

# THE FUTURE OF QUALITY INSULATION GLASS IS MULTIFUNCTIONAL - ENHANCING GLASS PROPERTIES

Several years ago the question was asked whether triple-glazing might also be an unrivalled option on large surfaces. Since then it has become the most common standard in quality insulation glass. But is there really no alternative?

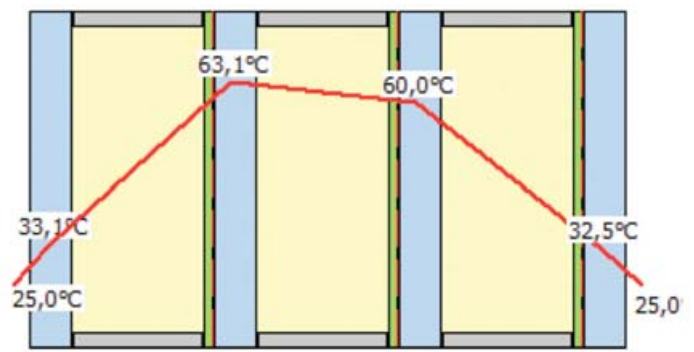
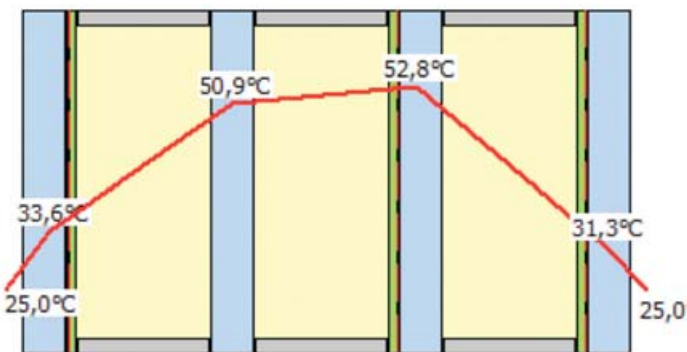
Requirements on quality insulation glass are continually rising, particularly in legislation. Moreover, the manufacturing industry is increasingly faced with the issue of multifunctionality, i.e. the need to create smart window and façade glass which can preserve heat,

use solar radiation, insulate sound and warrant security. Says Albert Schweitzer, sales manager at arcon Flachglas-Veredlung GmbH in Feuchtwangen: "In insulation glass with standard triple glazing and low-emission layers, a  $U_g$  value of  $0.5 \text{ W/(m}^2\text{K)}$  must be seen as the end of the story – for the time being, at any rate."

## CURRENT STATE-OF-THE-ART

The current standard is a 4/4/4 design, filled with argon gas and with  $U_g$  values of  $0.5$  to  $0.6 \text{ W/}$

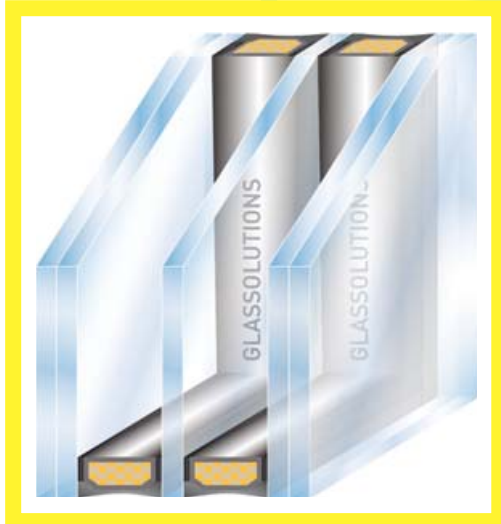
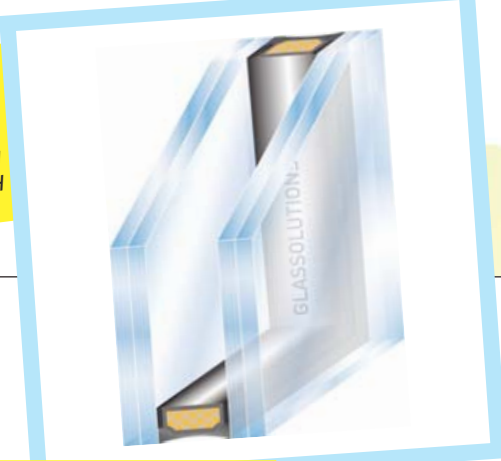
Is there any way to enhance the technical properties of contemporary quality insulation glass, i.e. its  $U_g$  value, light transmission and sound absorption? Several major forums are currently discussing the limits of feasibility and realism. The good news is that there is no shortage of ideas. But what will prove to be feasible in the future?



