

The role and use of pigments, NIR absorbers and additives

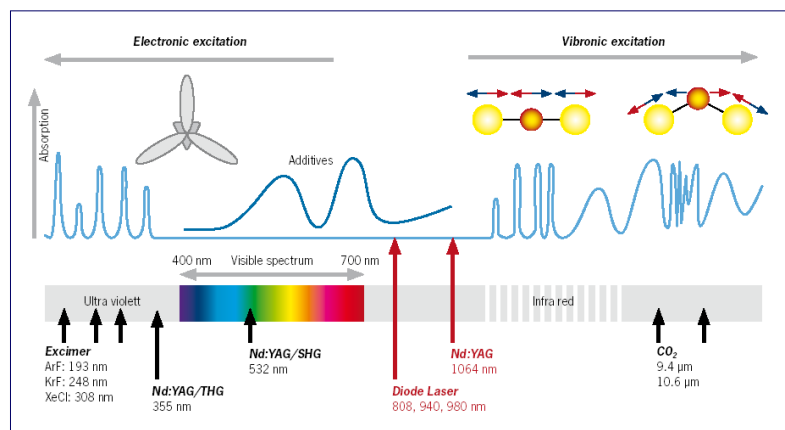
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Topics

- What is colour?
 - colour
 - colorants
- Laser welding of polymers
 - material
 - colorants – additives
- Conclusions

What is colour?

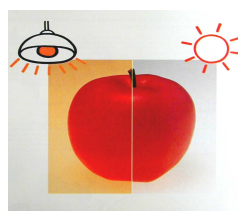
Wavelengths



What is colour?

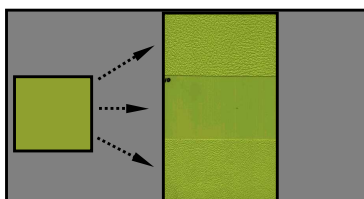
- In the range of 400 to 700 nm the electromagnetic waves are visible for the human eye.
- Illuminated objects reflect a fraction of the wavelengths spectrum of a light source which is detected by the eye and identified as colour.
- Colour is an individual perception which is stimulated by light received by the eye.
- The observed colour is influenced by the light source.

What affects colour?

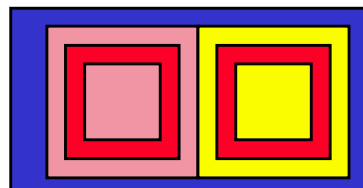


light source

surface structure



adjacent colours



Colorants

Classification of colorants

Colorants

Dyes

soluble in plastics

organic



Pigments

insoluble in plastics

organic

inorganic



Properties of colorants

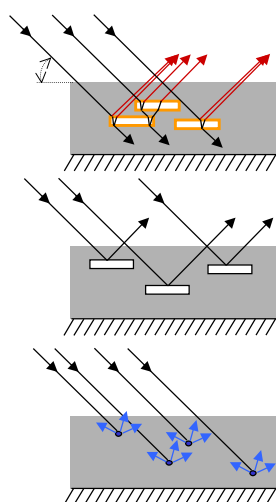


Properties	Inorganic Pigments	Organic Pigments / Dyes
Particle size	0.5 – 1.0 mm	0.01 – 0.1 mm / dissolve
Colour strength	low - moderate	high
Transparency	generally opaque	generally transparent
Heat resistance	high	low to high
Light fastness	moderate to excellent	low to excellent
Weather fastness	excellent	low to excellent
Migration	excellent	Moderate to excellent / low to moderate
Plate-out	no	in function to the recipe
Dispersion	usually good	difficult / soluble



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Interaction pigment - light



pearl luster pigments

Specific colour, gloss and colour shift due to light interference (reflection and scattering)

metallic pigments

Metallic gloss due to reflection

absorption pigments

Specific colour due to light absorption

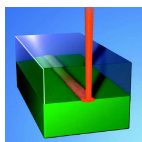


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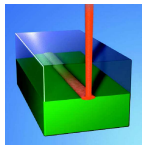
Influence on laser welding

- Absorption pigments
 - Used in laser transparent and laser absorbing colour application
- Pearl luster pigments
 - Due to platelets structure nearly no use in laser transparent colour formulations
 - Use in laser absorbing formulations possible (e.g. as NIR absorber)
- Metallic pigments
 - Due to the brilliant surface of the platelet structured pigments and therefore, mirror effect, the use in colour formulations for laser welding is not recommended.

