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Turbo mode for solar modules: Second- and third-generation front glasses

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ABSTRACT

Competition in the premium sector is becoming more and more fierce. This is forcing PV module manufacturers to differentiate themselves through product benefits and better performance in terms of efficiency. While attention has previously been focused on cell technology, it is likely that, in the future, all module components will become part of this competition – a competition in which premium front glasses present an especially promising element. Anti-reflective coating (ARC) is only the beginning of this evolution. Not only do deeply textured front glasses promise significant increases in output – up to 7% – but their specific product characteristics also make them suitable for niche applications, such as airplane entry lanes and airport buildings. EuPD Research has issued a white paper devoted to solar glass, of which a synopsis is presented here.

Introduction

The worldwide PV market is currently experiencing an upheaval. Previously strong sales markets – such as Germany, with an installation volume of 7.4 gigawatts (GW) in 2010 – are experiencing a decline in demand. The promising markets in the USA, Italy, France and the UK are lagging behind in their expectations. In view of the decreased demand in the first half of the year and the simultaneous increases in production capacity on the part of the manufacturers, the industry is currently steering towards an overproduction scenario, in which unsold products will have to be left in storage. Although cyclic demand is a normal occurrence in other branches, it poses a significant problem for the PV industry because of the dramatic decreases in price that solar modules and components experience. Differentiation via product features and services, especially increased efficiency at competitive prices, affords the best conditions for a strong position in the market. Module price is still the most important aspect of differentiation.

Differentiation is not just a question of cell types

So far, most manufacturers have focused on their cell technologies as the driver for higher efficiency and increased output, but it is also worth taking a closer look at other module components. While contacts, EVA encapsulation foils, junction boxes and frame mouldings all offer marginal potential for lowering costs and increasing output, another crucial component is gaining in importance: front glass. This is particularly interesting, since various refinement and texturing processes have been developed in the last few years, which have prompted a dramatic improvement. With their white paper, EuPD Research, the leading service provider in the analysis of the solar energy and CleanTech markets, have taken account of this development. For the first time, experts have carried out a detailed analysis of the subject of front glasses.

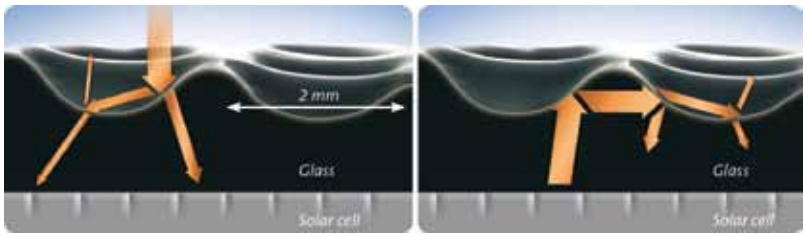

Figure 1. Deeply textured glass uses the geometric 'light-trapping' effect that boosts energy output.

In an increasingly competitive market environment, PV manufacturers are well advised to differentiate their products from those of their competitors by marketing their specific features. So far, mainly the price and origin of the modules have provided this differentiation, but in today's market, manufacturers are focusing ever more on the design and visual aspects, as well as on the suitability of the modules for use in niche sectors. Comprehensive studies conducted by EuPD Research have concluded that the main arguments which convince end customers are still price, efficiency and yield; this analysis takes into account the previous value-added steps of the installer or wholesaler. The use of anti-reflective glass or deeply textured front glasses has been proved to achieve increases in output of up to 7% (in kWh/kWp), depending on a system's alignment. Deeply textured glass has so far shown the best results, through the use of geometric 'light-trapping' effects and because of the increased temperature reduction due to its larger surface area, giving owners of east- and west-oriented roofs, for the first time, a product that boosts energy output to a convenient level for such installations.

Deeply textured glass proved to increase efficiency

The main disadvantage of textured glass technology is the higher cost of producing the specialized front glasses. Although there is currently a surplus of extra-white solar glass, and a high level of price-based competition among glass manufacturers, it is still necessary to carry out a critical examination of the situation. The independent Institut für Solarenergieforschung (ISFH) in Hameln, Germany, has conducted a study of the effects of deeply textured front glasses on module output, and established an average increase in output of 5.4% when the modules were ideally aligned at a 30-degree angle and faced directly towards the south. The researchers found that the increases in output through the use of deeply textured glass were more significant when it was used in installations with less ideal alignments and in more northerly sales markets, due to the optimum exploitation of indirect light provided by the specialized glass. Increases in output of more than 7.5% have been shown both in laboratory tests and in practical use. In the latter, temperature effects on the modules led to a further 0.5% increase in efficiency, due to the larger surface area of the deeply textured glass in comparison to normal front glasses. This was first verified by the scientists at

