Glass for photovoltaics – a promising material for the future

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ABSTRACT

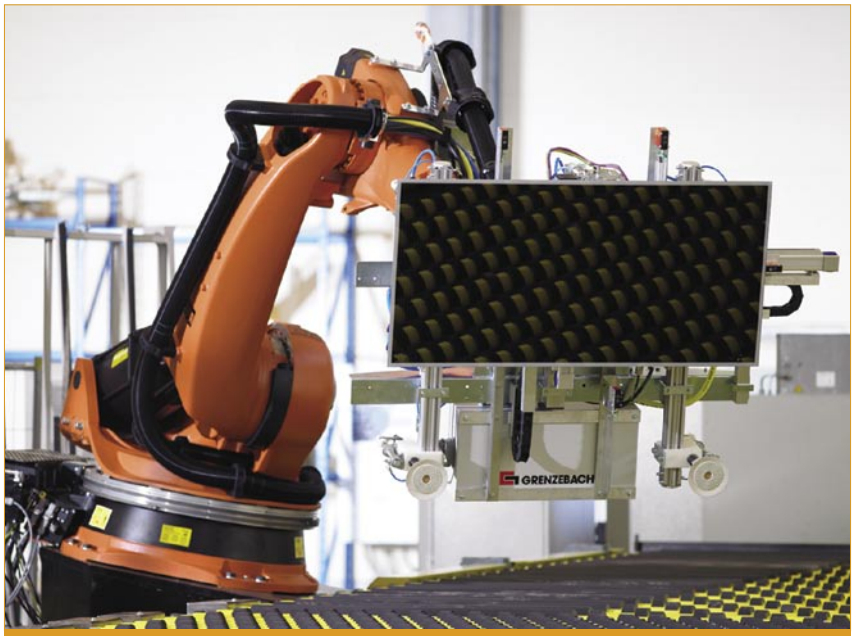
Glass plays an increasingly important role in photovoltaics. The rising demand for solar modules is pushing the glass industry to the fore. As a result, mechanical engineering companies around the world are working to meet the demands of the solar industry, with the tremendous potential of glass, especially in the thin-film sector, at the epicentre of this effort. This paper presents the beneficial properties of glass for use in the photovoltaics industry, and its potential for future applications.

Introduction

No matter where the source of their supplies, be it the United States, Europe, China or Australia, module manufacturers have had to face the same problem again and again. A considerable percentage of solar glass orders arrive unfit for production and can be classed only as waste. This waste glass would either have been shipped in defective packaging or damaged by humidity penetrating during intermediate storage, which can lead to surface corrosion, rendering the material incapable of being processed. In other cases, edges can be faulty, thickness or other dimensional tolerances agreed on with suppliers are off the mark. As experts are aware, this scenario is most common in cases where open-top containers are used. Waste quotas can reach 10% or higher quite often. Delivery problems can be a major factor in thwarting planning schedules of quite a number of companies. One of the main reasons behind these difficulties is that some parts of the international glass-making industry have not yet properly taken up the demands of the sector. But change appears to be on its way.

Much needed high-quality properties

Solar glass is indispensable both as a carrier material for thin layers of semiconductors and to cover modules. Glass of optimum quality, which is very much in demand, should have high transparency values, be break-resistant and should also readily accept anti-



Courtesy: Grenzebach Maschinenbau GmbH.