Laser welding of polymers

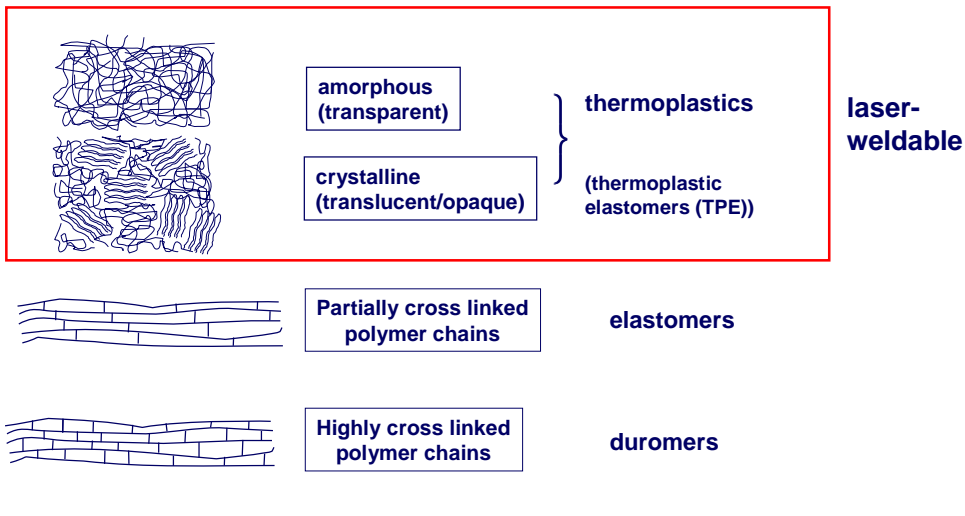


Laser welding of polymers



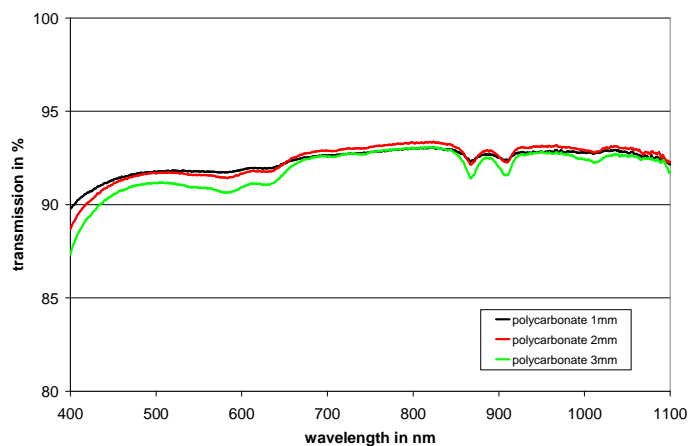
material

Polymer type



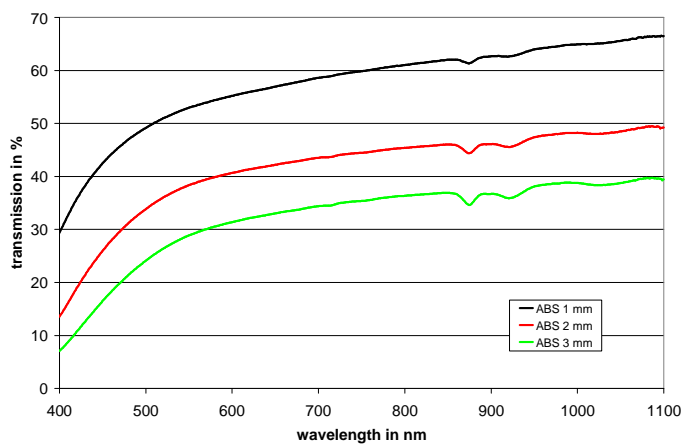
Transmission spectra

Transmission depending on wall thickness of visually transparent polymers



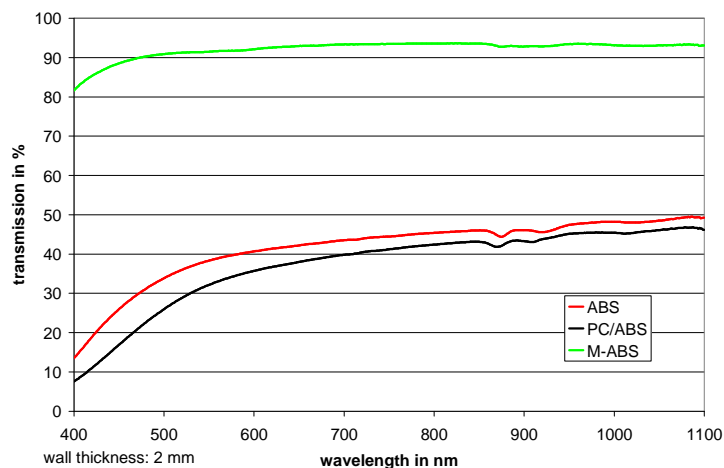
Transmission spectra

Transmission depending on wall thickness of opaque polymers



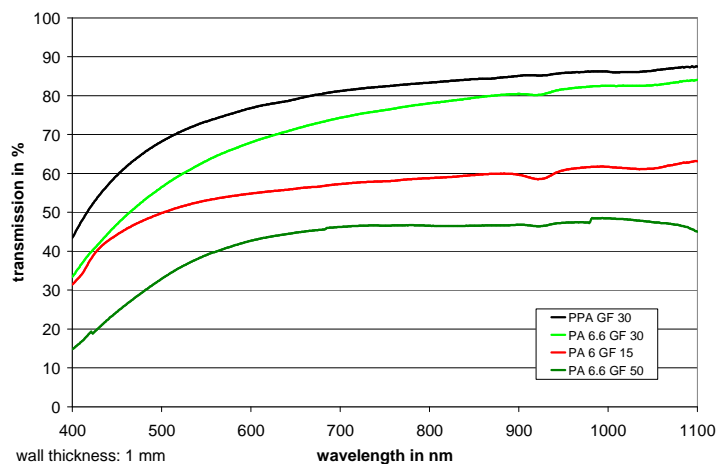
Transmission spectra

Transmission of styrene based polymers



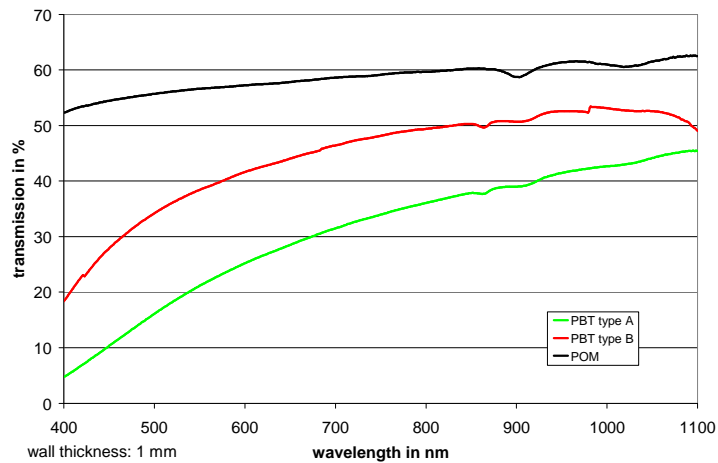
Transmission spectra

Transmission of glass filled polyamides



Transmission spectra

Transmission of several engineering plastics



Optical properties of thermoplastics

Behaviour of thermoplastics in regard to light in the visible and the NIR range:

- transmission
- scattering
- reflection
- absorption (very low)

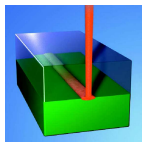
- depending on wavelength and wall thickness

Influence of fillers on the transmission

„Macroscale“ fillers have a negative influence on the function of the NIR-transparent joint partner.

