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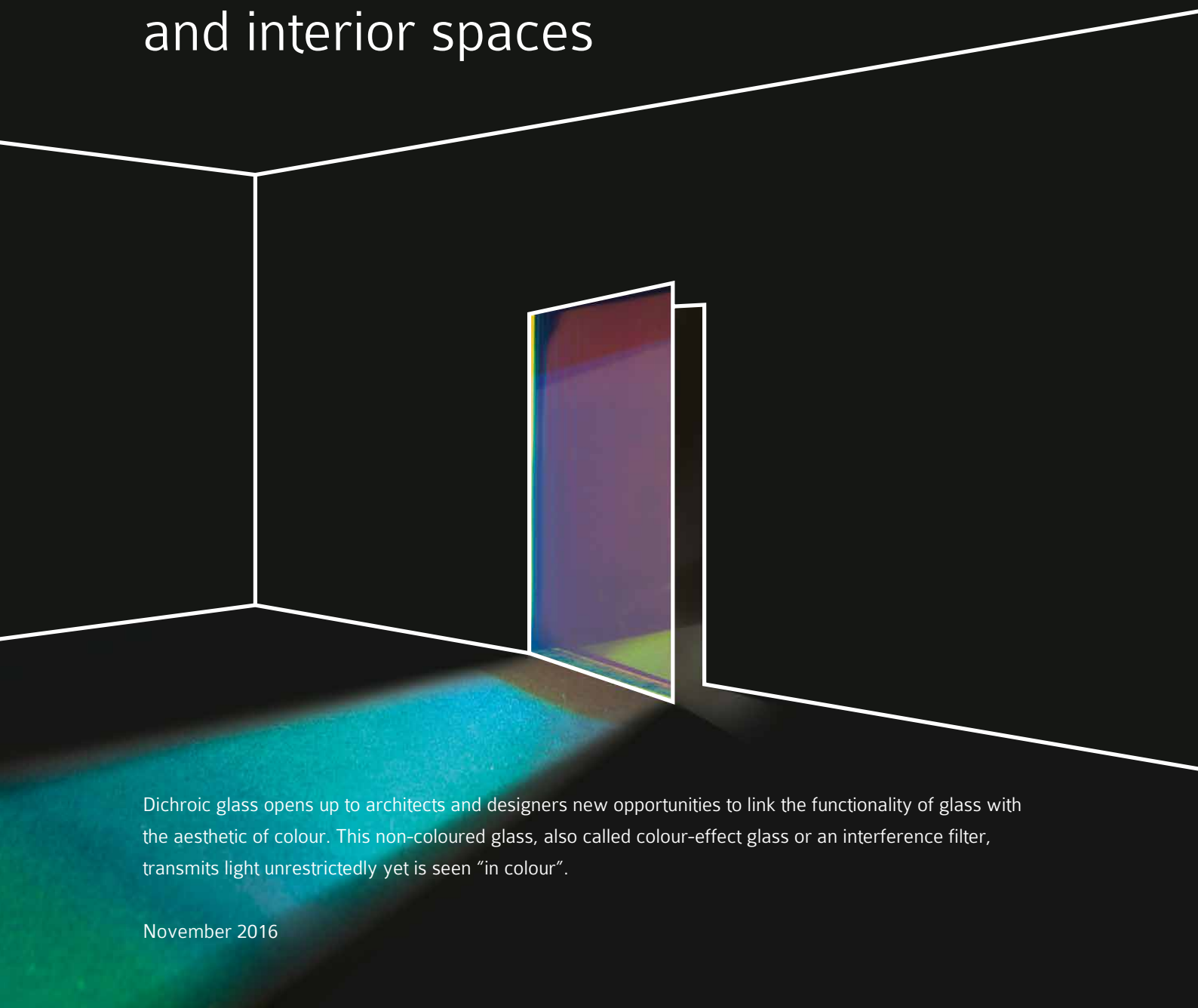
LIGHT BECOMES COLOUR

Dichroic Glass in Architecture
White Paper

The use of colour-effect glass in the design of exterior facades and interior spaces



Dichroic glass opens up to architects and designers new opportunities to link the functionality of glass with the aesthetic of colour. This non-coloured glass, also called colour-effect glass or an interference filter, transmits light unrestrictedly yet is seen “in colour”.