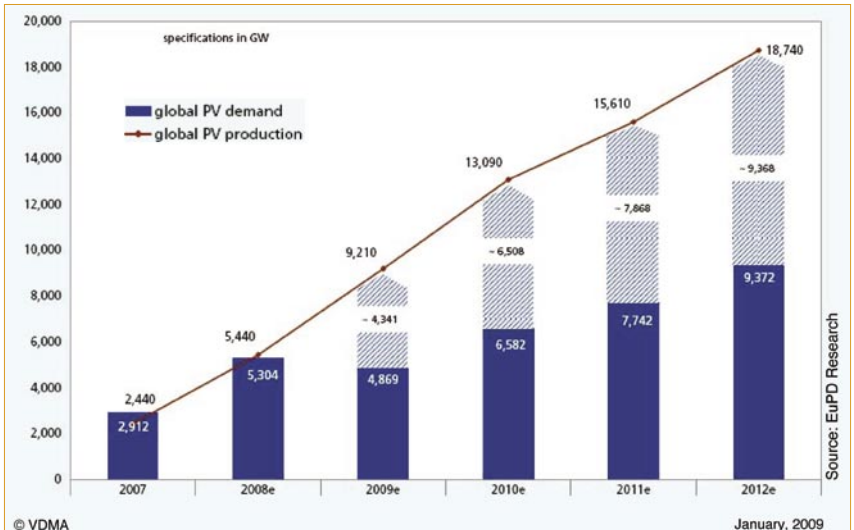
Figure 1. Robotic devices developed by Grenzebach, the German glass machinery manufacturer, take over contactless manufacturing of thin-film modules.

reflection blooming coatings. High-quality glass should be as thin and as cheap as possible and, very importantly, accurate to size. The international glass industry has so far not lived up to all of these challenges. A considerable number of glass manufacturers have viewed solar glass as a marginal phenomenon, at least until now. The main reason for this is the relatively small amount of glass being taken up by the photovoltaics sector to date.

Glass used in the PV industry is referred to as sheet glass, which may be produced using two different processes. For the so-called float glass process, red-hot and semi-liquid molten glass is poured on a bed of liquid tin, a process that is carefully controlled. Initially, glass will float on the tin surface like a thin layer, after which its temperature will be reduced with as little stress as possible. This type of manufacturing is used to make some 95% of sheet glass produced all over the world. Alternatively, rolled sheet glass is the result of glass being put through a series of rollers, which process the viscous mass and produce the desired shapes and dimensions.

Demand for solar glass

It would be quite a challenge to quote exact figures for the percentage of sheet glass taken up by the photovoltaic industry out of the total of about 45 million tons produced annually. Expert circles of the glass-making industry put that proportion at about 1%, leading us to believe that some 450,000 tons of sheet glass are used to make photovoltaic devices annually. Considering the total volume of the international glass-making industry, this is a fairly small percentage. Continuous glass-making units measuring several hundreds of metres in length are capable of making several hundred tons a day without running into any problems.



Courtesy: Grenzebach Maschinenbau GmbH.

Figure 2. Global PV demand vs. PV production and resulting oversupply.

The recent strong increase in demand for solar modules, which in turn involves more demand for solar glass, however, has produced a different approach in at least some parts of the glass-making industries. Glass manufacturers expect strong growth not only for silicon wafer-based modules, but also in regard to the thin-film sector and its wide-ranging applications for the future. Nevertheless, it is open to speculation how high growth rates will eventually become. Estimates put the growth for thin-film cells at far above 50%. As far as the entire photovoltaics sector is concerned, there are experts who predict a market volume considerably above 40GW in 2012, requiring a close to tenfold increase in the amount of glass currently being used in the industry.

New float glass works for Germany

In order to help meet these future needs, Interpane, a German glass maker and finisher, and the Scheuten group from the Netherlands have launched a joint venture to set up a new float glass plant in Germany. The float glass-making section of the f I glass GmbH, to be commissioned in August 2009 by the two companies, will produce 700 tons a day. In addition to making base glass (float glass), the two companies will focus especially on the production of dedicated solar products, required in solar industry applications. Interpane AG, which will hold 49% of this joint venture, already operates one of Europe's largest float-glass operations in France. Both companies are also involved in the solar sector. A company spokesman for Interpane said that this investment had been made "with a view to the photovoltaics sector".