For example, glass fibres, glass balls, chalk, talcum powder, flame retardants etc. decrease the transmission values by scattering, reflection and absorption.

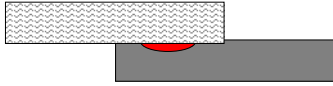
Laser welding of polymers



Colorants - Additives

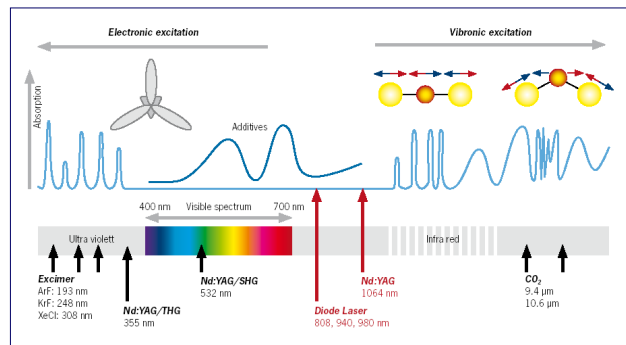
Joint partner LST/LSA - Colorants

LST



LSA

Absorption range of polymers



Requirements for the colouring of the transparent joint partner

Colorants should influence the NIR-light as little as possible.

Colorants create wished colour.

Linking of the colour in the visible and the function in the NIR-range.

Requirements for the colouring of the absorbing joint partner



Colorants respectively additives absorb the NIR-light and change it effectively into heat energy.

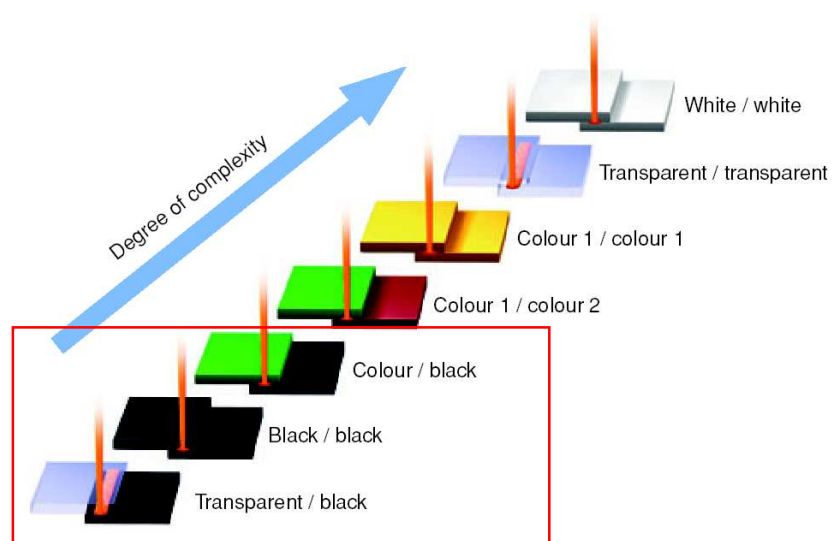
Colorants create wished colour.

Linking of the colour in the visible and the function in the NIR-range.



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Degree of complexity



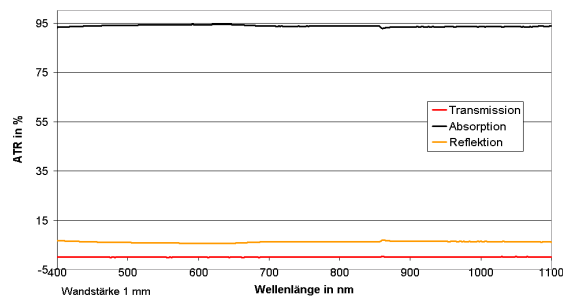
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Black – NIR absorbing

- Carbon black
Broadband absorber for all wavelengths.
- Only for dark, grey and black applications