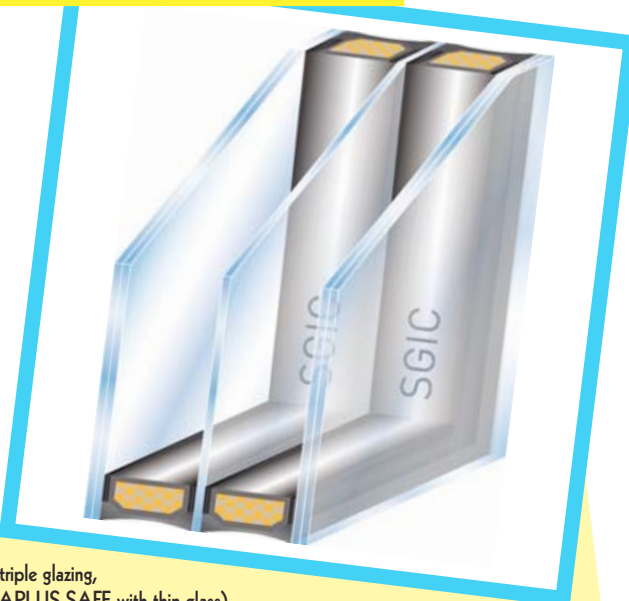
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Depending on the position of the coating, multiple glazing panes are exposed to considerable temperature differences. This usually requires prestressed glass.

Soundproof double glazing,  
SGG CLIMAPLUS SAFE (each  
with 4 mm basic glass)  
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Soundproof triple glazing,  
SGG CLIMAPLUS  
SAFE (each with 4 mm  
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Soundproof triple glazing,  
SGG CLIMAPLUS SAFE with thin glass)  
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Soundproof double  
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(m<sup>2</sup>K). Some manufacturers use krypton for the space between the glazing layers, an inert gas which, according to their data sheets, has a Ug value of 0.4 W/(m<sup>2</sup>K). These are certainly the best values that can be achieved at the moment.

Yet another crucial point in triple glazing has always been its substantial weight of 30 kg/m<sup>2</sup> and the resulting problems in transportation and installation. It's a problem which has been highlighted by window manufacturers for quite a while. So what might be possible solutions?

### VACUUM WINDOWS

Vacuum insulation glass (VIG) with its low E-coating and Ug values of 0.3 W/(m<sup>2</sup>K) has been under discussion for many years now as a smart, lightweight alternative, although it is still not available as a marketable product. Weighing about 50 per cent less than triple glazing, such insulation glass was clearly in the lead. Various research teams – also in Germany and Switzerland – were given the task of eliminating the blatant weakness of the glass, e.g. in the edge seal of VIG, and of paving the way for mass production. The VIG project ran from 2004 to 2006. Another project, entitled Production Engineering for Vacuum-Insulated Glass (ProVIG) ran from 2007 to 2011, sponsored by the

German Ministry for Economic Affairs and Energy. The final report has now been available since January 2012. Next, a research project called Winsmart was launched in August 2012, sponsored by the EU with EUR 3.8 million. It is designed to look at all the various multifunctionality aspects of VIG. The results have been impressive, and the project is due to be completed in September 2016.

