Coatings Trends & Technologies SUMMIT

Revolutionizing Safety with Color Innovation:

Crystal Glass Pigments Technology

for new coating trends

September 6th, 2024
Lombard, Chicago, USA

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CEO Ink Invent BV

Disclosure

Ink Invent BV – Effect Pigment Manufacturer

- Developer of a new class of effect pigments Crystal Glass Pigments RheoLight™
  - A privately owned company – established beginning 2018
  - Located in Nieuwegein, the Netherlands
  - With 2 locations: head-office & manufacturing premises
- Developer of the Tunable Detection & Determination Technology™
- Developer of **AIPOV** Visibility, **Twin-Flop** Effect and 3D Color **Visibility Label**
- Technology protection through proprietary technology & wide patent portfolio (9)
- Ink Invent is specialized in adding the Crystal Glass Pigment Effects to existing paints and coatings for new color effects and increased visibility
- Ink Invent provides **Crystal Glass Pigments ColorLab Academy** Training & Workshops for industry and application specific product development

Coating Trends & Technologies

The functions of color in coatings

Color in coatings has three main functions:

1. Colors evoke emotions – beauty
2. Colors influence visibility – safety*
3. Colors influence temperature – thermal comfort

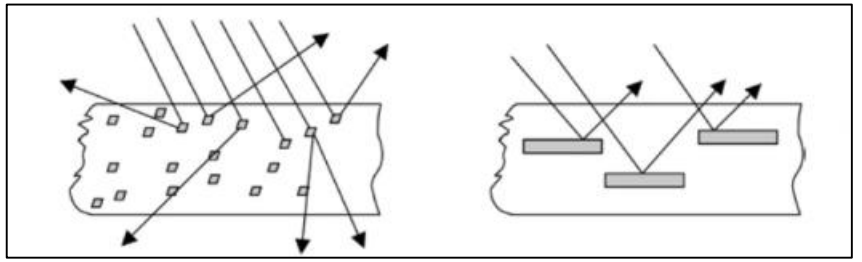
- How have colors changed over time?
- What are the current trends in color?
- What are the functions of color in a coating?
- Are there any new trends? New needs?

What's the visibility of the colored coating on your car and truck?

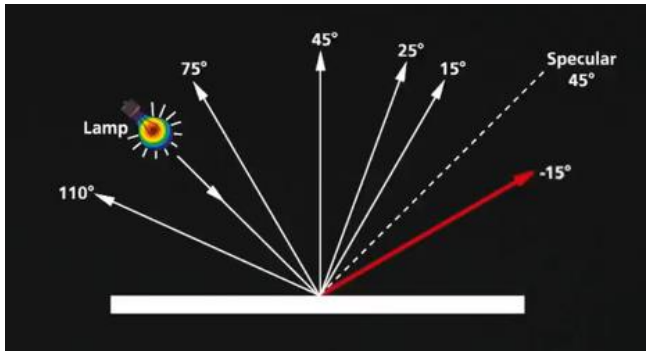
*: 'Unsettled Topics Concerning Coating Detection by LiDAR in Autonomous Vehicles' - SAE Edge: ERP2021002

Effect Pigments changed the color landscape

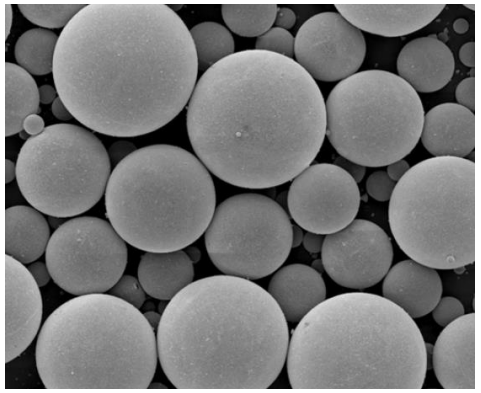
Profoundly … for the first time



- Mid 1920-1960's: enter metallics and pearlescents
  - Based on a new pigment **morphology**: flakes
  - 'Changed' existing colors, added new color concepts: **'Flop'** and '**Sparkle'**
  - For new colors and effects
- Effectively championing the 1st paradigm shift in color landscape

