PV-modules with optimized energy balance

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ABSTRACT

The overall energy balance of a solar PV-module across its life time needs a consideration incl. its energy consumption during manufacturing process versus its energy harvesting capabilities during life time. A glass-glass-module based on thin tempered glass on front and backside can dramatically influence this overall balance, since more than 50 % of encapsulation materials manufacturing energy can be saved, followed by a an further impact on frameless mounting of light-weighted modules, reducing mounting costs and enabling simpler BIPV

Keywords: PV-Glass-Glass-Modules, Thin Tempered Glass

1. INTRODUCTION

Since the world faces increasing challenges in renewable energy recourses, all kind of aspects come into the game of not only cost-effective but also energy effective manufacturing methods for PV modules, reducing carbon emission and optimized energy harvesting properties.

1.1 Todays conventional approach

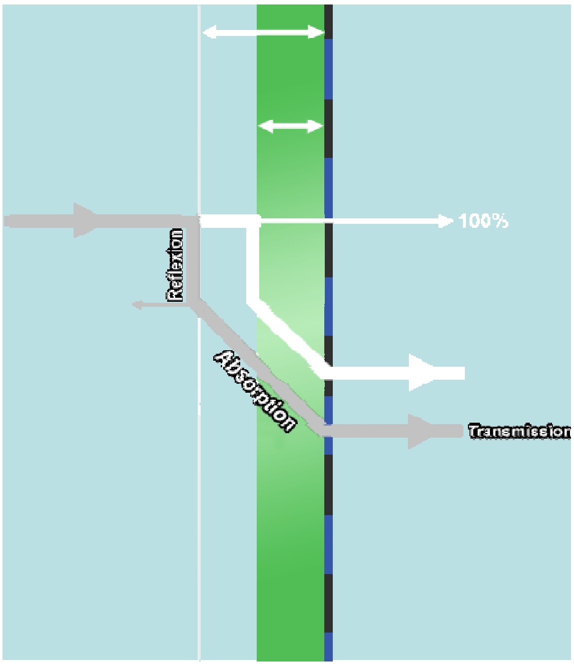
Our todays conventional crystalline PV module manufacturing process involves three major “energy spending materials” – silicon as cell material (mono- as well as poly crystalline), glass and backsheet as encapsulation materials and finally framing and substructure material (typ. aluminium).
Several institutions are working on new approaches for poly-silicon production, this paper focuses on encapsulation material and - as “added value” - on framing and substructure.
As glass is the proven “face” of a PV module, absorbing the first portion of sun radiation, efforts towards minimizing this absorption are of interest. Low iron content of glass and anti reflection coatings are proven concepts, going thinner in glass was limited so far by manufacturing processes like thermal toughening to aro. 3 mm. Any additional reduction could bring another small portion of transmission efficiency, thus a reasonable amount of payback over lifetime of a PV module.

1.2 LiSEC`s thin glass approach

The commercial availability of 2 mm thermally toughened ultra clear glass is an enabling tool to consequently go this route; float glass as well as patterned glass with these properties is available in quantities today, a strong growth in capacity is ongoing.

In terms of cost reduction from glass side 2 mm seems to offer the highest potential in respect to reduced material vs. increased efforts and costs for handling, breakage etc. Going any thinner might not be feasible from todays point of view.

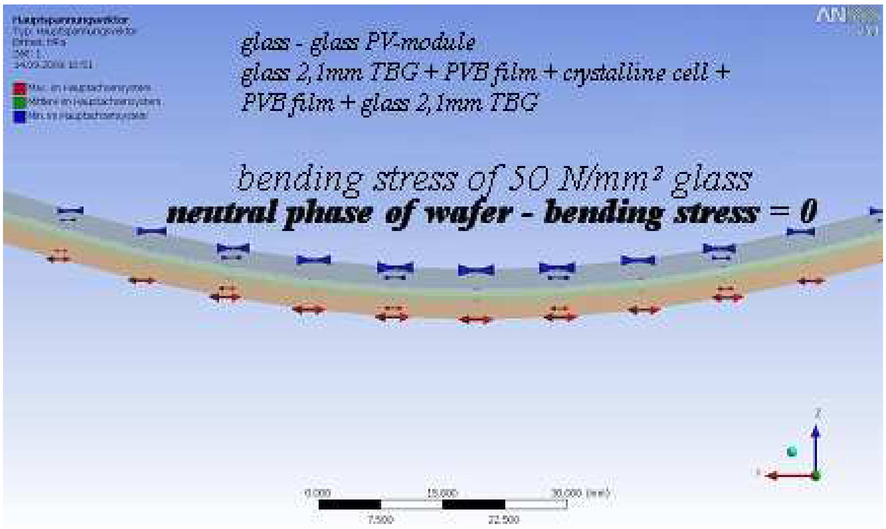
Comparing 2 mm glass in terms of cost with conventional backsheet materials it turns out that even tempered glass is competitive in this respect. As glass is a proven, long-lasting, stable and hermetic resistant material it makes sense to consider this as replacement of backsheet



material – along with an hermetic edge sealing this turns out to be the choice for a new generation of PV modules.

The overall advantages of this concept include several issues like

+ transmission – thinner glass provides higher transmission efficiency
+ module thickness – 5.5 mm overall thickness
+ module weight – less than 10 kg/m2
+ hermeticity – glass is excellent in this respect to humidity, gases etc.
+ frameless – suits best for backrail mounting solution
+ energy consumption of materials used for encapsulation



2. ENERGY BALANCE

In order to specify the energy savings in this configuration we compared the encapsulation material only (no cells and embedding foils considered).
The energy consumption for producing float glass is well known (2,5 kWh/kg) and can easily be scaled for 2 x 2 mm (front and back = 12,5 kWh) in comparison to 1 x 3,2 mm (front only = 20 kWh). Same applies for thermal tempering process (0,3 kWh/kg glass).
Furthermore the amount of energy for a typ. backsheet was evaluated with approx. 14 kWh/m2 and aluminium frame elimination – just acc. aluminium melting process – gives another 32 kWh for a typ. 2,5 kg of aluminium/m2 of PV module.
This calculation gives a 56% lower energy consumption for raw material production for a glass-glass-module compared to a conventional glass-backsheet module.

Energy balance of encapsulation materials			
module size: 1,65 x 0,98 m			
	3,2 Glass-Backsheet [kWh]		2+2 Glass-Glass [kWh]
Frontglass 3,2 mm	20,0		
Frontglass 2 mm			14,0
glass tempering	2,5		1,5
Backsheet	14,0		
Backglass			14,0
Frame (Edge sealant)	32,0		0,5
Total (kWh)	**68,5**		**30,0**
	56 % energy savings !!		

Table 1 – Energy Balance – not considering cells and embedding foil materials

3. CONCLUSION AND OUTLOOK

Considering the cost pressure coming from Chinese module manufacturers it is not only essential to work on further cost reduction itself but also considering the environmental impact of overall module production. Energy consumption is one major topic in respect to CO2-footprint, thus influencing the total environmental balance. If an advantage in this aspect can be gained along with multiple other features like enhanced lifetime through hermetic encapsulation, lower weight with reduced substructure, there is no reason not to switch towards this technology. The trend is clearly showing increasing demand and thus efforts in introducing glass-glass modules also for crystalline technology .