ADVANCED DESIGN OF GLASS STRUCTURES

Lecture 5 – Fire resistant glass, photovoltaic glass and aesthetic coatings

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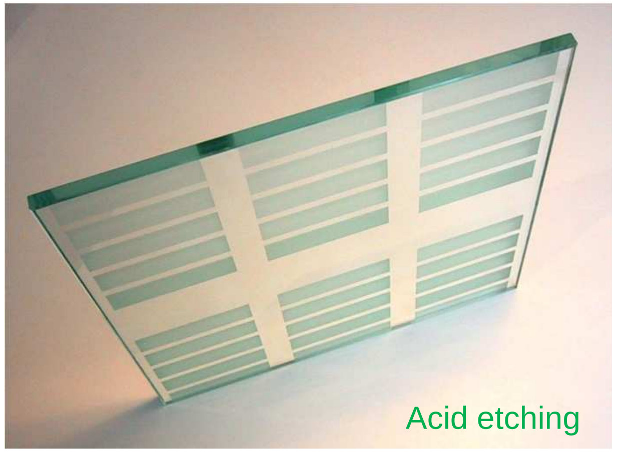
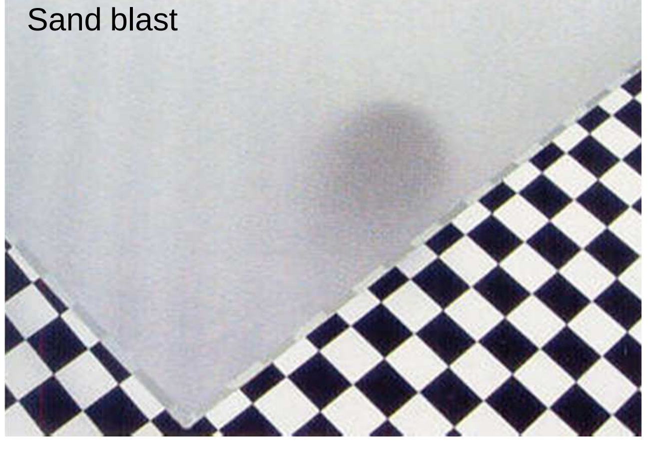
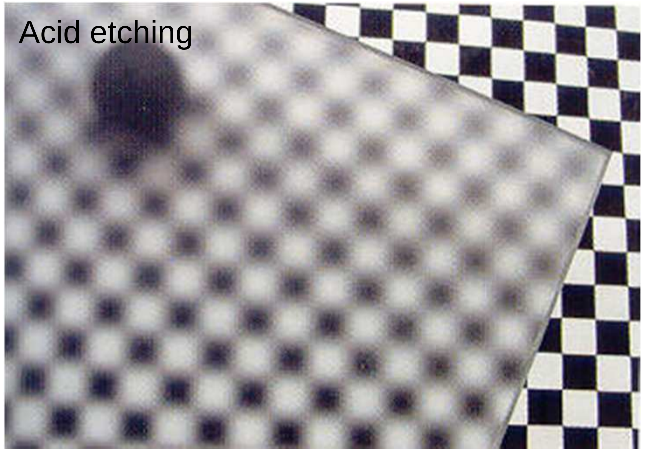
European Erasmus Mundus Master Course
Sustainable Constructions
under Natural Hazards and Catastrophic Events
520121-1-2011-1-CZ-ERA MUNDUS-EMMC

Decorative glass

Acid etching | The glass surface is treated with hydrofluoric acid, gaining a uniformly smooth and satin like appearance, with translucent effect. Sandblasting produces the same effect but with a rougher texture. Acid etching and sandblasted patterns (a.k.a. frosted glass) are very durable and not subjected to degradation due to weathering.