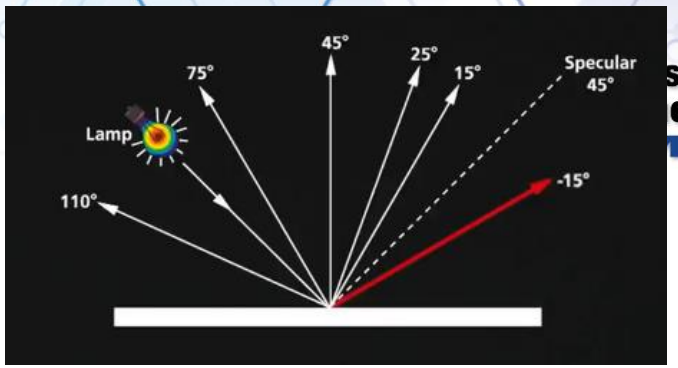


- 2023: Enter **Crystal Glass Pigments**
  - Based on a new pigment **morphology**: perfectly round Crystal Glass Microspheres
  - 'Changes' existing colors, adds new color concepts: **'Twin-Flop'** and '**AIPOV'** Visibility
  - For new colors and effects – different behavior in light
- Heralding a **2nd paradigm shift** in the color landscape



Current Automotive color Landscape

60-70% of new cars boast effect pigments



Now in early 2100's, automotive is dominated by effect pigments

Current Automotive Stylings: E.g. Automotive Styling Shades 2027

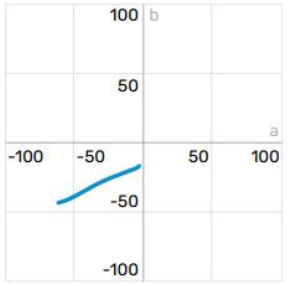
With new color trends Boasting 28 new colors: *All* including effect pigments

Can we quantify the visibility (incl. LiDAR) of curved surfaces?

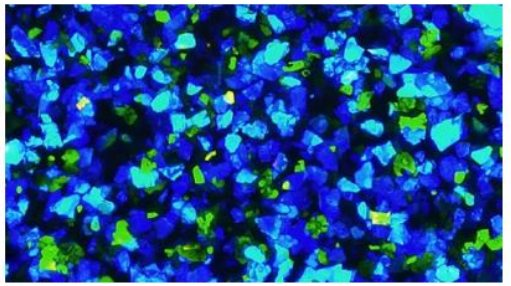
1 of 28

AC 2715
SEA JEWEL

COLOR CHANGE



MICROSCOPIC PHOTOGRAPHY



RECIPE

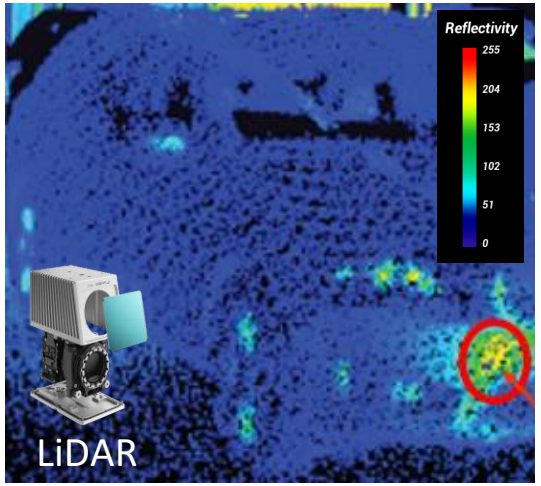
Hostaperm® Blue BT-728-D >	**25.00%**
Hostaperm® Blue BT-729-D >	**25.00%**
Edelstein CFX Sunstone Champagne >	22.00%
Edelstein CFX Topaz Orange >	6.00%
Xirallic® NXT M260-30 SW Leonis Gold >	22.00%