November 2016

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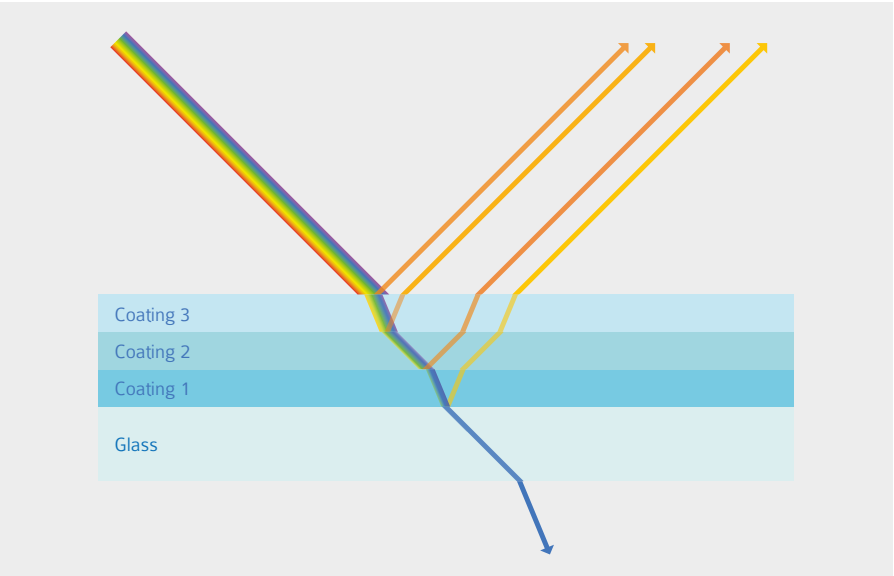
Obtaining colour from light

With dichroic glass (from the Greek "dichroos" = bicoloured), almost every colour of the spectrum can be generated, both additive (red, green and blue) and subtractive colours (yellow, magenta and cyan). This effect is based on the interference of light waves by thin, optically transparent coatings that split white light into colours.

The colours are produced by the superposition of light waves that are reflected both at the surface of a particular layer and at its lower interface. If two wave crests are superposed, the waves are intensified (constructive interference). However, if a wave crest meets a wave trough, each radiation cancels the other out (destructive interference). For example, if there is destructive interference in blue light, the irradiated white light is reflected without its blue fraction. So yellow light, the complementary colour to blue, is visible when reflected. At the same time, blue can be seen when looking through the glass. In principle, the visibility of interference colours and gradients is dependent on the respective incident light radiation and the viewing angle.

Colours on request

With VarioTrans glass from PRINZ OPTICS, it is possible to select the colour effect. The required colour is generated by appropriate interference coatings applied to the glass surface. The incident light is not absorbed by this and then converted to thermal radiation. In contrast, the effect of standard colour filters is based on the absorption of complete spectral regions. This can lead to serious heating, such as in lighting technology (colour filters in front of halogen spot lights).