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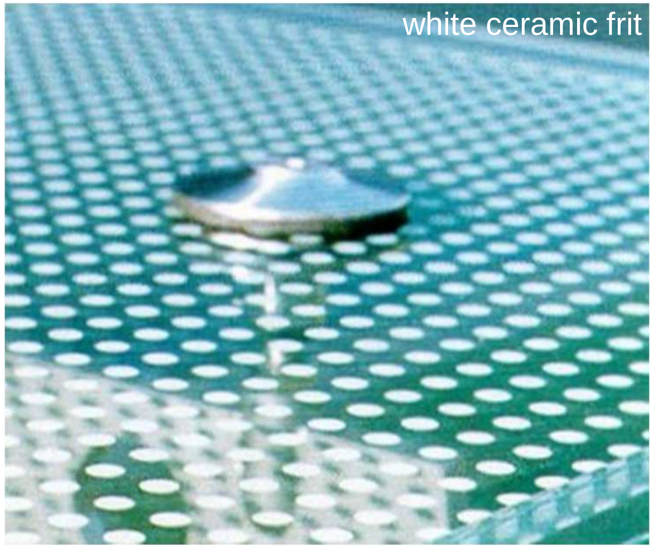
Decorative glass

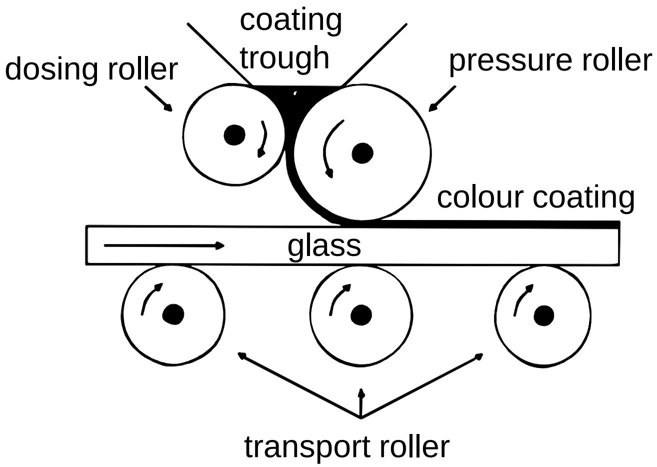
Enamel or screen printed glass| A ceramic frit colour (glass powder 70-95% and pigments 5-30%) is transferred onto the cooled annealed glass and then burned into the surface during the tempering process.

Image is rolled applied or sprayed through a screen

PVB or resins may still be used

The process reduces the mean value of the bending strength by 25-40%





principle of roller-applied colour coating

Decorative glass

Functional coatings

Switchable glazing

Photovoltaic glass

Fire resistant glass

Decorative glass

Body tinted glass| By adding metal oxides to the constituent materials during glass production.

Consistent colour through out the glass

Match exact colours in different lots is difficult because colour is very sensitive to the exact composition.

Green (iron oxides), red (copper oxide or gold oxide) and for blue (cobalt oxide).

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Decorative glass

Decorative glass

Functional coatings

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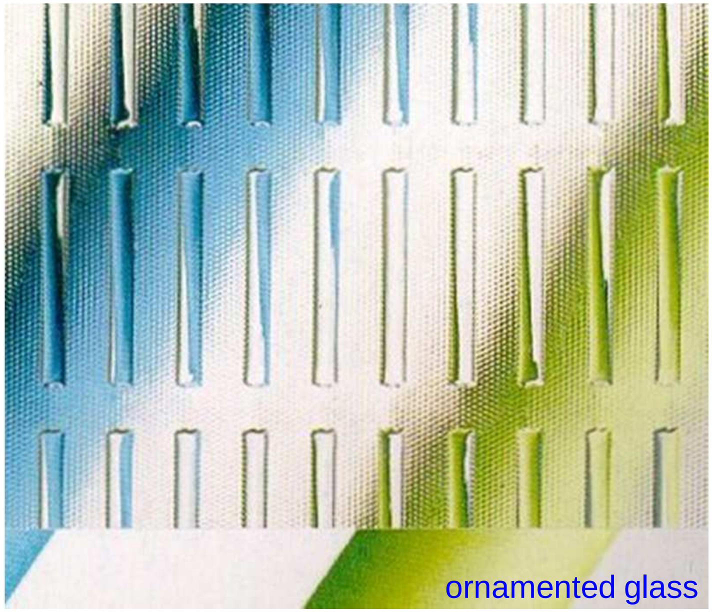
Fire resistant glass

Patterned glass| With embossed pattern on one or both surfaces.