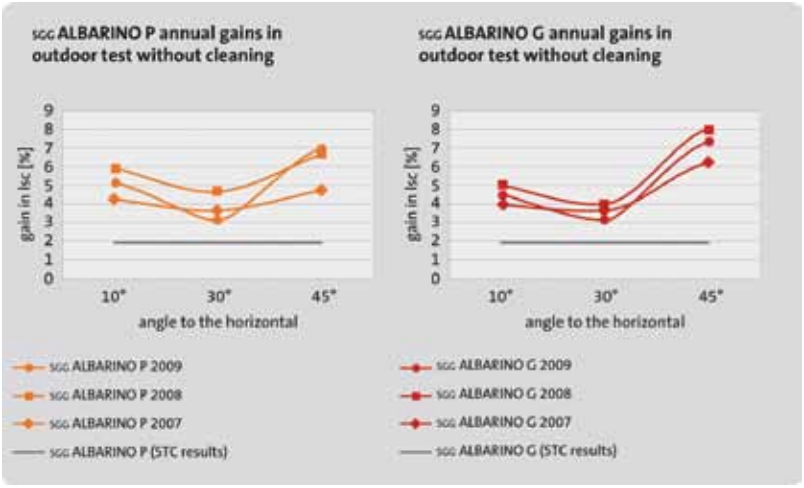

Figure 2. Outdoor field tests show that the annual energy gains depend on the angle between the panel and the horizontal. Cleaning has only a marginal effect.

Boston Fraunhofer Center for Sustainable Energy Systems. However, this effect can barely be measured in a laboratory, as such tests cannot simulate either the temperature increases of the modules in use or the cooling effects of the wind.

Unlimited product lifespan and better suitability for niche markets

The proven effects on temperature and the usage of indirect light provide two clear efficiency benefits for PV panels with deeply textured glass, as opposed to those with anti-reflective glass. Comparative calculations show that the extra costs involved in the use of specialized glass for solar modules are offset during the product's lifespan. These benefits can even be realized in the mid-term in the form of significant increases in efficiency (see model calculation in below), which over-compensate for the initial extra costs. Another fortunate side effect of textured glass is the reduction of the 'dazzle effect' caused by the shiny glass of normal PV modules. This is of particular benefit for use in densely populated areas, areas near to traffic hubs, and airports. While the use of solar panels in airports – for example on the roofs of parking lots, airport buildings, entry lanes or hangars – is currently banned in many countries because of the possible danger caused by the dazzle effect, this could open a new market niche for specialized modules using deeply textured glass. These modules would also prevent arguments among neighbours who are troubled by dazzle effects caused by solar panels.

Running field tests has also shown that cleaning modules incorporating textured glass is unproblematic and no more or less inconvenient than cleaning smooth test models. A significant benefit of this kind of surface, which is given to the glass by textured metal rollers, is that it is especially long lived. An anti-reflective coating (ARC) is either sprayed or rolled onto the glass, positioned via a vacuum process or, occasionally, etched on. Scientists are already researching ways to combine deeply textured glass and ARCs. The future of solar glass lies in deeply textured glass surfaces with added ARC. The first laboratory tests have been successful, and it is expected that the technology will be ready for mass production within the next few years.

Model calculation

Base: 150W/m^2

Assumption: 7% relative surplus production at 750kWh/kWp because of non-ideal installation conditions = +7.9kWh (annually)