How it works in principle: Superposition of light rays

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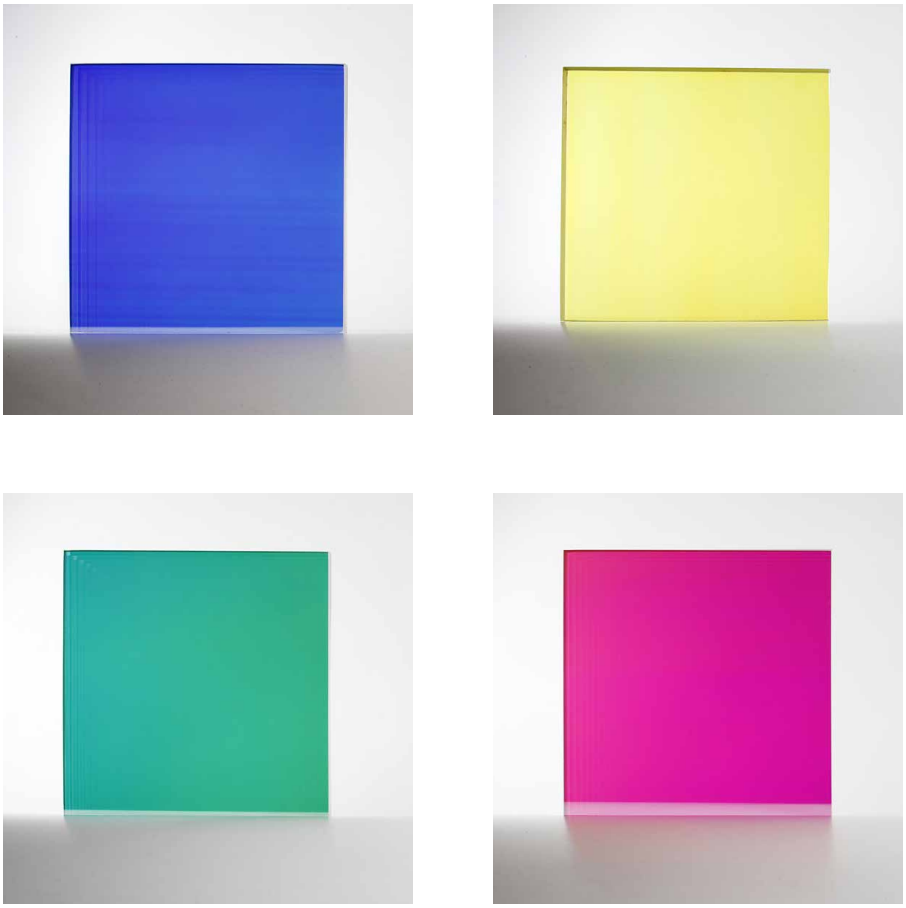
The colours

that dichroic filters can make visible include the whole visible spectrum. Both the additive (red - green - blue) and subtractive colours (yellow - magenta - cyan) can be generated, as well as any colour combination. All colours look brilliant and radiant.

The colour that appears when looking down on the filter glass is always the complementary colour to that which is produced when looking through it. Both colours are perceived in a lively play of colour.



(Fig. Blue, yellow, green and pink filters)

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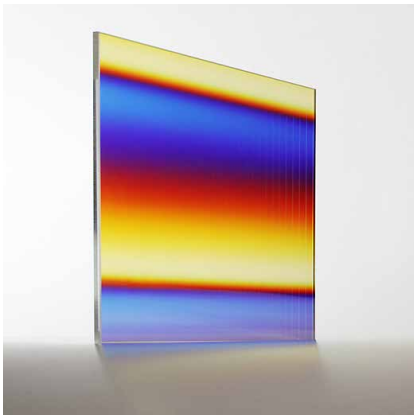
The colour gradients

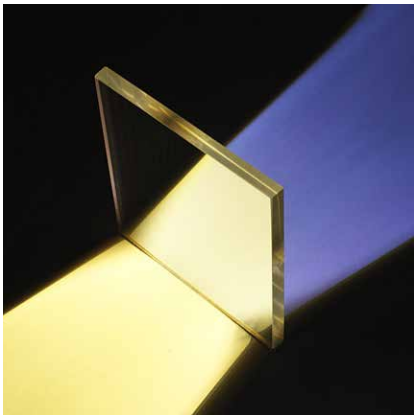
always consist of the colours of the subtractive YMC colour space. It is either fully or partially visible, e. g. from magenta through dark blue to blue. The scope of the colour gradients, as well as the length over which they extend, can be selected.



(Fig. Gradients)

The day/night effects

of the filters depend on the respective illumination. In daylight, there is a dramatic superposition of the colours when looking both down on, and through, the glass. Without daylight, the colour perceived depends on the position of both the light source and the observer. If both are in front of the filter, then the view from above will dominate; if both are separated by the filter, the colours seen when looking through the glass will dominate.