Mostly produced by the cast process with patterned rollers.

The strength is normally much lower when compared to flat glass.

The deeper the pattern, the greater the degree of obscuration and diffusion.



ornamented glass

textured rolled glass surface with wire mesh

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Decorative glass

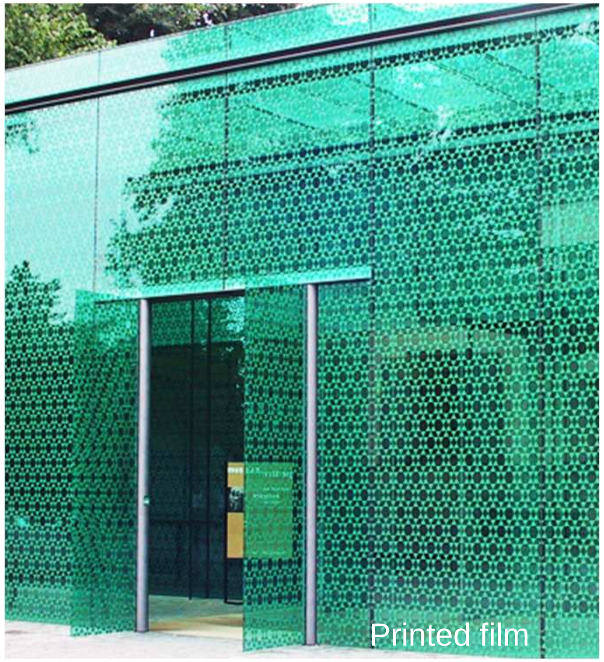
Inside laminated glass| Decorative element added to the internal film.

Coloured PVB films.

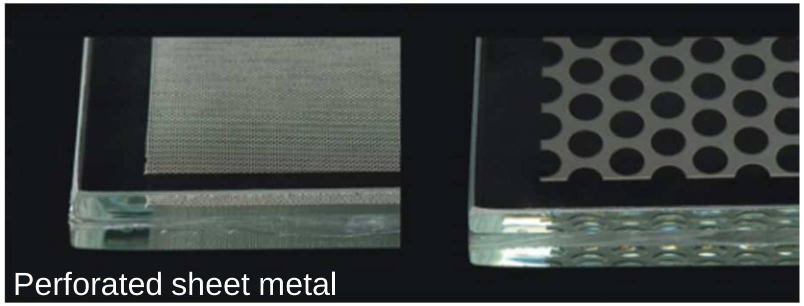
Printed film.

Perforated sheet metal.

Laminated glass with coloured PVB films



Printed film



Perforated sheet metal

Decorative glass

Functional coatings

Switchable glazing

Photovoltaic glass

Fire resistant glass

Functional coatings

Hard coatings

On line processes

Pyrolytic coating | Chemical vapour deposition process. A gaseous chemical mixture is brought in contact with the hot glass substrate (600-650º) and a pyrolitic reaction occurs at the surface of the substrate leading to the deposition of a coating that bonds to the glass. Because of the high temperatures required, the coating process is integrated in the float process or the annealing lehr.

Scratch resistant, temperable, bendable and can be glazed also to exterior.

Ex.: reflective glass

Off line processes

Dip coating | The glass is dipped into the coating solution and then heated up to 650ºC.