PIGMENTATION LEVEL

Pigment in wet paint	6.7%
Pigment to binder ratio	32.0%

NIR REFLECTANCE

900 nm	54.9%
1550 nm	75.4%
Flop Index	29.0
L [-15°]	70.2

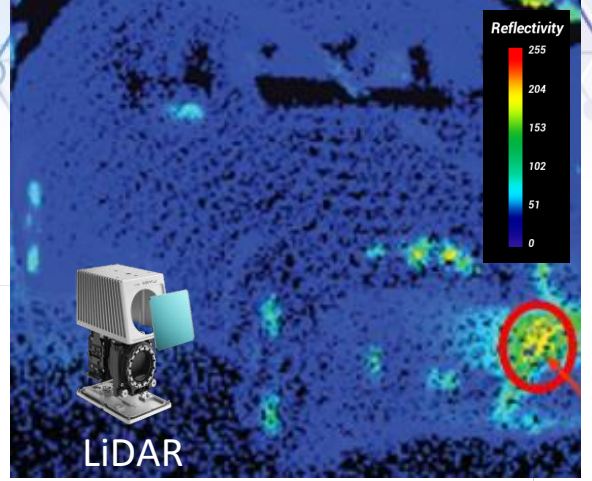


What is Visibility?

Commercial Silver Metallic Car

Visible by day

POV visibility decreases exponentially with increasing angle of incidence by night



POV visibility decreases exponentially with increasing angle of incidence: Night & DAY!

For any Point-of-View (POV):
>99% curved surface area

Only <1% is very visible to POV:
(near) perpendicular to vision and light source:
Perpendicular Single POV Visibility

Angular Dependency of Visibility

Increasing visibility of traffic participants

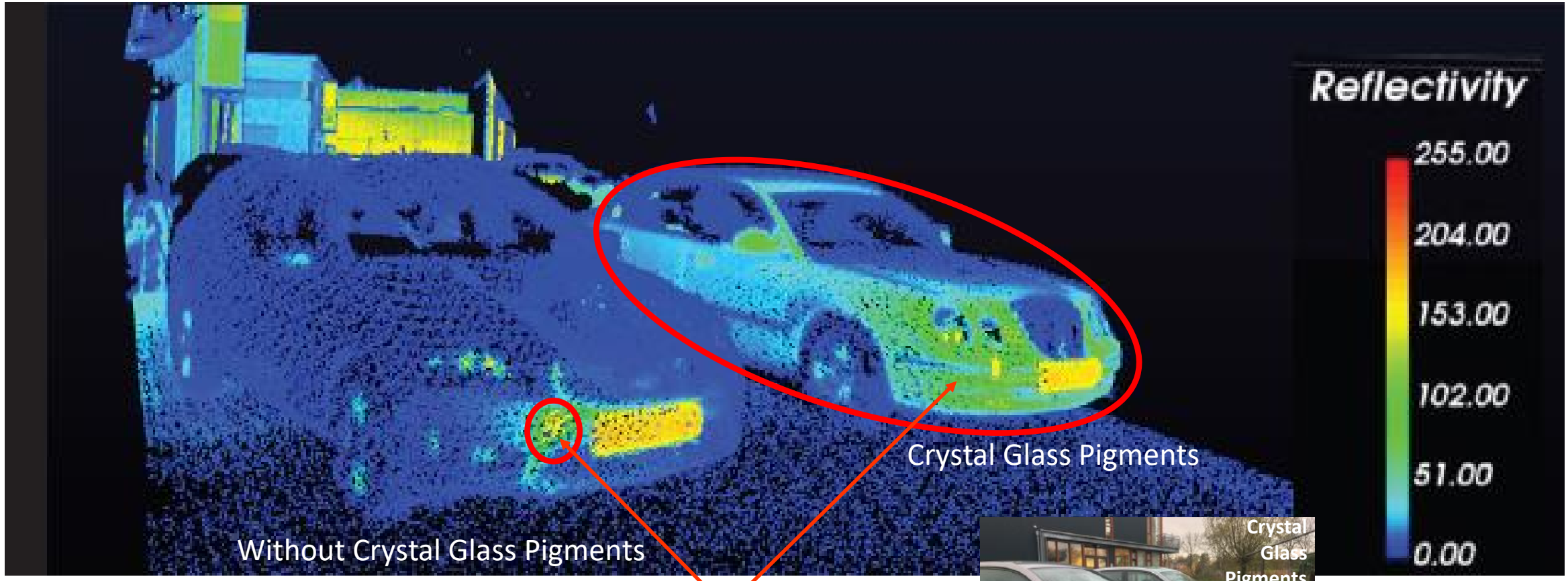
For any Point-of-View:
>99% curved surface area