(Fig. day/night effect)

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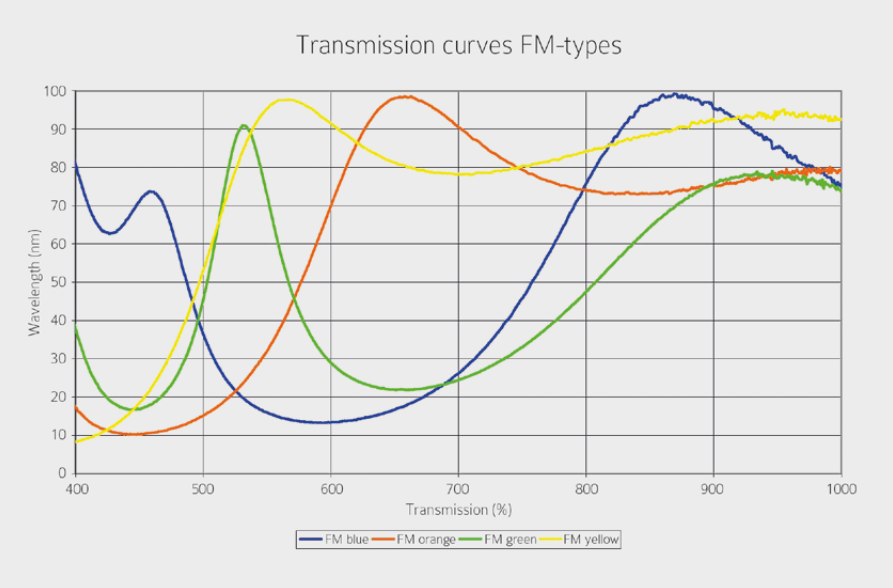
Dichroic glass

is produced by the application of several thin, dielectric (optically transparent) coatings on the glass. They consist of materials such as SiO_2, TiO_2, ZrO_2 and Ta_2O_5. The respective coating thickness is typically one quarter of the length of a light wave, i. e. about 100 nm.

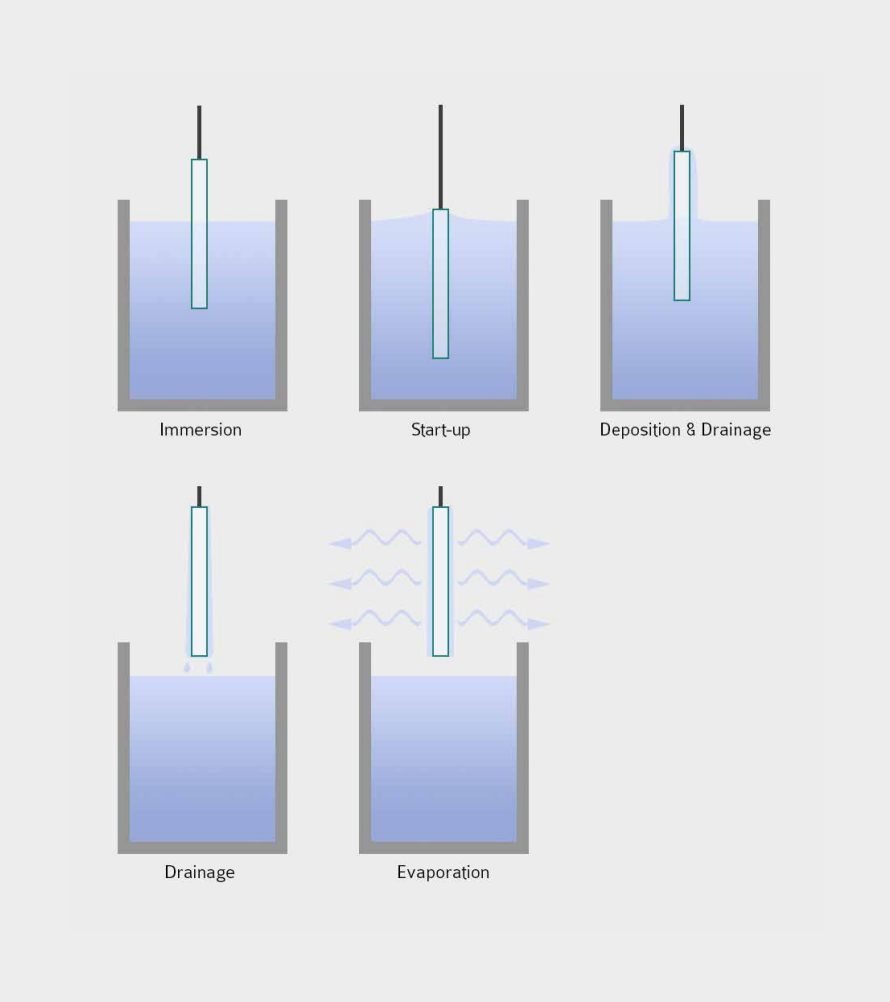
Transmission and reflection ranges are separated more sharply from one another with an increase in the number of coatings. This increases the transmission and reflection values, and thus increases both the contrast between transmission and blocking, as well as the colour saturation.