We do of course need to remind ourselves that vacuum insulation glass has been made and used in Japan (Pilkington) and China (Synergy) for quite a while. Unfortunately, however, such glass has been relatively short-lived until now. Twenty-five years should really be the minimum. One reason has been the inflexible edge seal which was unable to compensate for thermal strain. Since then the Chinese and Japanese have achieved improvements and created an edge seal in parallel with the glass surface and consisting of thin, outwardly protruding sheet metal. This seal is tightly bonded to the glass. The valve is situated in a hole in the VG unit. The filler gas is either argon or krypton, and the outer window pane is a low-E glass. The Chinese company Synergy is currently advertising for its products with a total thickness of 6.2 millimetres and a Ug value of 0.3



# MEM4WIN

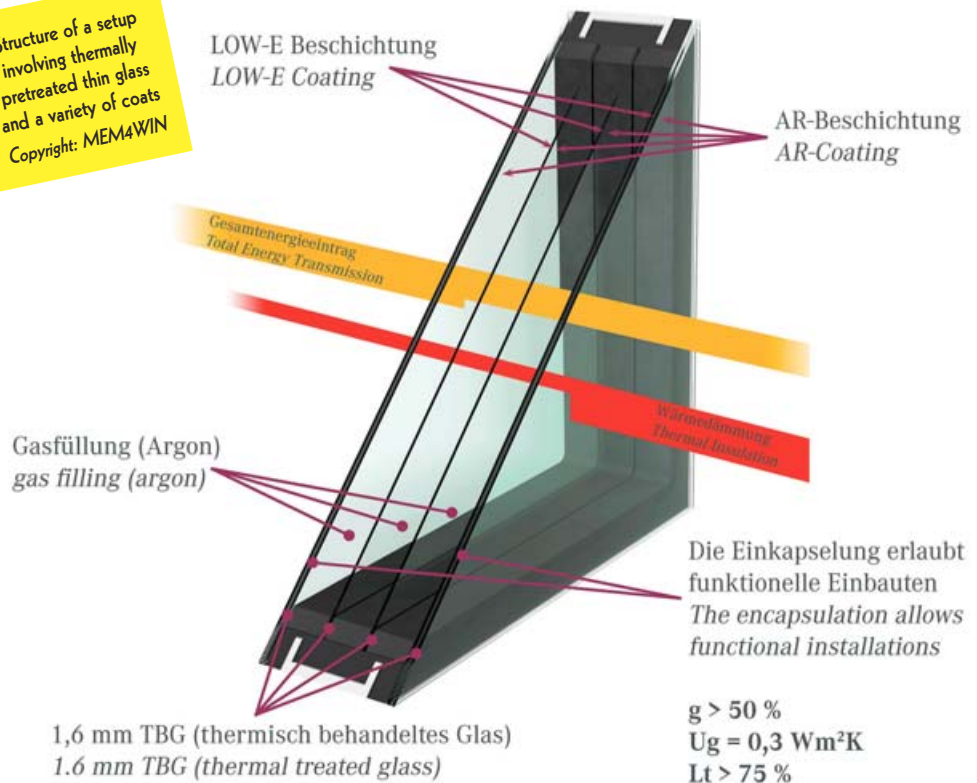
ADVANCED TECHNOLOGIES FOR SMART WINDOWS

W/(m<sup>2</sup>K). East Asian manufacturers even speak of dimensions up to 2.8 x 1.8 metres.

By now there are also quite a few manufacturers with vacuum façade panels in their product ranges – clearly a sign that lightweight construction is greatly valued in the building industry. Private customers and DIY home-builders, on the other hand, have far less choice in terms of suppliers. In Europe lean VIG panels – made, for instance, by Pilkington – are largely used for the restoration of listed buildings. It means that the general historic impression can be preserved while using the original profiles.

So why has this product still not gained widespread

Structure of a setup involving thermally pretreated thin glass and a variety of coats  
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Temperature gradation with conventional metal spacer: highly distinctive thermal bridges.



Window with thermal insulating spacer: less thermal bridges and therefore balanced temperature distribution even to the edges of the surface.

Audi Academy, Ingolstadt. The façade of the building was given two types of sun-protection glass. The ground floor has INFRASTOP® Brillant 70/35, a glass with excellent 70% translucence for optimum lighting in the ground floor rooms. On the upper floors the architects decided on sun-protection glass – INFRASTOP® Brillant 50/25. As well as featuring a low level of total energy transmittance (25%), this glass type also persuaded the architects with its good visual impact.