Decorative glass

Functional coatings

Switchable glazing

Photovoltaic glass

Fire resistant glass

Functional coatings

Soft coatings

Can be applied by various processes (dip coating, chemical or physical vapour deposition) but the most common is Magnetron sputtering (during sputtering energised plasma ions strike a target, composed by the desired coating material, and coating atoms are ejected traveling and bonding to the glass).

Multi-layer, high performance coatings of a variety of materials.

Very constant coating quality.

Allow for accurate repeatability.

Susceptive to aggressive environments and mechanical damage (need protection).

Example: low emissivity glass | Are predominantly transparent for visible light, but reflective for IR radiation and able to reduce the emissivity of glass from 0.84 to 0.05. Are sputtered or pyrolitic, transparent metallic or metallic oxidic coatings. Applied to protected panes (inside IGUs).

Switchable glazing

Glazed façades are often required to meet conflicting performance requirements such as the need to mitigate energy losses, reduce unwanted energy gain and visual discomfort from glare as well as to provide high levels of transparency.

One solution is to provide a smart and responsive façade where the properties of the glazing change to actively control solar gain, heat transfer and glare as well as the amount of IR radiation and thus optimize energy efficiency and comfort levels.

These smart systems respond dynamically to external references such as temperature and daylight. Materials or devices are embodied in the glass and change its optical characteristics upon command from the smart system.

solar modules integrated into the glass skin

Switchable glazing

Decorative glass

Functional coatings

Switchable glazing

Photovoltaic glass

Fire resistant glass

Passive or self adjusting systems

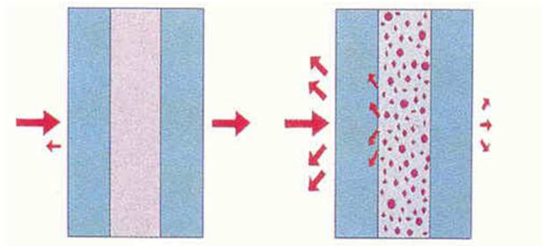
→ Directly respond

- Photochromic
- Thermochromic
- Thermotropic

Ex.: Thermotropic glazing

low temperature ⇒ transparent glass

higher temperature ⇒ non-transparent

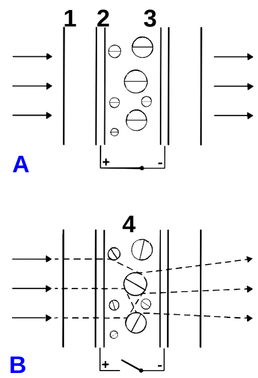


Active or externally activate

→ Require an external electrical current.

- Electrochromic
- Liquid crystal
- Suspended Particle
- Gasochromic

Ex.: Electrochromic glazing translucent glazing unit (B) becomes transparent (A) when an electric field is applied



1. glass
2. transparent electrode layer
3. polymer layer with aligned liquid crystals
4. polymer layer with randomly oriented liquid crystals