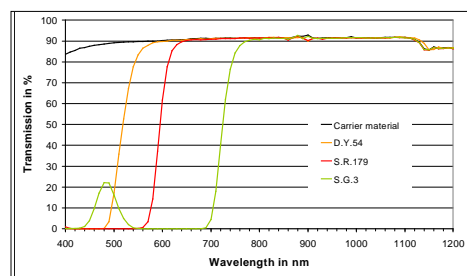
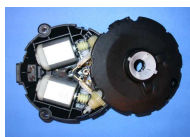


Source: Paragon AG



Black – NIR transparent

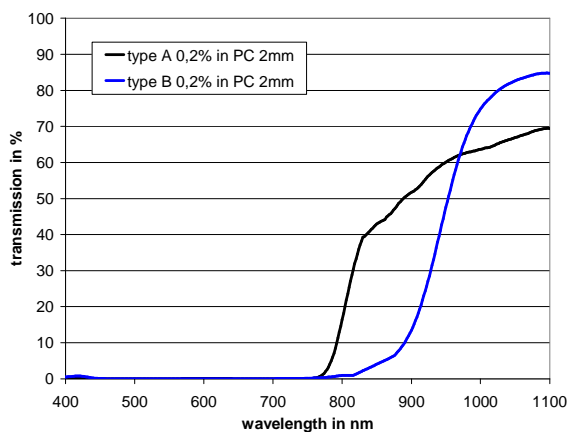
- Formulation is a mixture of different dyes:
Absorption between 400 – 700 nm (black)
transparent in the NIR
- NIR-transparent black already available for many polymers as a standard product.
- Many variations of black available!



in the visible

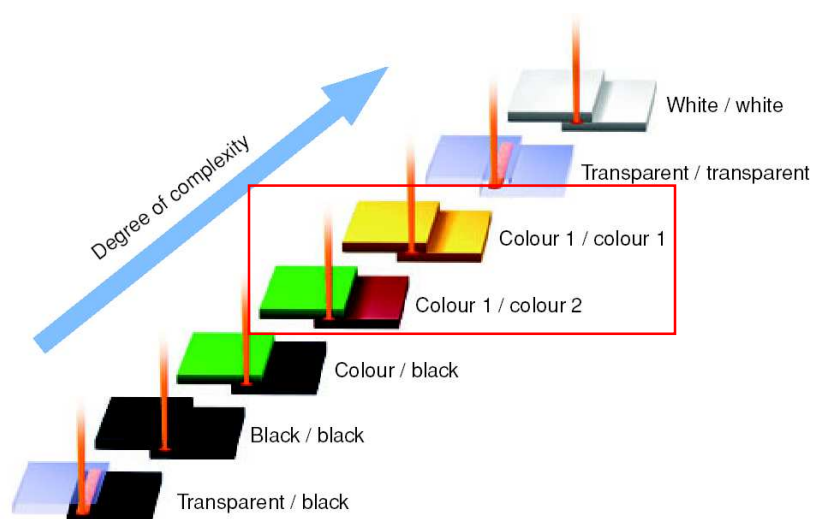
in the NIR

Black – NIR transparent



- Temperature stable up to 350°C
- Neutral black
- Stable to migration
- Excellent light and weather fastness
- Insoluble in organic solvents and water
- Inert against physical and chemical influences

Degree of complexity

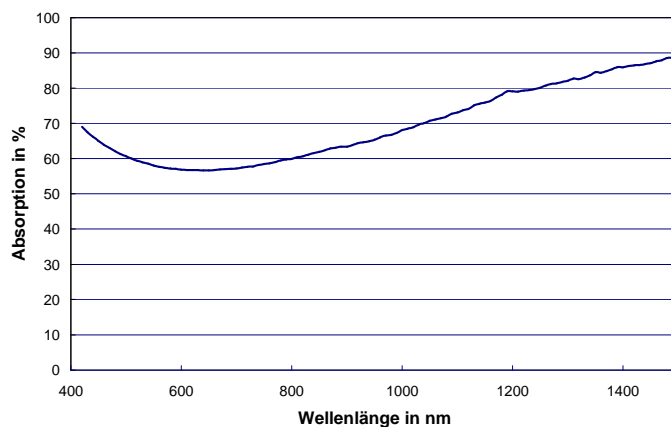


Colour – NIR absorbing

NIR-Absorber properties:

- Not based on carbon black
- Possibly neutral in colour (bright, without own colour influence)
- Wavelengths area 800 up to 1100 nm (1500nm)
- Mostly pigments in use
- Particle size in the μm range only for opaque colours
- Nanoparticles as additives for transparent formulations
- Polymer type
- Regulatory requirements

Colour – NIR absorbing



Example:

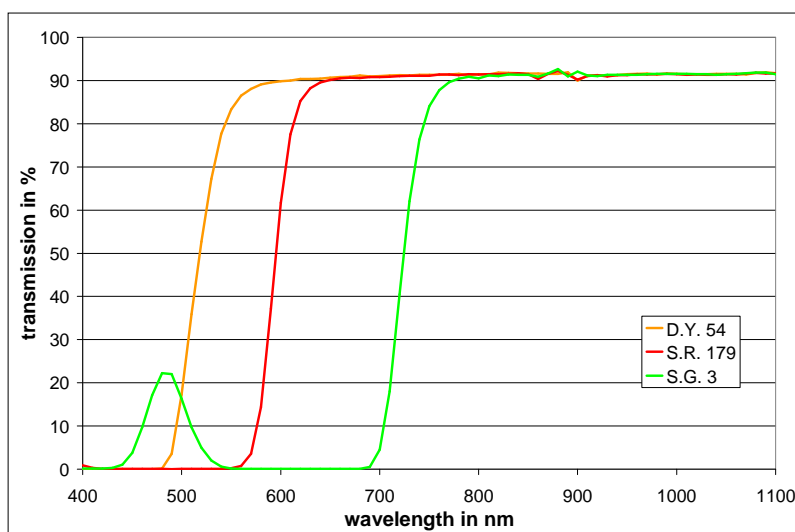
Inorganic NIR-absorber for opaque colours

1% in a transparent polymer, 1mm wall thickness

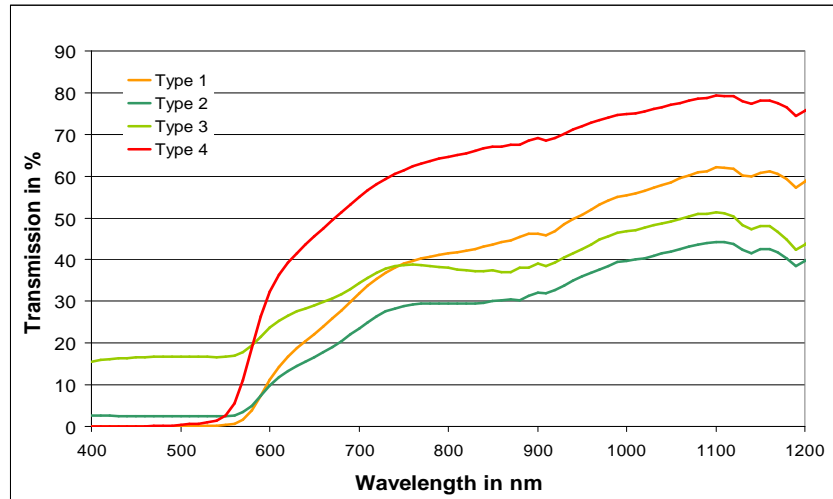
Colour – NIR transparent

- In general:
The darker the colour the better the transmission.
The exception proves the rule.
- Choice of colorant is depending on the transmission of the polymer (type, wall thickness, filler, etc.)
- Colour can also have an influence on the process parameters (welding time, laser power,...)
 - Opaque or translucent colours
 - Bright or dark colours
 - Wall thickness
 - Polymer