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Bonneshof Office Center, Düsseldorf-Golzheim: The pleated effect that characterises the shapes of the office buildings T.O.C. and B.O.C. creates a differentiated outside structure. On the original building the graphite-black façades were given special emphasis by some blue glass circles and, to provide a contrast, another building was panelled with reflective silvery balustrades. This theme was then varied in the new B.O.C. building.



Bonneshof Office Center, Düsseldorf-Golzheim - The transparent structure was given an additional glass shell. Depending on the direction and the interior, the architects used black "photovoltaic panes" and "climate panes" with white print for the secondary façades of the B.O.C. Not only does this produce less heat, but it also creates a pleasant, variable lighting ambience within the building.

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New building created by the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (German Society for National Cooperation, GIZ) in Eschborn: The room-high glazing of the flat façades involves the use of impact-proof glass from FLACHGLAS Wemberg. It is a soundproof type of glass, called PHONSTOP® 35/44L. As well as fulfilling its function of being impact-proof (outer pane, VSG), the structure of the glass has good sound insulation values (44 dB) and has impressed both the owner and the architects with its  $U_g$  value of  $1.1W/m^2 K$ , as it meets the required thermal insulation values.

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The general principle can be illustrated by the INFRASTOP® III Brillant 45/24 with its sun-protection coating whose outer pane strongly reflects the infrared radiation of the sun. Any loss in heating energy is substantially reduced by the thermal insulation coating of the inner pane. Both effects are enhanced by the spaces between the panes, which are filled with inert gas.

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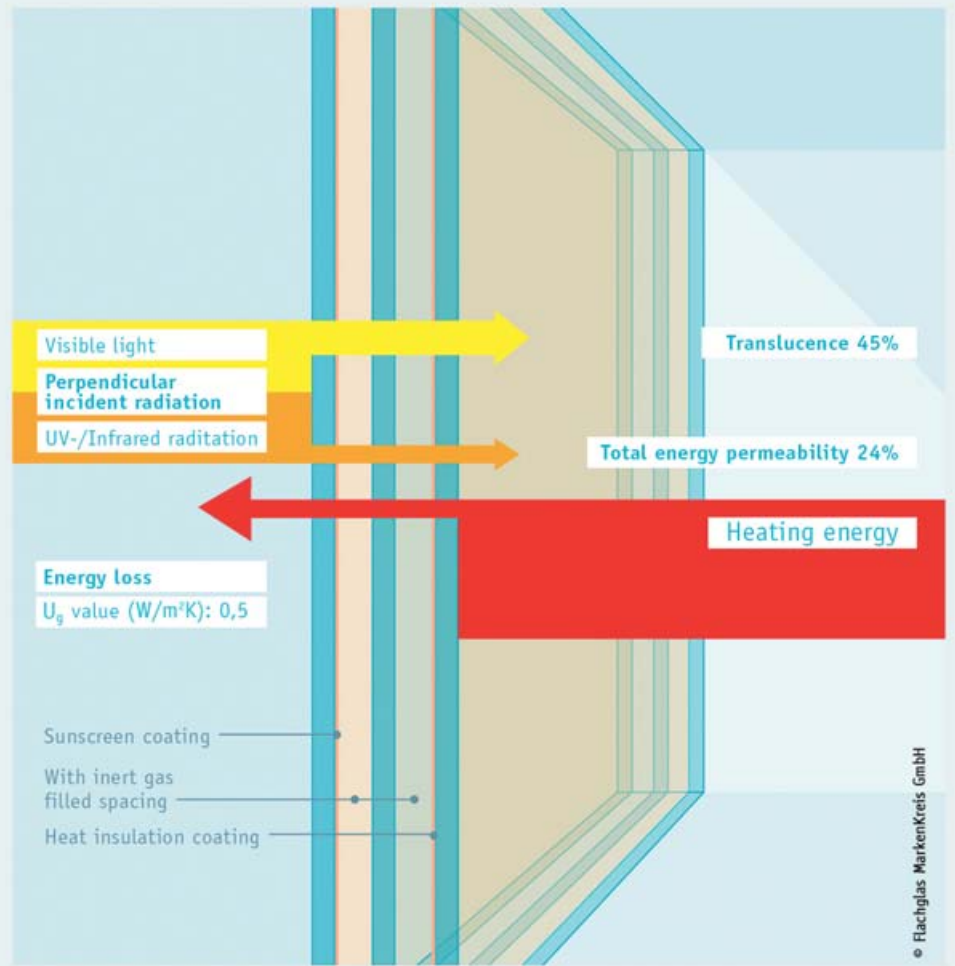
ad acceptance? The issue has been under discussion in the industry since 2001, and research is still taking place. This shows the complexity of the underlying technologies and the obstacles that need to be overcome. The Winsmart research project, which is still in progress, is seeking to solve the problem of the edge seal through the use of tin. A liquid tin alloy is injected into the edge area between the panes. To create a tight glass-tin seal, the frame is briefly exposed to a suitable electric current.