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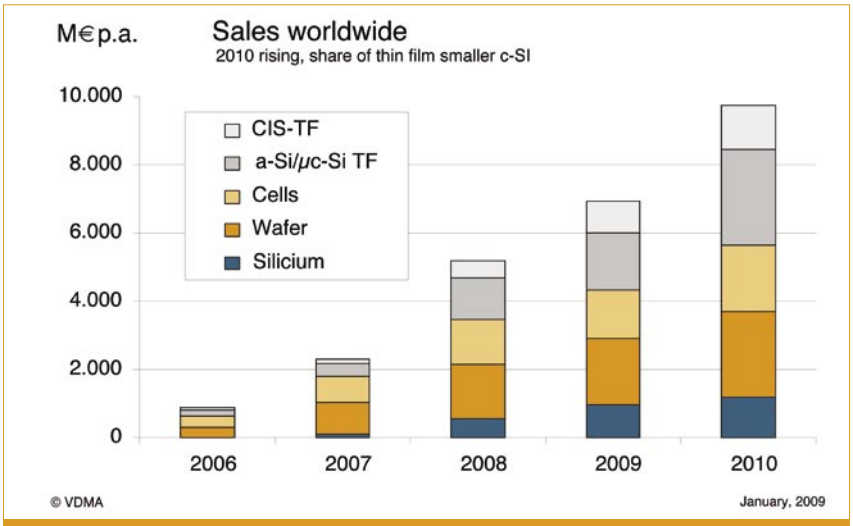
Glass offers tremendous potential to the whole of the photovoltaics industry, particularly the thin-film sectors. The decisive criterion of light transmission is being increased all the time. Standard sheet glass panes, still in use today, for the most part consist of silicate glass with light transmission ratios ranging from only 85 to 88%. This is brought about by a high percentage of iron. People are therefore using more and more low-iron glass with light transmission ratios of up to 91%. This changeover from silicate glass – so-called 'green' float glass – to the 'lighter' low-iron float glass results in an increase in solar module efficiency



Source: LBBW.

Figure 3. Worldwide sales of materials used in the PV industry.

of about 2%. The latest available layer technologies may bring up light transmission by another 5%. Values up to 99% have been reached in laboratories.

Thin-film modules' structures

Demand for glass is not only increased via growth in the wafer-based field, but also by advances in the production of thin-film modules. There are already over one hundred companies employing this technology, with others just waiting to begin. Thin-film technology offers one decisive advantage over traditional modules based on silicon wafers: both cells and modules may be mass-produced on completely automated machinery. The structure of the modules is similar to that of laminated glass, in that they are made of two layers of glass put together. Simplifying matters to some extent, one might say that there is no organic substance but solar cells between these layers, as is the case with laminated glass.

German glass machinery builders realised the advantages of this new technology quite early. They modified their manufacturing technology to facilitate its use for the completely automated mass production of thin-film solar modules. 'Turnkey' solutions, which combine complete production lines and services from one supplier, are also on the market. Lenhardt Maschinenbau GmbH, a German glass machinery manufacturer affiliated to the Bystronic group, was the first company in the world to develop a laminate-free thin-film module as well as the technologies required for industrial mass production. Investors from all over the world are showing great interest.

Case studies: successful German companies

The German Engineering Federation (VDMA), Europe's largest industrial association, represents engineering companies based in Germany, serving the interests of over 80% of the German glass machinery industry. Two years ago, this organisation set up a working group for photovoltaics and solar thermal energy, as well as a body whose charter was to investigate the manufacture of photovoltaics tools. Both groupings wish to bring together the branches involved in this manufacturing chain to realise greater benefits from synergies.

Grenzebach, a German glass machine maker, developed plant and machinery encompassing all processing steps for manufacturing thin-film solar modules, irrespective of which type of solar cells make up the module in question. Such machines carry both the substrate and the glass cover along the whole processing line,

Courtesy: Interpane.

Figure 4. Sheet glass used for solar cells is manufactured on several float glass units, each of which is one hundred metres long.

starting with sheet glass and ending up with the finished module. The advantage in this case is that separate processes were 'tied' together. The owner of this particular project developed his own machinery for processes such as cutting and breaking glass, storing, packaging and laminating, as well as quality control. The VDMA also provided the manufacturing execution system (MES), a control unit, representing the central element of this entire plant and an essential element for module quality and material throughput. As Mr. Egbert Wenninger, a member of the board of Grenzebach puts it: "Our technology is behind one hundred per cent hands-off mass-manufacturing of thin-film modules."

