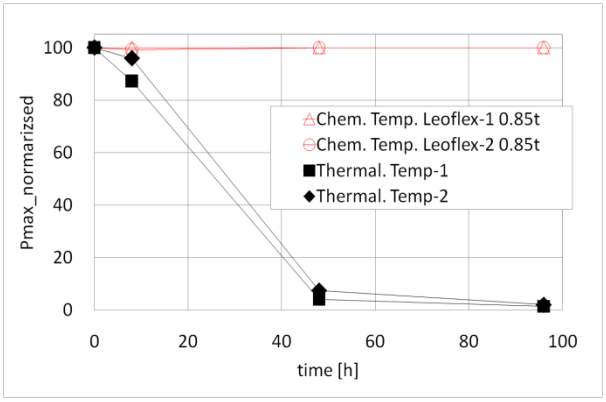
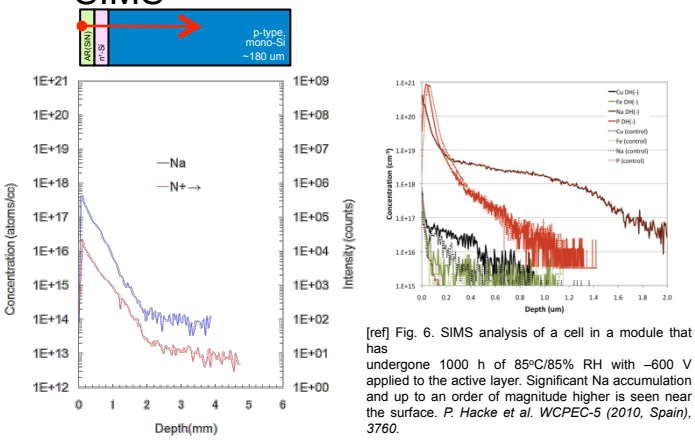


Fig. 4. Normalized performance of four 4-poly-Si modules, with thermally tempered glass and with chemically tempered glass "Leoflex™", in 60ºC/85% RH, -1000 V applied to the active layer for 96 h. Two modules were prepared and operated PID test for each type of the module.

SIMS



[ref] Fig. 6. SIMS analysis of a cell in a module that has undergone 1000 h of 85ºC/85% RH with –600 V applied to the active layer. Significant Na accumulation and up to an order of magnitude higher is seen near the surface. *P. Hacke et al. WCPEC-5 (2010, Spain), 3760.*

Fig. 5. Na and N depth profiles of a p-type mono-Si wafer in a module with chemically tempered glass that has undergone 48 h of 60ºC/85% RH with –1000 V (dipped in water) applied to the active layer. Na migration into Si wafer is suppressed by using chemically tempered glass compared to Fig. 6. Resolution of depth is not high enough because surface of the Si wafer is rough.