Perpendicular Single POV Visibility
vs **Full Object Visibility**

Angular independency for POV
Visibility for Crystal Glass
Pigments car

Angular Dependency of LiDAR Visibility

Crystal Glass Pigments Effect demonstrated in NIR (LiDAR: 905 nm)



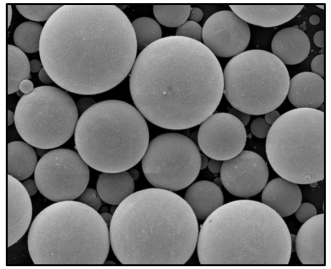
TELE-15 LiDAR results at 20 meters (LiVox)

LiDAR

Perpendicular Single POV Visibility vs **Full Object Visibility**

Crystal Glass Pigments for Automotive and Mobility Applications

- Perfectly round Crystal Glass Microspheres
- Water-based (WB) Dispersions (60w% solids)
- Solvent Based (SB) Dispersions (CAS 112-07-2: BGA) (70w% solids)
- Density dispersions: ~1.9 kg/liter
- Pigment Particle density: ~4.5 kg/liter
- C-Type: Coatable (for use with clear coat)
- N-Type: Non-Coatable (effect disappears with clear coat)
- X: Extra Effect – more light reflection, non-'X'-versions give more 'colored' return



Type
Coatable - Mobility
Non-coatable
Non-coatable Extra

Size Version	Particle Size D50 (µm)	Particle Size D90 (µm)
Size 1 - OEM	5	8
Size 2 - Aftermarket	7	11
Size 3 - VRU	10	16
Size 4 - Mobility	20	27
Size 5 - Mobility	25	35
Size 6 - Mobility	40	45

D_{100} sharp top cut-off:

- OEM: $D_{100} < 10$ micron
- Aftermarket: $D_{100} < 15$ micron
- VRU: $D_{100} < 25$ micron

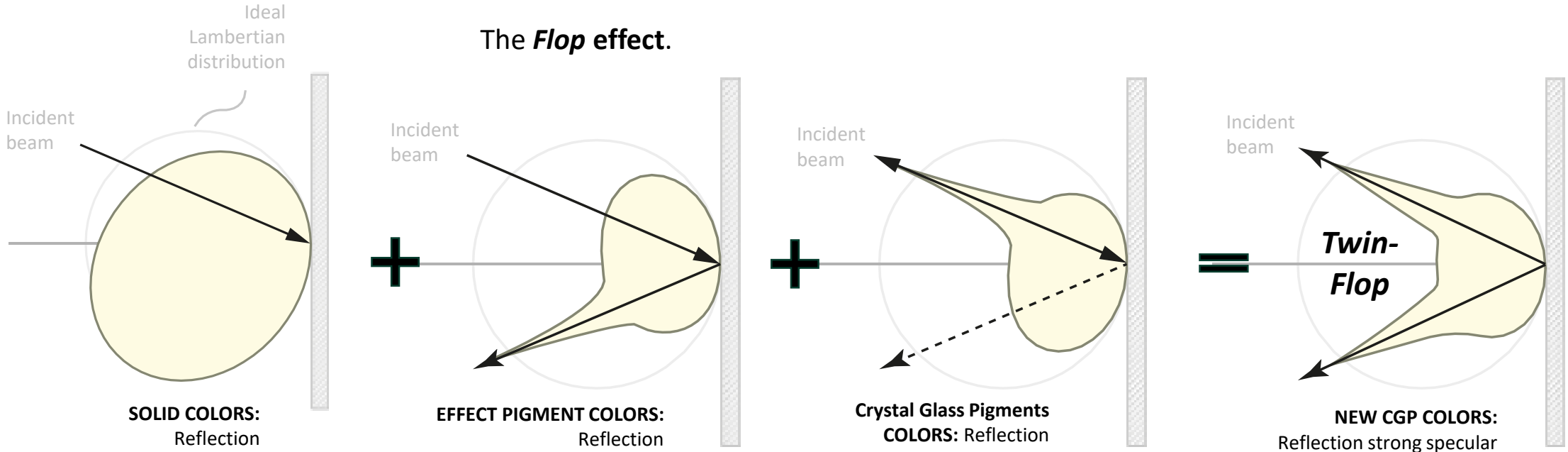
Crystal Glass Pigments (CGPs) Dispersions