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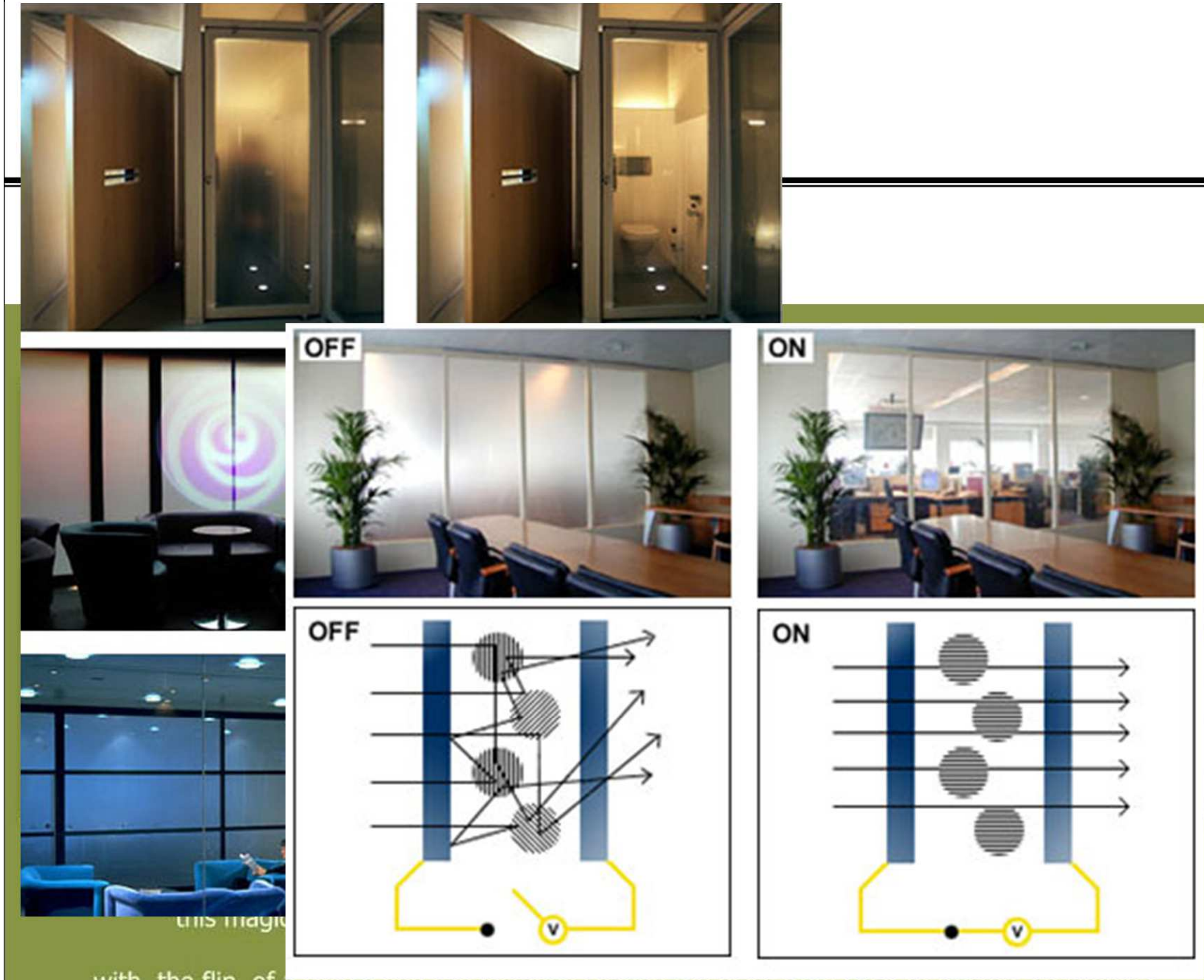
Functional coatings

Switchable glazing

Photovoltaic glass

Fire resistant glass



this magic

with the flip of a switch you can instantly change the glass from clear to frosted ,so simple !