Moreover, the Winsmart project also seeks to ensure multifunctionality.

Nevertheless, there are still doubts about the marketability of VIG. The valve may start leaking, and both the valve and the metallic spacers between the panes are seen by many as vulnerable and visually distracting. Should efforts finally succeed in eliminating all the drawbacks, then it is still in the balance whether a mass product might actually be financially viable. Even Winsmart is assuming that the development will take 5 to 10 years.

This principle can be illustrated with THERMOPLUS® III S3 where the heat transfer is effectively reduced by two heat-insulating coats of precious metal and two spaces between panes, filled with inert gas. Further heat is obtained from the sunlight.

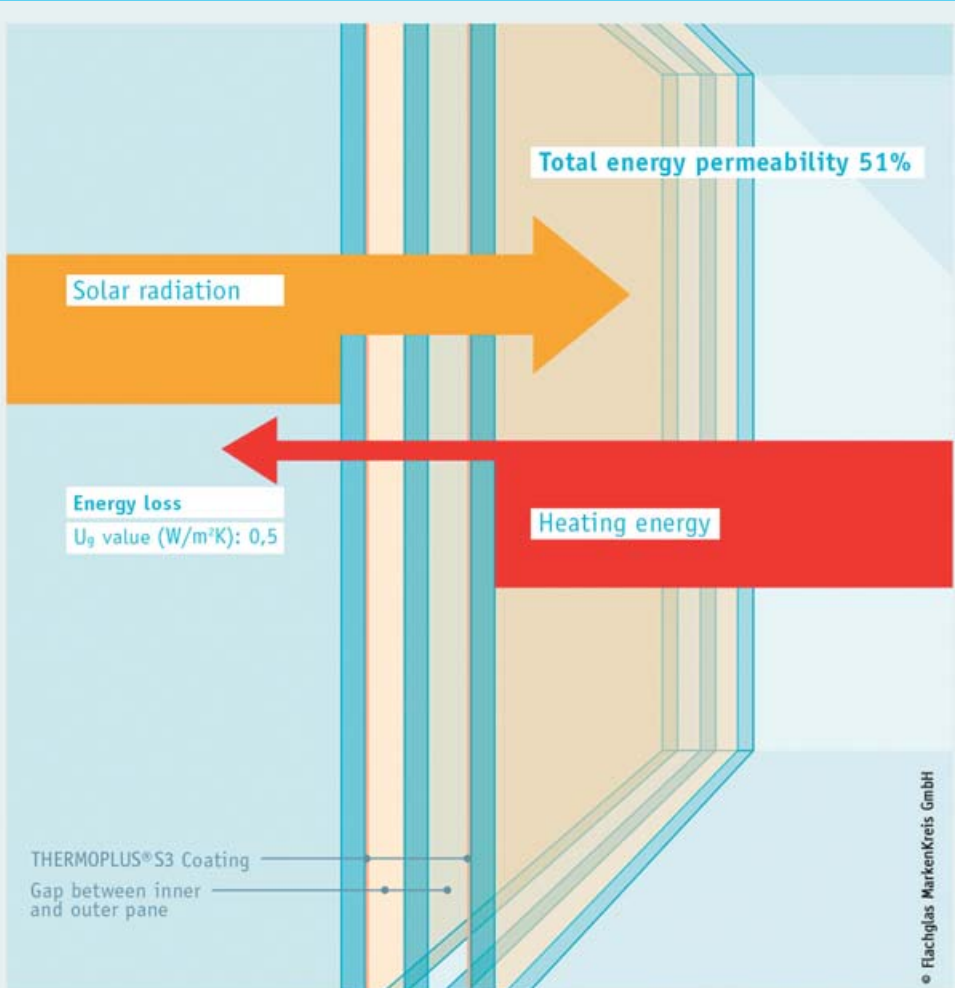
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INFRASTOP® III 45/24