Result: +€2.15/m^2 per year; over a 20-year lifespan = +€43.00/m^2

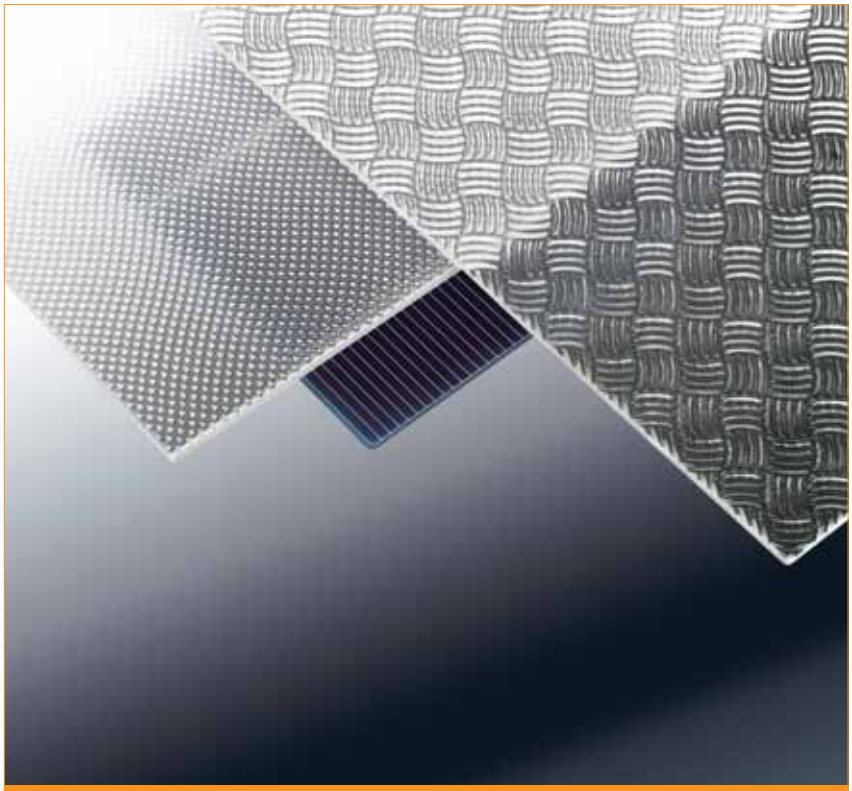

Figure 3. The French manufacturer Saint Gobain Solar is the current leader in the production of deeply textured solar glass. The unique front glasses have textured shapes of either pyramids or waves.

Textured front glasses: functional and aesthetic benefits

The benefits of third-generation solar glass can be classified into two groups. On the one hand, there are the functional benefits, which lead to increased efficiency and therefore to higher output for the system operators; on the other hand, there are the visual benefits, although these are of secondary importance. Alongside increases in efficiency of more than 7%, and even more in unfavourable alignments, temperature effects and a longer lifespan also lead to increased functionality of textured front glass. Initial market research surveys have shown that specialists and customers notice other, incidental benefits in the improved surface structure, which allow these modules to be used in niche markets. The aspects of decreased dazzle effects and recognition value of the modules were barely even touched upon.

These examples show that there are still neglected niche markets and room for product optimization that manufacturers

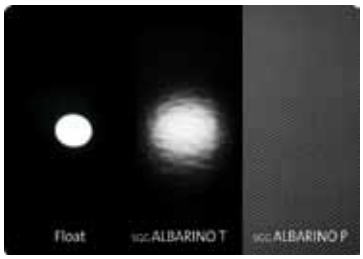

Figure 4. The non-reflective effect is evident when making a direct comparison of regular float glass (left), structured glass (centre) and deeply textured glass (right).

could take advantage of. In view of the decreasing cost-reduction potentials of solar modules in general, manufacturers can secure new market shares through a differentiation in individual product components while simultaneously optimizing output levels. The use of functional front glasses is particularly appealing in the premium sector, which is starting to show the first signs of saturation. The efficiency-heightening benefits of third-generation solar glass provide a special marketing feature for this sector. Alongside Germany, the French sales markets, which are specialized in building integrated PV, as well as the less sunny regions in the UK and Scandinavia, where its optimal usage of indirect light would come into effect, could also benefit greatly from the use of textured solar glass. Nevertheless, Spanish and Italian installations can also benefit from improved performance by using textured glass fronts.

Readers and subscribers can download the entire solar glass white paper in the 'Technical Papers' section of the PVTech.org website, or directly via EuPD Research.

Technological terminology

First-generation solar glass: this category includes high-purity, non-reflective front glasses with a strongly reduced iron content. A reduction of light-absorbing iron-oxide compounds results in an extra-white glass that reflects 4% of the light reaching it.

Second-generation solar glass: this includes bright-white non-reflective front glasses, with an ARC. The light flow-rate is increased, and the light reflection is decreased, although 2.5% of the light is still reflected.

Third-generation solar glass: this glass not only has a low iron content and an improved light flow-rate, but also creates a 'light-trapping' effect because of a textured surface which is either pyramid or wave shaped – the geometric refraction of the light means that more of it is trapped inside the module.

Rolled glass: the most important types of flat glass are rolled and float glass. Rolled glass, also known as cast glass, is rolled while it is still molten, and is generally slightly 'purer', contains less iron and is therefore whiter. This flat glass is more suitable for photovoltaic applications.

Float glass: instead of being rolled like rolled glass, float glass is pulled while it is still slightly liquid and then 'floated' in a bath of tin. Because of the low material embedding, float glass is a little clearer, but slightly more reflective. However, it is still suitable for photovoltaic applications.

Light-trapping effect: this effect is based on the reduction of reflection and the geometric enclosure of the light through repeated refraction. More light is directed into the glass through the surface treatment, while the refraction of the light directs it into the module. This way, up to 10% more light can be trapped inside the module, depending on the alignment and installation site.

About the Author

Daniel Pohl graduated with an M.A. in North American studies, literature and political science from the University of Bonn and Paris-Sorbonne University. He has been working as an editor and media consultant in the field of economics and renewable energies, and is currently head of the corporate communications department at EuPD Research and 360Consult in Bonn. Throughout his career he has published numerous articles on diverse energy topics in national and international special interest magazines. Aside from that he has worked for national newspapers as well as broadcasting stations and a TV production company.

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