Transmission spectra of selected dyes



Transmission spectra of four types of P.R. 101




Colour/Colour

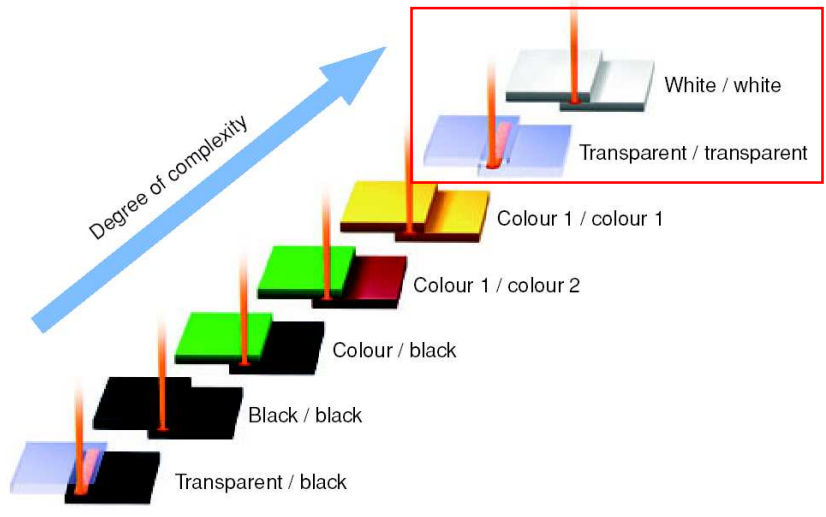
- Laser transparent and laser absorbing parts require different colour solutions.
- Challenge: metamerism, i.e. both samples need to look identical at different illuminations
- Marquardt IP (EP 0 751 865 B2)





Degree of complexity




Colour follows function



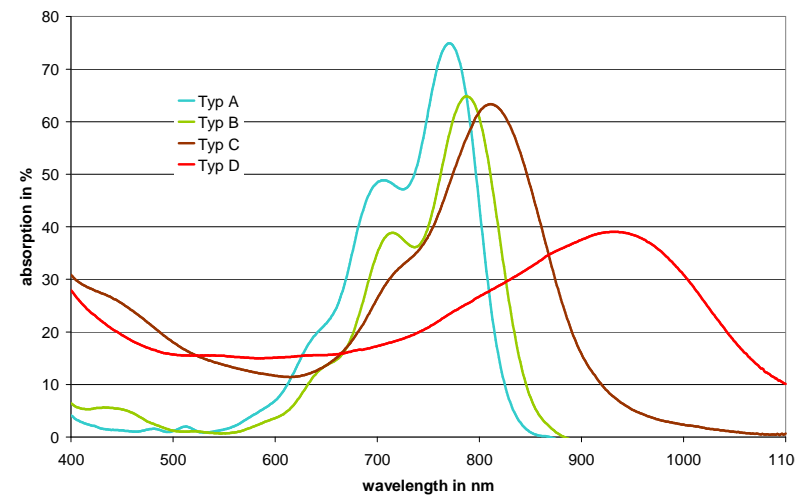
Degree of complexity ↑
 White / white
 Transparent / transparent
 Colour 1 / colour 1
 Colour 1 / colour 2
 Colour / black
 Black / black
 Transparent / black



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Transparent NIR-absorber



Colour follows function



Wavelength (nm)	Typ A (%)	Typ B (%)	Typ C (%)	Typ D (%)
400	5	5	30	30
500	2	2	18	18
600	5	5	15	15
700	45	35	25	20
780	75	65	45	25
800	5	65	60	30
820	0	10	65	35
900	0	0	15	38
950	0	0	5	40
1000	0	0	2	35
1100	0	0	0	10



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White / White

White surface => total reflection of the visible light

Laser absorbing part:

By use of colour neutral NIR-absorber a RAL 9003 is possible.

Laser transparent part:

Challenge

⇒ transmissive scattering

⇒ adjustment milky translucent



Conclusion

- Knowledge about spectral data of colorants and absorber additives are essential for the formulation of NIR-transparent and absorbing colours.
- Broad range of colours, from transparent to opaque and from bright to dark are possible.



Thank you for your
attention!



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