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THERMOPLUS® III S3

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Casement with double glazing and Super Spacer® hot edge spacer from edgetech Europe GmbH  
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Double glazing with Super Spacer® hot spacer from edgetech Europe GmbH  
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before required from case to case, weighing the pros and cons. On the one hand quadruple glazing has somewhat better thermal insulation, while on the other hand it has values around 0.4 W/(m<sup>2</sup>K), which is clearly below those in triple glazing. So there is no clear answer.”

To obtain genuine benefits, the new quadruple glazing apparently requires new techniques and products, e.g. pre-stressed thin glass, anti-reflexive coatings or indeed pressure compensation. “The solution is obviously neither quadruple glazing nor indeed triple-glazing with an extra pane,” Feldmeier continues.

The fact is that quadruple glazing is already available on the market, as SGT GmbH in Tauberbischofsheim has develo-

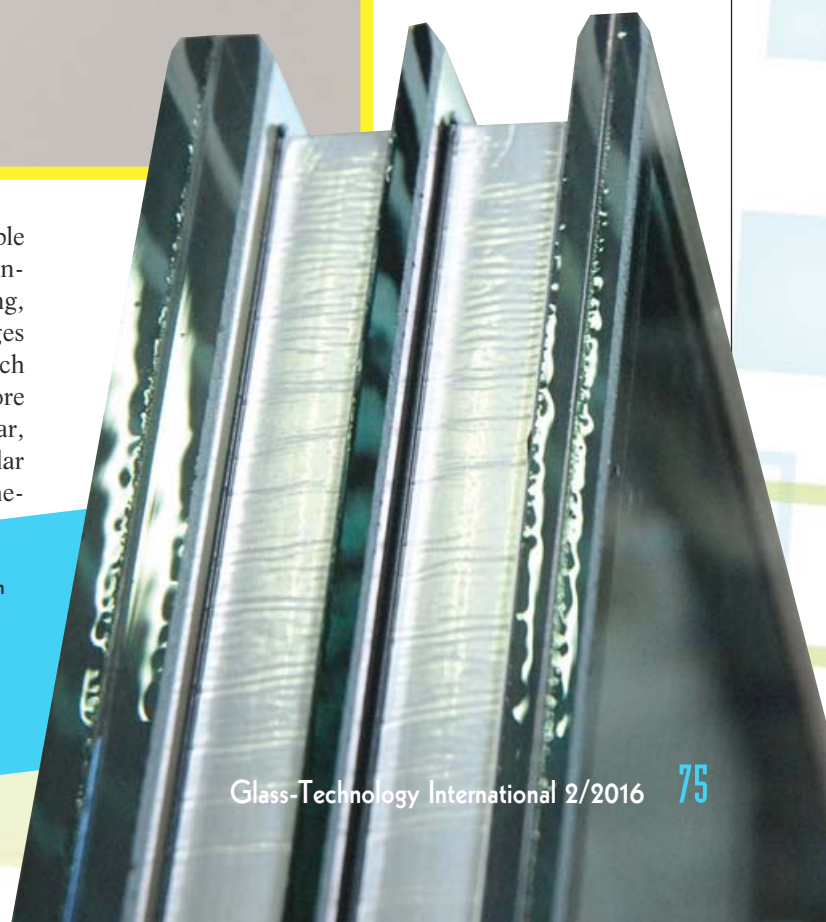
ars (from 2012) before the project is of a sufficiently high quality in all aspects, so that it can then become standard.