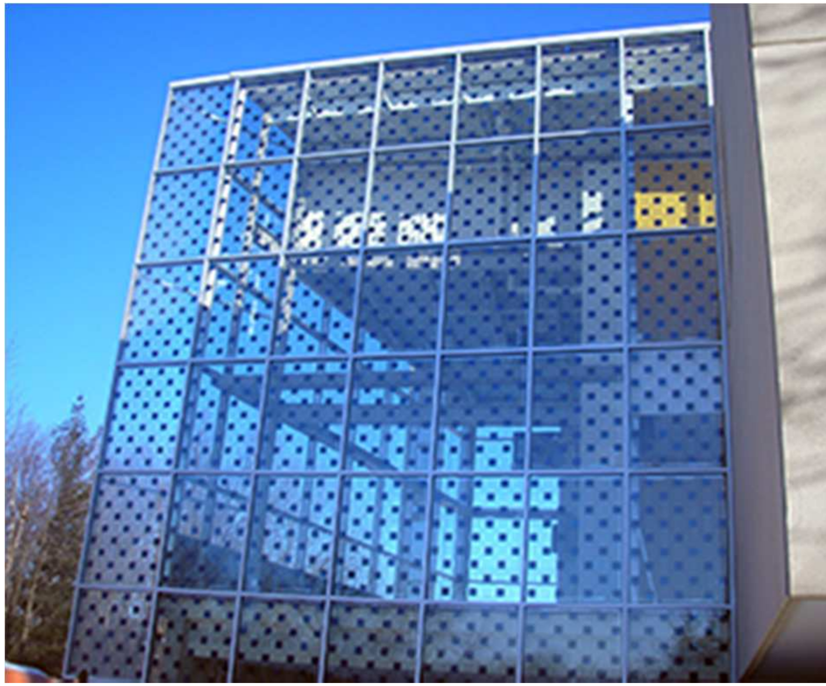
Photovoltaic glass

Photovoltaic effect – Direct conversion of light into electricity.

Photovoltaic glass

Laminated glass with integrated solar cells to convert solar energy into electricity.

The solar cells are embedded between two glass panes by means of EVA interlayer. The EVA interlayer is preferred to the traditional PVB used in standard laminated glass as the former does not require autoclaving, which would damage the solar cells.



Photovoltaic glass
Syracuse glass company

Photovoltaic glass

Each individual cell has two electrical connections, which are linked to other cells in the module, to form a system which generates a direct electrical current.

There are a wide range of solar cells available, though the bulk of the material in use is semi-conductor silicone cells.

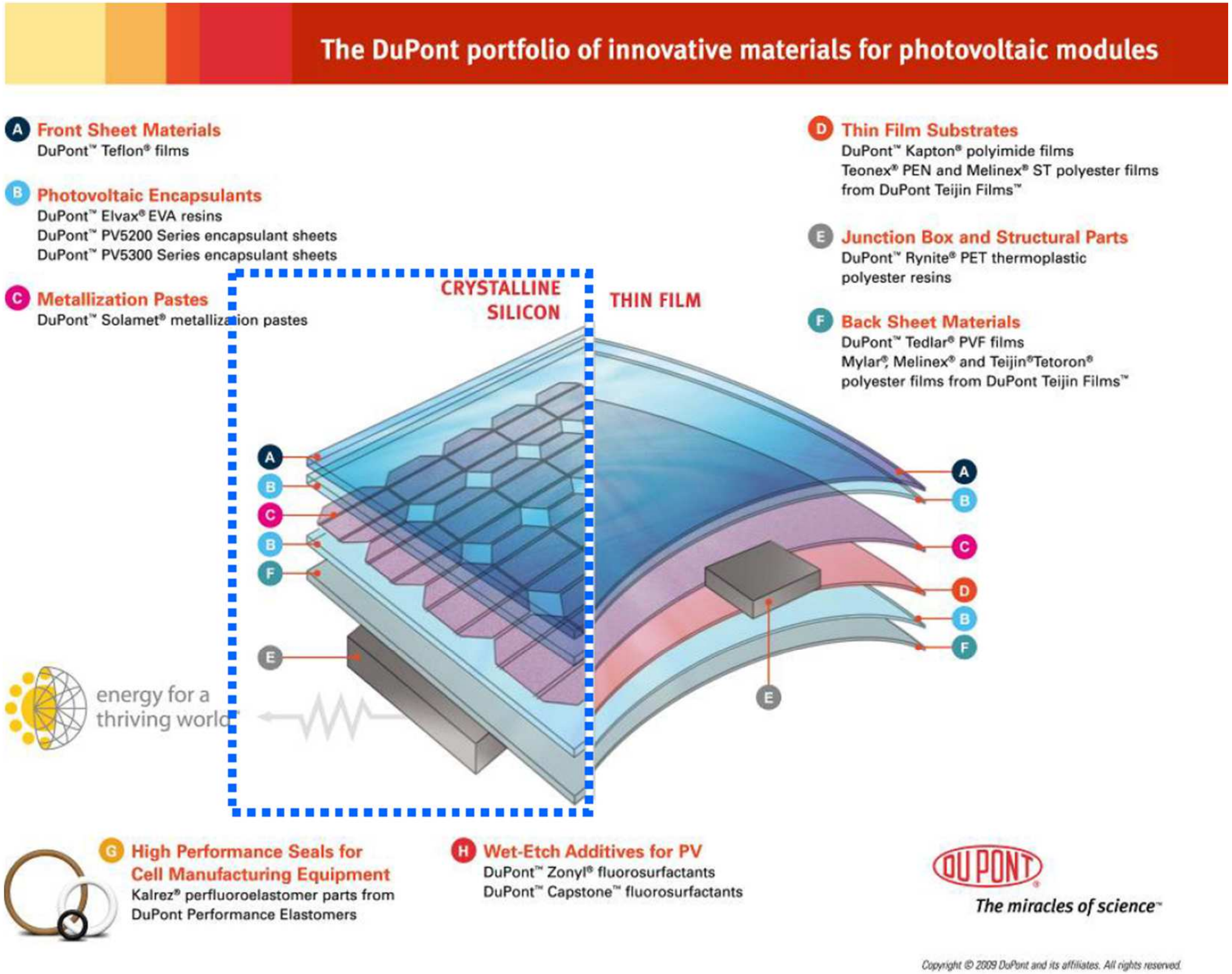
Spacing between the cells may be varied in each direction, thus allowing a degree of transparency through the photovoltaic panel.