An Industry Tested Trend – already being used in new color stylings

- A new class of Effect Pigments (Crystal Glass Microspheres)
- Used best in combination with metallic or pearlescent pigments (flakes)
- Stable aqueous and solvent-based liquid dispersions
- Easy-to-use stir-in products for paint and coatings
- High-end result *(thin layer, homogenous effect, high coverage)*
- Compatible with existing industrial production processes, infrastructures and application methods (high speed bell, disk spraying, robotic, refinish, etc.)
- Industry standard QC validated *(adhesion, hiding power, scratch-resistance, UV, humidity, salt water, etc.)*
- Automotive OEM manufacturer tested automotive grade at 0, 10 and 20% addition in standard automotive silver - all with the same good QC results

Crystal Glass Pigments introducing Twin-Flop

The ***Flop*** **effect**.



SOLID COLORS:
Reflection
strong diffuse component

Diffuse Reflection

EFFECT PIGMENT COLORS:
Reflection
strong specular component

Effect Pigment Reflection

Effect Pigments can decrease POV Visibility.

Crystal Glass Pigments COLORS: Reflection
strong return component

Crystal Glass Pigments Reflection
(high Crystal Glass Pigments %)

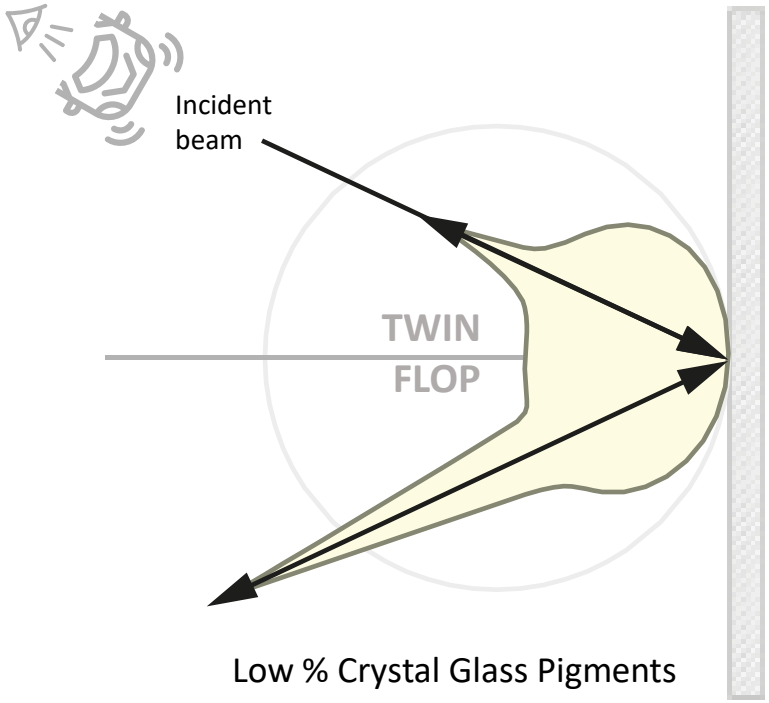
Crystal Glass Pigments increase POV Visibility.