### QUADRUPLE GLAZING – A STEP IN THE RIGHT DIRECTION?

Prof. Franz Feldmeier from the University of Rosenheim says: “This is actually the question we

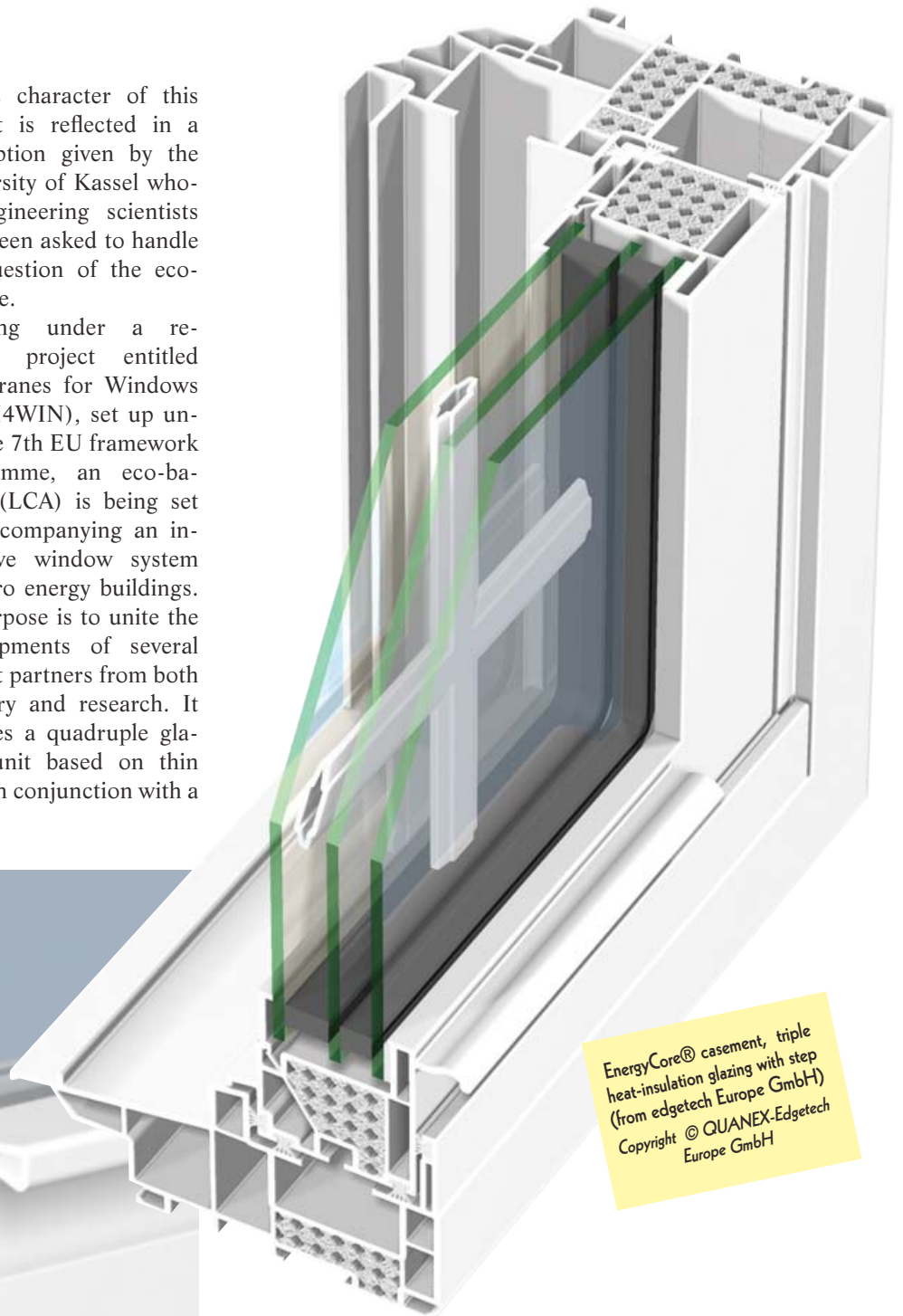
asked ourselves with triple glazing, which is now standard. Quadruple glazing, too, has its advantages and disadvantages, such as thicker edge seals, more weight and, in particular, less daylight and less solar energy. A decision is the-

