Quadruple IG-Unit with thin glass membranes

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Keywords
1=Tempering
2=Air Cushion
3=Thin Glass
4=Lamination
5=Quadruple IG-Unit
6=Smart Window

Abstract

The "window of the future", which will include a lot of functions, will be developed as part of the EU funded project "MEM4WIN". MEM4WIN is one of six current EC funded research projects on "Smart Windows".
The Austrian industrial company LiSEC – global leader in glass processing machines and a pioneer in the production of insulating glass – is coordinating the international research project. The Austrian research company PROFACTOR, five universities and six additional companies from the industry are partners within the project consortium. The project, which began on 1 October 2012 has a duration time of 42 months (project closes: March 2016).

[1] MEM4WIN will introduce a novel IG-Unit for quadruple glazing containing ultra thin glass membranes dedicated as frameless openable windows for direct application in facades. Due to this approach U-values of 0.3 W/m²K can be achieved reducing weight by more than 50% and costs by 20%.
[2] MEM4WIN will implement ink-jet printed organic photovoltaics (OPVs), fully integrated solar thermal collectors for energy harvesting, integration of organic light emitting diodes (OLEDs) for artificial lighting as well as micro mirrors for energy and day lighting control.
[3] Fabrication costs will further be reduced by replacing conventional and cost intensive materials used for contacts like ITO and silver by graphene and by implementing novel high-throughput production methods e.g. for anti-reflective coatings, encapsulation of moisture sensitive films and sealing of the IG-unit.
[4] At the end of the project the aforementioned modular components like micro mirror arrays, OPVs, solar thermal collector as well as OLEDs will be integrated into a fully functional demonstrator showing the suitability of the used equipment, processes and new materials developed.

Introduction

LiSEC is an internationally active company offering comprehensive solutions with regard to the production and refinement of flat glass. With more than 1,500 employees LiSEC is worldwide leading in solutions working with flat glass and sets standards in quality and technology. Our worldwide presence with more than 20 affiliated companies and agencies facilitates the quick implementation of our projects including the necessary supervision conducted by our specialists on-site. Our customers can rely on our consistent and trustworthy approach and as a consequence will have secured their investments long term. We provide a comprehensive portfolio of Machines, Software and Services.

Targets for the insulating glass of the future [Figure 1]

- Intelligent shading and light control
- Power generation (electrical, thermal)
- Integrating lighting
- Reducing weight and costs
- Appearance ("frameless sash")
- Lowering the U-value further (down to 0.3 W/m²K)

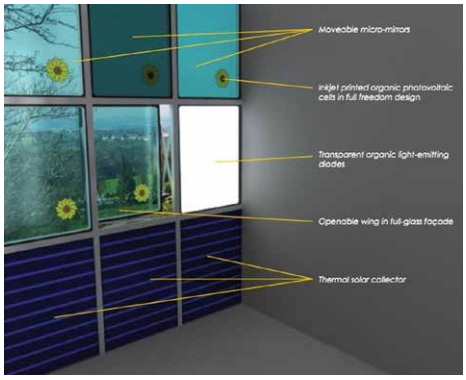

Figure 1: MEM4WIN Facade Sketch

Which technologies can we use to meet these targets?

The following technologies:

- Quadruple-glazed insulating glass [Figure 2]
- Thin glass technology
- New edge bond
- Encapsulation with diffusion tight edge sealing
- AR and LOW-E coatings

Facilitate:

- U-value of 0.3 W/m²K
- Lowering the primary energy requirement for manufacturing
- Reducing weight and costs
- Frameless, self-supporting structure
- Integration of functional coatings such as micro mirrors, OPV, OLED, etc.
- Increasing light transmission and the g-value