The front pane of glass is generally a heat strengthened low iron glass. The inner pane of glass can be of any type.

Photovoltaic glass panels may form part of IGUs.

Photovoltaic glass solar shading
Airsun CLARITI PV

Photovoltaic glass



Photovoltaic glass

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Fire protection glass

Introduction

Decorative glass

Functional coatings

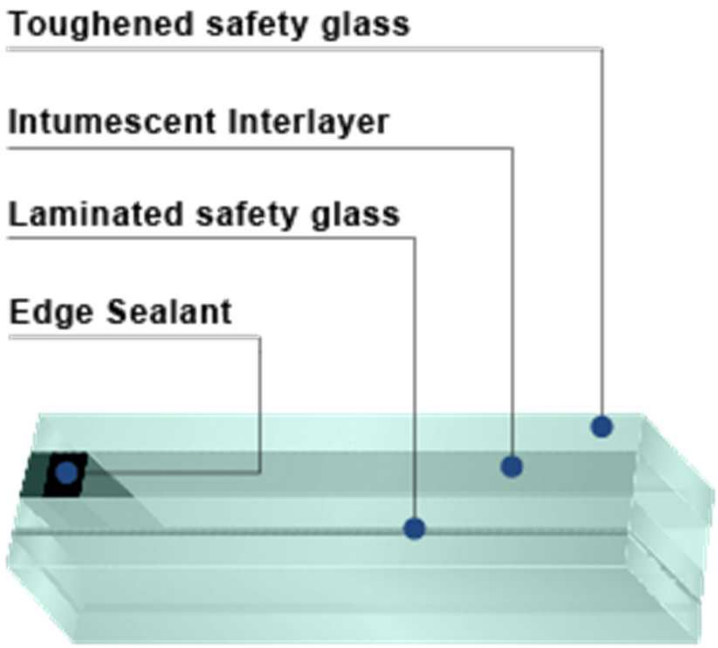
Switchable glazing

Photovoltaic glass

Fire resistant glass

Tempered safety glass with a layer of transparent metallic oxides.

Tempered or laminated glass with one or more special transparent intumescent interlayer(s). When exposed to fire, the pane facing the flames fractures but remains in place and the interlayers foam up to form an insulating shield that blocks the heat and the blaze.