Triple heat-insulation glazing with Super Spacer® hot spacer from edgetech Europe GmbH  
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ped a quadruple glazing product based on thin glass. And the technical specifications are impressive: with a structure of 2/2/2/2, 12-millimetre spaces and a  $U_g$  value of  $0.3 \text{ W}/(\text{m}^2\text{K})$ , its total weight is no more than  $20 \text{ kg}/\text{m}^3$ . Critics, however, fear that more glass, more frames and more fittings will primarily mean higher production costs and thus a poorer energy balance for the entire product, so that its excellent  $U_g$  values are then rendered irrelevant. The industry is set to accept this further responsibility. Helped by EU sponsorship funds, it launched a research project in early October 2015. The am-

bitious character of this project is reflected in a description given by the University of Kassel whose engineering scientists have been asked to handle the question of the eco-balance. Working under a research project entitled Membranes for Windows (MEM4WIN), set up under the 7th EU framework programme, an eco-balance (LCA) is being set up, accompanying an innovative window system for zero energy buildings. Its purpose is to unite the developments of several project partners from both industry and research. It involves a quadruple glazing unit based on thin glass in conjunction with a



Sash door with heat-insulation glazing and Super Spacer® hot spacer from edgetech Europe GmbH  
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EnergyCore® casement, triple heat-insulation glazing with step (from edgetech Europe GmbH)  
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shading and light control system made from micromirrors (so-called active windows, INA, University of Kassel) as well as segments using organic photovoltaics, a solar thermal setup and organic light diodes (OLED)."

Ultra-thin glass here means thermally pre-treated thin glass with a thickness of 1.6 millimetres – the same type of glass that is used on a smart phone. Unlike 4-millimetre



Super Spacer Triples Clean Corners.jpg: Triple glazing with Super Spacer® hot spacer from edgetech Europe GmbH

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1) Interview in Glaswelt magazine, October 2015

2) Presentation: "Drei sind nicht genug – kommt die Vierscheibenverglasung?" ("Three isn't enough – will we have quadruple glazing?"), Glasbau (Glass Engineering) convention in Dresden, 2015

float glass, it is very light – weighing only 15 kg/m<sup>2</sup> – while also being strong, highly elastic and requiring very few resources. Also, manufacturing costs are apparently 15 per cent lower, and CO<sub>2</sub> emissions 45 per cent less than with similar insulation glass. Here, too, the aim is to reach a U<sub>g</sub> value of 0.3 W/(m<sup>2</sup>K). The opening casement will no longer have a frame. The fittings of the casement are embedded within the insulated edge seal.

In this research project all four panes have single-sided AR coating, and the two inner panes and insides of the outer panes, on the other hand, have low E-coating. The spaces between the panes will be filled with argon. What

makes this window a smart window – i.e. a window with its own electric power supply – is the photovoltaic cells printed on it by means of an inkjet printer. This is required to light up the integrated OLEDs, so that the entire surface – which functions as a window during daylight hours – turns into large-scale lighting after dark. The University of Kassel contributes mobile micromirror actuators which provide shading and ensure optimum lighting conditions. The lighting within a room (i.e. the strength and the direction of the light) then depends on the positioning of the mirrors. All this is made possible by nano-imprint lithography. Forming part of the system, solar thermal collectors are used,

heating up the process water of the building, both in a residential and commercial property.

Implemented in its current form, a MEM4WIN window will have a total thickness of 70 millimetres. The edge seal has been designed so that fittings can be attached directly.

The project is due to be completed at the end of March 2016, when it will enter the race for mass manufacturing capability and marketability. By 2021 legislators want to see all construction sites producing zero energy buildings only.

#### glasstec 2016

glasstec 2016 will feature a range of solutions and innovations whereby the

glass industry is seeking to master future challenges in this segment of highly insulating thermal multiple glazing. The leading global trade fair for the glass industry will be held in Düsseldorf from 20 to 23 September. As well as presenting the entire range of construction glass, the international trade fair will provide a comprehensive overview of the latest production and finishing technologies for display glass. The trade fair – particularly with its special show Glass Technology Live – is an ideal venue for architects, planners and façade builders wanting to gain new ideas and a place that showcases energy-efficient systems and forward-looking multifunctional façades.