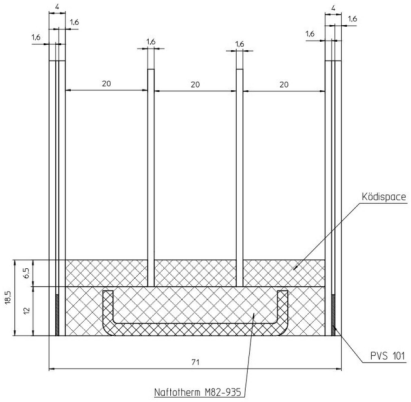

Figure 2: quadruple IG sketch

Energy required to manufacture the additional chamber [Figure 3]

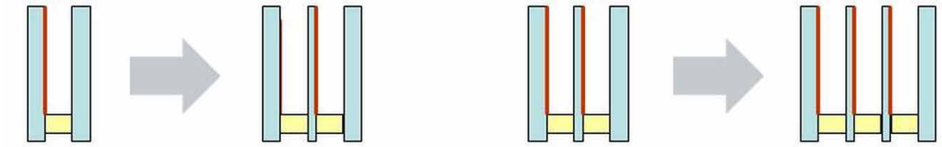

Figure 3: IG-versions

Comparison of 2-pane and 3-pane glass

Ug-value improvement when changing
from 2-pane to 3-pane glass
1.1 to 0.6 = **Δ - 0.5 W/(m²K)**

Thermal heat requirement is reduced
by 37 kWh per m² per annum
Primary energy requirement is reduced by 47 kWh per m² per annum

4mm glass
3.85mm TVG+
49.8 kWh/m² glass

Glass sheet edge
Spacer + Butyl 18mm width
4.9 kWh per linear meter
argon filled 18mm air space
0.1 kWh/m²
I.G. line energy requirement
1 kWh/m² (source: TS-LiSEC)

Total
70 kWh/m²

Comparison of 3-pane and 4-pane glass

Ug-value improvement when changing
from 3-pane to 4-pane glass
0.6 to 0.3 = **Δ - 0.3 W/(m²K)**

2mm glass
1.85mm TVG+
27.8 kWh/m² glass

Glass sheet edge
Spacer + Butyl 18mm width
4.9 kWh per linear meter
argon filled 18mm air space
0.1 kWh/m²
I.G. line energy requirement
1 kWh/m² (source: TS-LiSEC)

Total
48 kWh/m²

When using 2mm glass, the energy balance is already achieved after 1 year!

Temperature variation: Quadruple glazing / South Moscow in autumn [Figure 4]

- Addition of the tensions caused by temperature differences and bending the glass sheet (membrane effect)
- This use is accommodated insofar as possible with tempered thin glass.

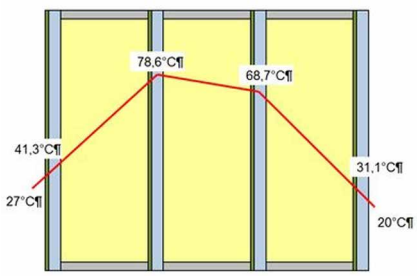

Figure 4: IG temperature

Calculation / simulation of the climatic load [Figure 5 + 6]

- Room temperature 20°C
- Outside temperature -20°C
- Size of insulating glass unit
  1180 x 780mm

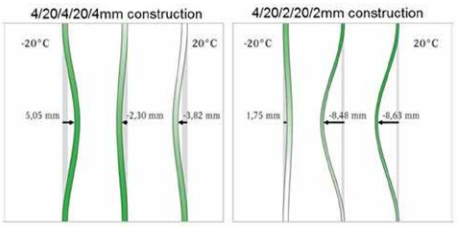

Figure 5: climatic loads

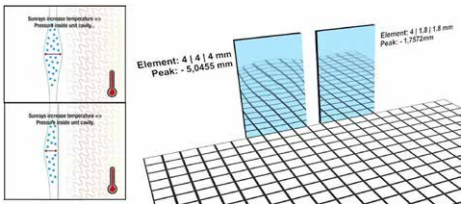

Figure 6: IG optical reflection regarding climatic loads

Test samples for DIN EN 1279-3 climatic change test

Dimensions:	380 x 530 mm [Figure 7]
Construction [mm]:	VSG/TBG4-20-TBG1.6-20-TBG1.6-20–VSG/TBG4
Primary sealant:	Kömmerling Ködispace
Secondary sealant:	Naftotherm M82-935, a GRP U profile is embedded in the secondary sealant that is around 12 mm high