(Fig. 2 Curve charts)

The coating can be applied physically or chemically. In the physical procedure, the relevant metal oxides are released in a vacuum (by evaporation/PVD or atomization/sputtering) and deposited on the substrate. In the chemical procedure, the coating is either generated through a reaction in the gas phase (CVD, vacuum procedure) or it occurs using the Sol-Gel procedure where a liquid reacts to the glass surface.

VarioTrans glass is produced using the Sol-Gel procedure. Here the cleaned substrate - only white glass is used due to its optimal colour reproduction for architectural applications - is evenly coated by being dipped into and extracted from Sol dipping baths. Metal alcohol solutions are used for the coatings, which, in a subsequent thermal process, are converted into adhesive metal-oxide coatings and fired into the glass surface.



(Fig. Dipping procedure)

At the end of this procedure, the next respective coating can be applied.

In order to guarantee a consistent quality in the coatings, optical measurements are continually taken during the process. The photometer used, specially modified by PRINZ OPTICS, allows transmission and reflection measurements of 250 to 1100 nm, as well as the calculation of colour values, coating thicknesses and refractive indices.

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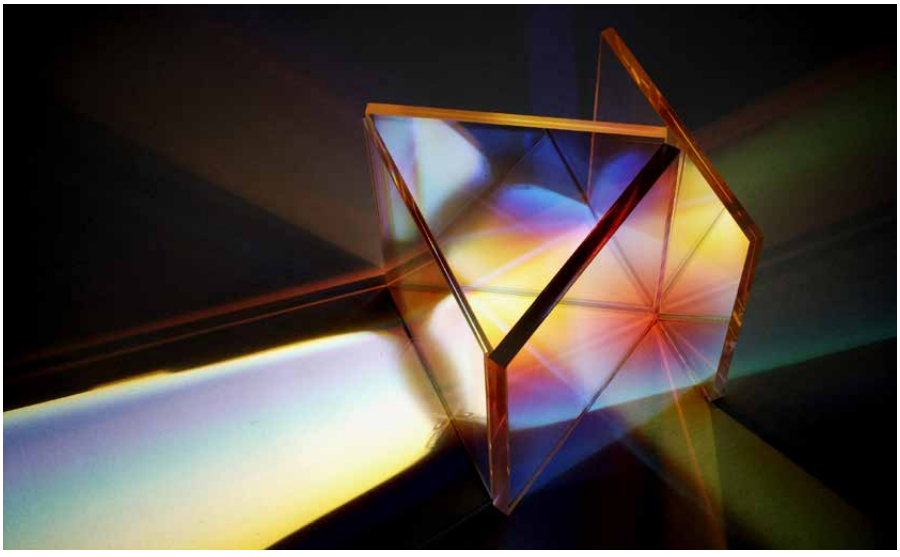
The properties of dichroic glass

are primarily determined by the purely inorganic nature of the coating:

- Heat and UV radiation cannot affect the filter properties. Unlike glass that is coloured throughout, it is not subject to any ageing process. There is no bleaching of the filters.
- Thanks to its high durability and long service life, VarioTrans glass can be finished using almost every standard glass-finishing method (cutting, grinding, drilling, bevelling, etc.).
- On the other hand, bending is only possible for bend radii > 1 m due to restrictions regarding the process design and possible colour shifts. Tighter bend radii can lead to tears in the coating.

The aesthetic effect

of the colour-effect filters is based on the simultaneous real perception of colour and an associated emotional sensation. The beauty of a successful colour-light design is not just an end in itself. Rather, it excites attention and notice, generates interest and appeal, and thus triggers a sense of wellbeing. Outside on streets and squares, as well as in prestigious interiors, surfaces that were crystal clear at one moment appear at the next glance to be a changing play of light and colour when seen from a different perspective.



(Fig. Multiple colour effect)

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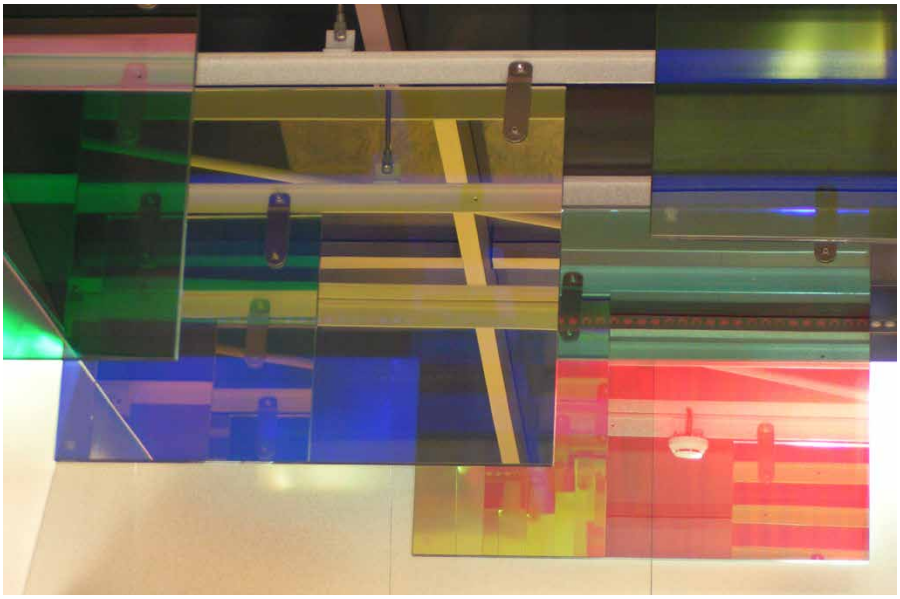
VarioTrans glass, with its impressive interplay of transmission and reflection, is destined for architectural applications. Due to its unrestricted transparency in association with a mix of subtractive light, colour-effect glass is equally suitable for the design of both interiors and facades.

For interiors,

dichroic glass offers a broad spectrum of creative opportunities. Optically weightless, yet at the same time highly stable, this material is destined for room divisions and realizing room-in-room concepts.

Doors, in particular, made from colour-effect filter glass provide a surprising feature. Depending on the coating, the incident light and the viewing perspective, they can be transparent or multi-coloured with gradated and fluctuating colours. Doors are made from laminated safety glass and can be delivered ready-made.



(Fig. International airport, Zurich)

In interiors, dichroic glass is generally used as a double-laminate safety glass with an uncoated protective glass sheet, or as a single sheet of glass. Filters with paler colours can also be finished into single-sheet safety glass. However, slight changes in colour can occur here during the necessary hardening process.