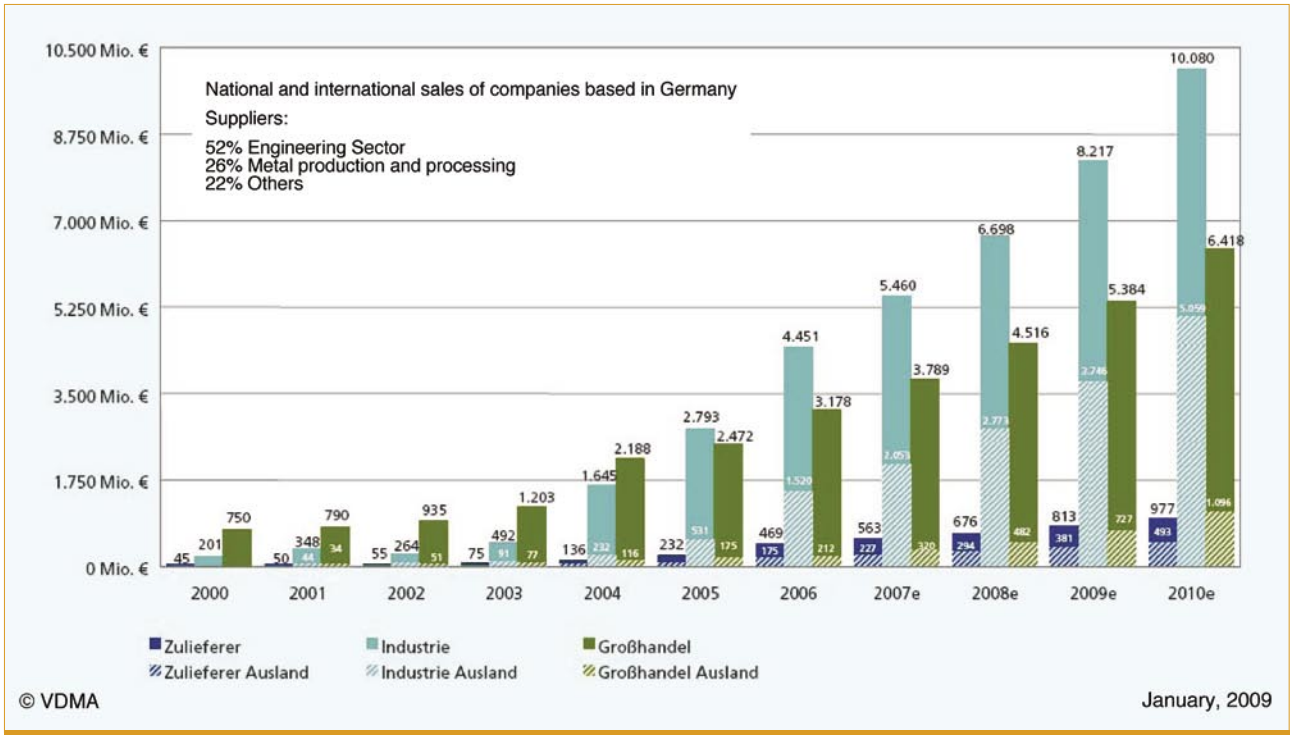
The decisive factor – cost per watt installed

Efficiency of thin-film modules currently ranks below that of silicon wafer-based modules. However, the deciding factor in this issue is not efficiency, but the cost per watt installed. At present, the price ranges between €5 and €8 for thin-film units. Mr. Wenninger of Grenzebach feels that by next year the market will see the first modules breaking through the magic €1 barrier. This would mean that electricity generated by thin-film cells would come at the same price as that generated by conventional power stations.