Figure 7: TPA application

Results of DIN EN 1279-3 climatic change test [Figure 8]

Description of climatic change test
Storage under changing climatic conditions:
2 weeks (28 cycles) -18°C to +53°C
High humidity climate test:
4 weeks +58°C at 100% relative humidity.
Reconditioning:
1 week +23°C at 50% relative humidity.

IFT Rosenheim results
- Test passed

Summary / conclusion
- Moisture absorption is very low
- Gas loss rate is very low for values of good 2-pane à insulating glass
  (Result: 0.65%/a and 0.56%/a à DIN EN 1279-3 requirement: < 1.00%/a)

Figure 8: IFT certificate for quadruple IG-Unit

Frameless opening sash [Figure 9]
Excellent facade appearance thanks to
- Parallel glass surface (when sash is open)
- Frameless structure

Figure 9: facade mockup

The differences between air cushion technology and conventional roller furnaces include [Figure 10]:

- The glass surface is not touched
- Air cushions are used instead of ceramic rollers
- Maximum convection in the circulation system
- Symmetric energy input
- No downtime when changing the glass type
- Minimum optical distortions (no rollerwaves)
- Easy integration into automatic production lines

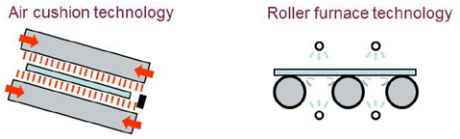

Figure 10: different tempering technology

Figure 11: air cushion tempering line

Encapsulation technology with an additional edge sealing for integrated functional coatings

- Symmetrical modular design [Figure 12]: Cell in neutral bending phase
- Additional edge seal [Figure 14]: Water vapour diffusion tightness 0.01 g/m²day 700 times better than the open module edge
- Absolutely diffusion-tight and UV-resistant
- Transparent laminate structures
- Patented vacuum laminating procedure [Figure 13]
  No edge rubber folds / edge delamination
- Short, energy-efficient processes
- Greater flexibility when selecting the interlayers (e.g.: low temperature interlayers)

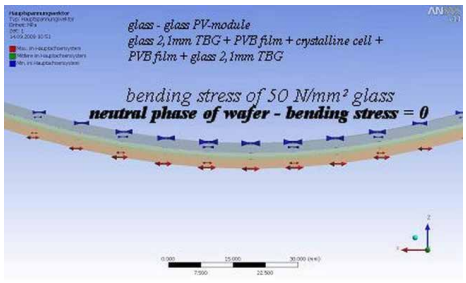

Figure 12: bending stress

Figure 13: Vacuum laminator for glass-glass-modules

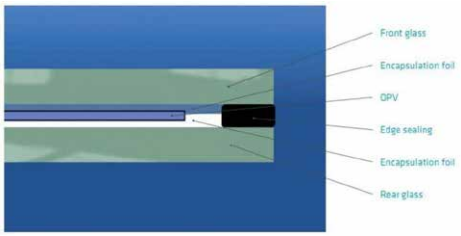

Figure 14: module with edge sealing

Conclusions and summary

The 3 main targets U-value of 0.3W/m²K, weight reduction with thermal tempered thin glass and a diffusion tight edge sealing for moisture sensitive films are achieved with new developed machines from LiSEC such as
- Air cushion tempering with turbo boost function for fully tempered 2mm thin glass
- Vacuum lamination technology for glass-glass laminates with edge sealing
- Quadruple IG-Line for thermo plastic spacer application for frameless windows

Acknowledgements

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