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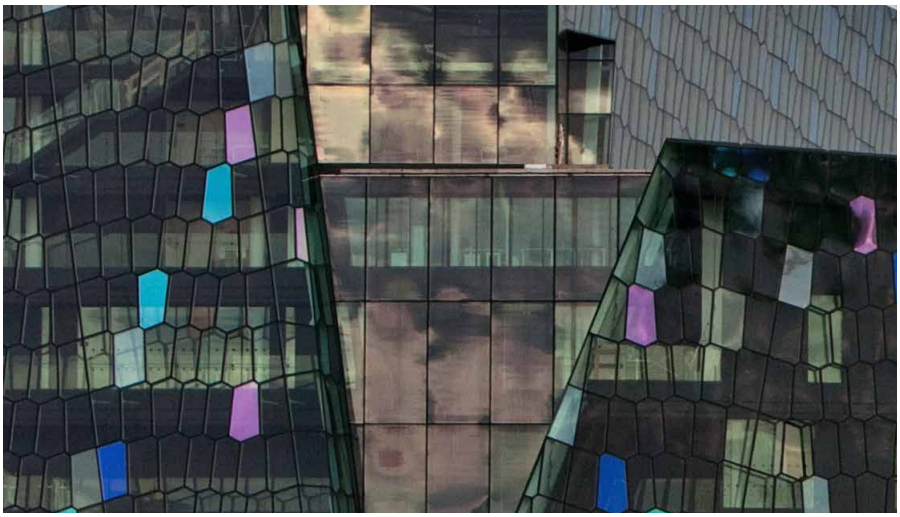
For exteriors,



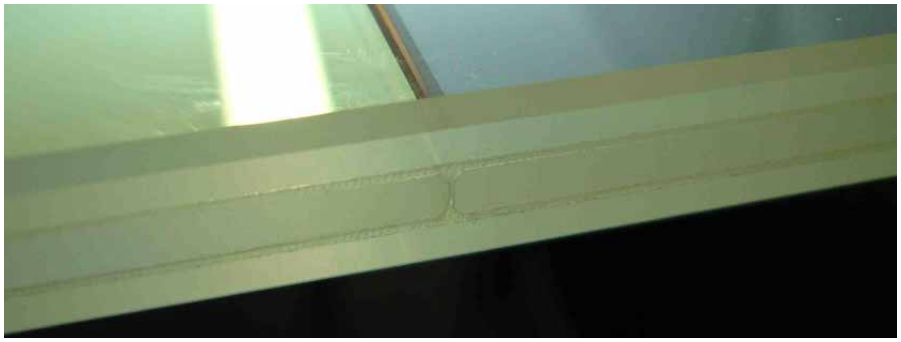
(Fig. Harpa facade, Reykjavik)

dichroic glass has to be used as a triple-laminate safety glass.

The thickness of the uncoated cover sheets applied to both sides should be at least 3 mm – to prevent environmental damage and for safe cleaning. However, at the end of the day this is dependent on structural conditions.

Its thermal insulation properties meet all the standards due to its ability to be processed (workability) into insulated glass.

It is quite possible to combine different colours in one sheet, such as in the form of a mosaic, as well as to join it to half-silvered mirrors and clear glass through butt-joint assembly.



(Fig. Butt joint)

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Instead of a summary evaluation:

From the jury's reasons for awarding the 1st Prize for Innovation in Architecture and Glass (Glasstec Düsseldorf 2006):

"The VarioTrans product meets the expectations of architects for whom the sensory quality of their projects is of prime importance. Further properties have been added to the well-known qualities that are perceived in glass, such as transparency and reflection. Changing colours, multifaceted views and coloured shades allow a simple, well-known object - a sheet of glass in the light - to be read in an inexhaustibly complex manner. With all the force of its effect, the VarioTrans pane of glass is captivating due to properties that are rare today: it keeps its distance, remains secretive, and makes a contribution to elegance in architecture."

Examples

of the aesthetically impressive yet economical and functional application of this innovative material in architecture can be seen around the world today. PRINZ OPTICS is happy to provide interested parties with documentation on projects that have been carried out.

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