Fire protection glass
Introduction

Glazing might break but stay in position without falling down.

Fire protection glass

Security classes

Several levels of protection

- Class E: resistance to flames, smoke and hot gas for at least 30 minutes.
- Class EI: total heat insulation in the event of fire for between 30 to 120 minutes.
- Class EW: indicates that the product also offers limited protection against heat radiation.

	Requirements	Classification (acc. to EN 13501-2)	Product line
	Full thermal insulation (basic integrity + thermal insulation)	EI...	Pilkington Pyrostop®
	Enhanced integrity (basic integrity + reduced heat radiation)	EW...	Pilkington Pyrodur®
	Basic integrity (barrier against smoke, flames and fumes)	E...	Pilkington Pyroclear®

- Decorative glass
- Functional coatings
- Switchable glazing
- Photovoltaic glass
- **Fire resistant glass**

Fire protection glass

Security classes

	Product	Maximum fire rating	Offers impact safety**	Passes hose stream test	Blocks heat transfer during fire	Complies with energy codes	Compatible with TGP framing	Provides acoustic barrier	Advantages/ Disadvantages
THIN	Fireglass® 20	20 min.	●				●		+ Moderate initial investment - Cannot withstand thermal shock
THIN	Pilkington Pyrodur®	20 min.	●				●		+ Moderate initial investment - Cannot withstand thermal shock
THIN	Wired Glass	45 min.		●			●		+ Least expensive option - Institutional appearance - Low impact resistance - Limited sizes
THIN	WireLite®	45 min.		●			●		+ Moderate initial investment
THIN	WireLite® NT	90 min.	●	●			●		+ Surface-applied fire-rated film + Cat. I and II impact safety + Withstands thermal shock + Passes hose stream test - Possible abuse to surface film
THIN	FireLite®	90 min.		●			●		+ Heat resistance of ceramic - Low impact resistance
THIN	FireLite® NT	3 hrs.*	●	●			●		+ Surface-applied fire-rated film + High impact resistance - Possible abuse to surface film
THIN	FireLite Plus®	3 hrs.*	●	●			●		+ Durable laminated construction + High impact resistance
THIN	FireLite® IGU	3 hrs.*	●	●		●	●	●	+ Energy efficient + Acoustic barrier + Wide choice of appearances
THICK	Pilkington Pyrostop®	2 hrs.	●	●	●	● +	●	●	+ Floor-to-ceiling glass designs + Reduces heat transfer + Tested as a wall - Can be heavy

*For doors. Consult product literature for maximum ratings in other openings. **Meets CSPC 16CFR1201 (Cat. I or II) + In an IGU make-up.

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Fire protection glass

Standards

EN 1991-1-2-2002
Eurocode 1. Actions on structures. General actions. Actions on structures exposed to fire

EN 357:2004 Glass in building - Fire resistant glazed elements with transparent or translucent glass products - Classification of fire resistance

EN 15998:2010 Glass in building - Safety in case of fire, fire resistance - Glass testing methodology for the purpose of classification

EN 1634-1:2008 Fire resistance and smoke control tests for door, shutter and, openable window assemblies and elements of building hardware. Fire resistance tests for doors, shutters and openable windows

BS 476-22:1987
Fire tests on building materials and structures. Methods for determination of the fire resistance of non-loadbearing elements of construction

EN 13501-2:2007+A1:2009. Fire classification of construction products and building elements. Classification using data from fire resistance tests, excluding ventilation services

EN 14600:2005. Doorsets and openable windows with fire resisting and/ or smoke control characteristics. Requirements and classification

BS EN ISO 13943:2000. Fire safety. Vocabulary

This lecture was prepared for the 1st Edition of SUSCOS (2012/14) by Prof. Sandra Jordão (UC).

Adaptations brought by Prof. Viorel Ungureanu (UPT) for 2nd Edition of SUSCOS