According to Wenninger, applications need not be confined to solar farms. "Why," he asks, "should people go to so much effort and plaster houses at great expense, if façades could also be covered with large solar modules, providing heat insulation at the same time?" If pre-fabricated solar modules were able to serve this purpose and generate energy, it would eliminate the sense in roofs being covered with tiles or other conventional materials. The plunge into solar energy, taken three years ago, is paying off for Grenzebach. By now, its share of business in this sector is already larger than for companies involved in traditional glass machinery making. The story reads the same for quite a few others, judging from data taken from approximately 80 glass machine manufacturers based in Germany. Following VDMA data, by now over half of them are involved in the photovoltaics and solar energy sectors. They established lines of cooperation and for many of these companies this new line of business has already grown into a major second line of business.

Development of the first non-laminated thin-film module

The Grenzebach company is not alone among German glass machinery makers in its recognition of a market holding tremendous potential for photovoltaic elements integrated into buildings. At present, its share of the entire photovoltaics market stands at less than 2%, but this figure is expected to rise with the blossoming of the thin-film sector. Significant growth rates are anticipated not only in Germany but also in the United States, Asia, France, Italy and Great Britain.



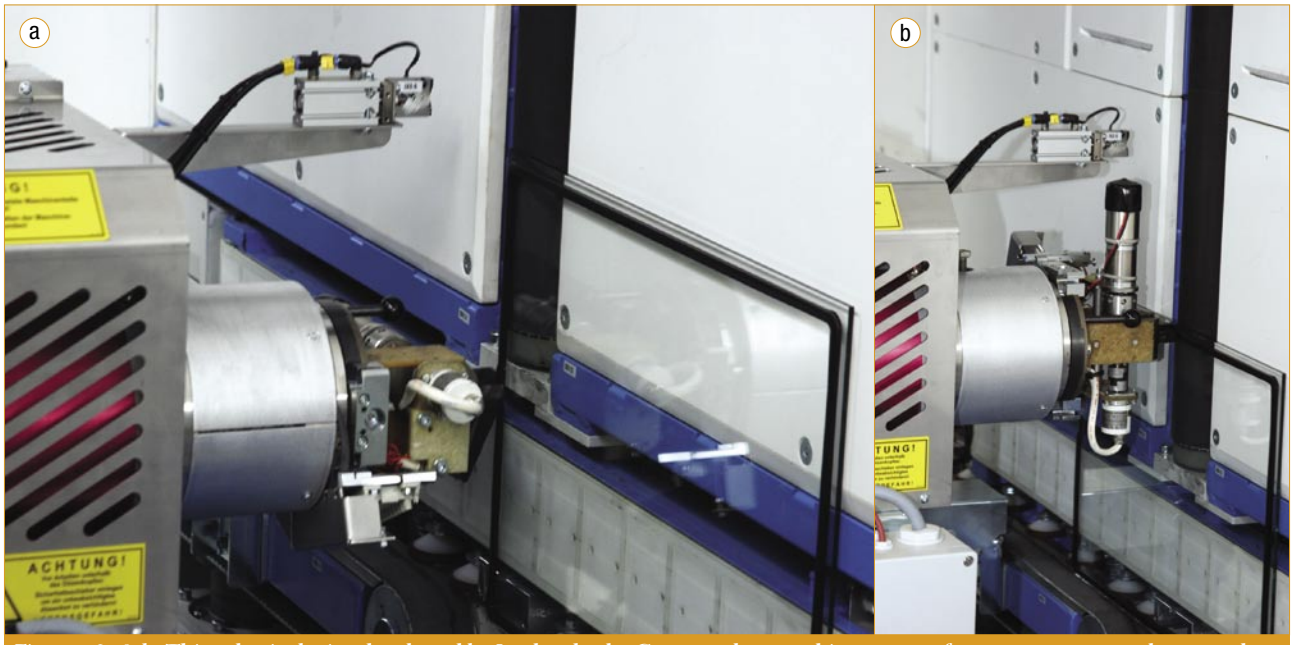
Source: EuPD Research, ifo.

Figure 5. National and international sales of Germany-based companies (2000 to 2010).

Mr. Siegfried Glaser, head of VDMA's photovoltaics/solar energy working group, is convinced "that it will not take very long and solar modules shall have become some totally normal features integrated into structures. This will come at a price acceptable to ordinary people building their own homes." Following Glaser, this idea of integrating modules into buildings brings out the specific advantages of the thin-film technology. Not only will modules generate energy, but they can also act as elements of multi-use glasses and glass systems for façades, roofs and facings for buildings. Additional design functions may be provided, such as safety and sound insulation, protection against the sun and heat, as well as controlled opacity and shading. Mr. Glaser adds: "The sky is the limit when it comes to sizes, shapes and colours."

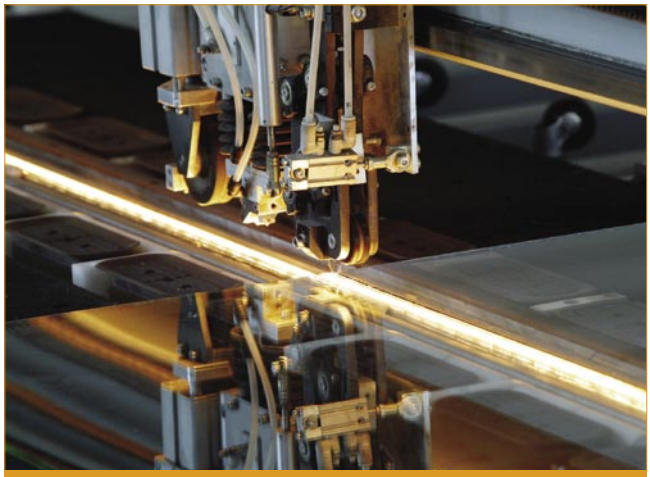
Representatives of Lenhardt, a German glass machinery manufacturer, also refer to the considerable potential offered by glass materials for thin-film technologies. This medium-sized company not only provided a completely new product when it offered the first laminate-free thin-film module, but it also put on the market ready-to-apply newly developed industrial manufacturing technologies that were much needed.

The production process is essentially the same as that for standard insulating glass, a product that is made all over the world in large quantities and in cycles spanning a few seconds. A glass pane, holding a thin-film cell of any possible type, is positioned on a conveyor to be moved towards a robotic device. This unit sprays a layer of thermoplastic starch (TPS) along the outer margins demarcating the solar cells. The two bus bars that will carry electricity from the cell later are then inserted, reaching the



Courtesy: Lenhardt.

Figures 6a & b. This robotic device developed by Lenhardt, the German glass machinery manufacturer, represents the central element of its unit to manufacture laminate-free thin-film modules. The device sprays a plastic material around the cells positioned on a glass substrate. The photo does not show solar cells.



Courtesy: Interpane.

Figure 7. Solar glass also needs high-quality edges. Robotic devices operate at speed, guaranteeing precision.

outside through a layer of TPS. In order to coat the bus bars on the plastic layer, the robotic device sprays another thin layer of plastic on the one already in place. Afterwards, a second panel is placed on top under high pressure. An inert gas such as argon fills any intermediate spaces. A socket is then inserted in this intermediate space. Alternatively, the bus bars can be shrunk into the plugs. Silicone then seals the module at its edges. Afterwards, the thin-film module is ready for use. "And," as Mr. Bernhard Schmidt, a manager of the Lenhardt company states, "it will be fully leak-proof".

Conclusion: modules manufactured in seconds

There is no longer any need for time-consuming and costly laminating procedures fusing solar cells embedded in very thin plastic coatings with a carrier material. This significantly reduces manufacturing cost. Mr. Schmidt adds: "Adapted glass making technology also guarantees the manufacture of king-size modules in a matter of seconds." Up until recently, several minutes were needed. Another positive feature is that machines operate vertically – the module-in-making is not lying on a conveyor, but it is held in an upright position inclined through six degrees. Schmidt sums up as follows: "Given that glass making technology allows for two-by-three metre modules, the factory may be significantly downsized."

About the Author

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