NEW CGP COLORS:
Reflection strong specular
and return component

Twin-Flop Reflection
Effect Pigment + Crystal Glass Pigments
(low Crystal Glass Pigments %)

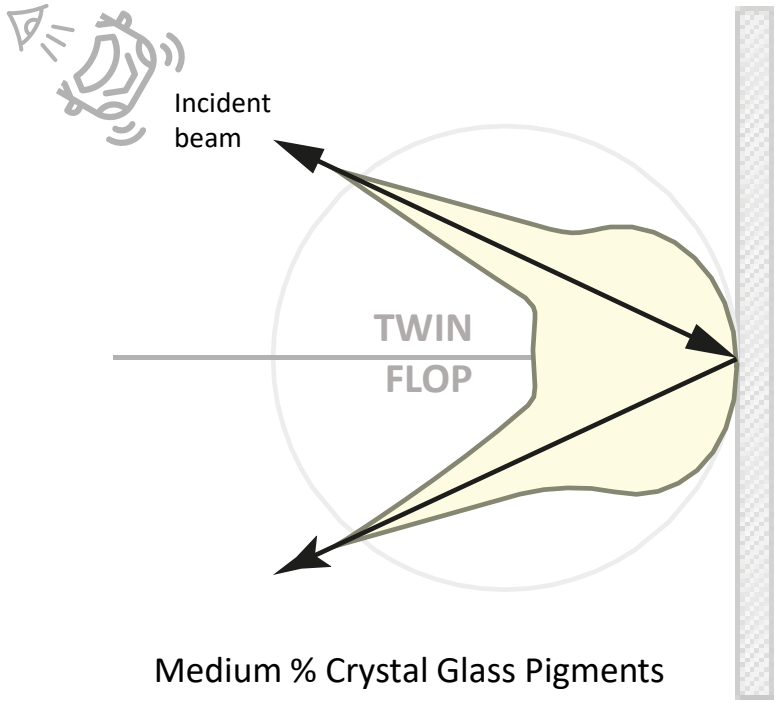
The *Twin-Flop* Effect - Crystal Glass Pigments increase POV Visibility.

Twin-Flop: Crystal Glass Pigments Tunable Detection & Determination (TDD™) Technology



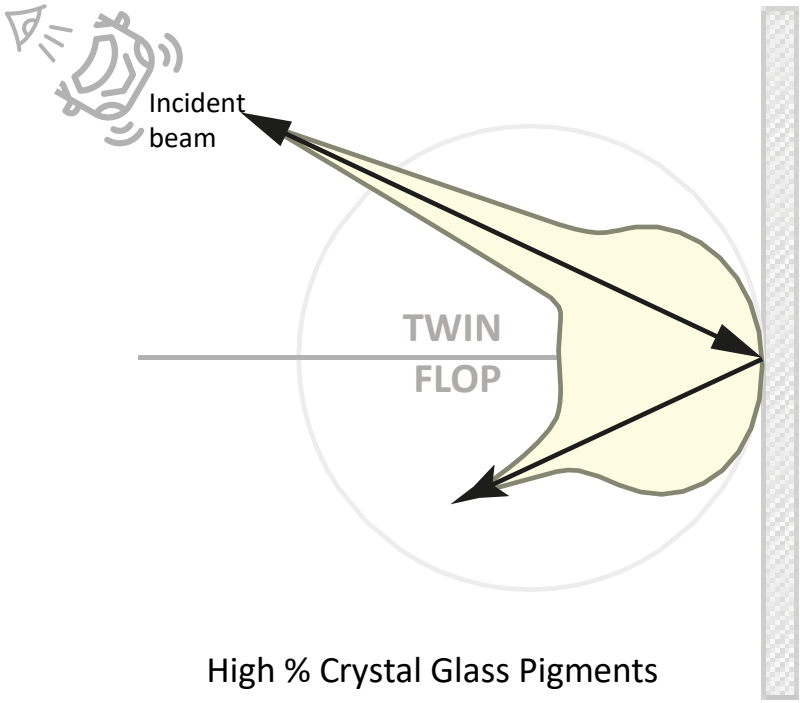
Low % Crystal Glass Pigments

Increasing AIPOV-Visibility
By adding low Crystal Glass Pigment Concentrations For Automotive



Medium % Crystal Glass Pigments

Twin-Flop

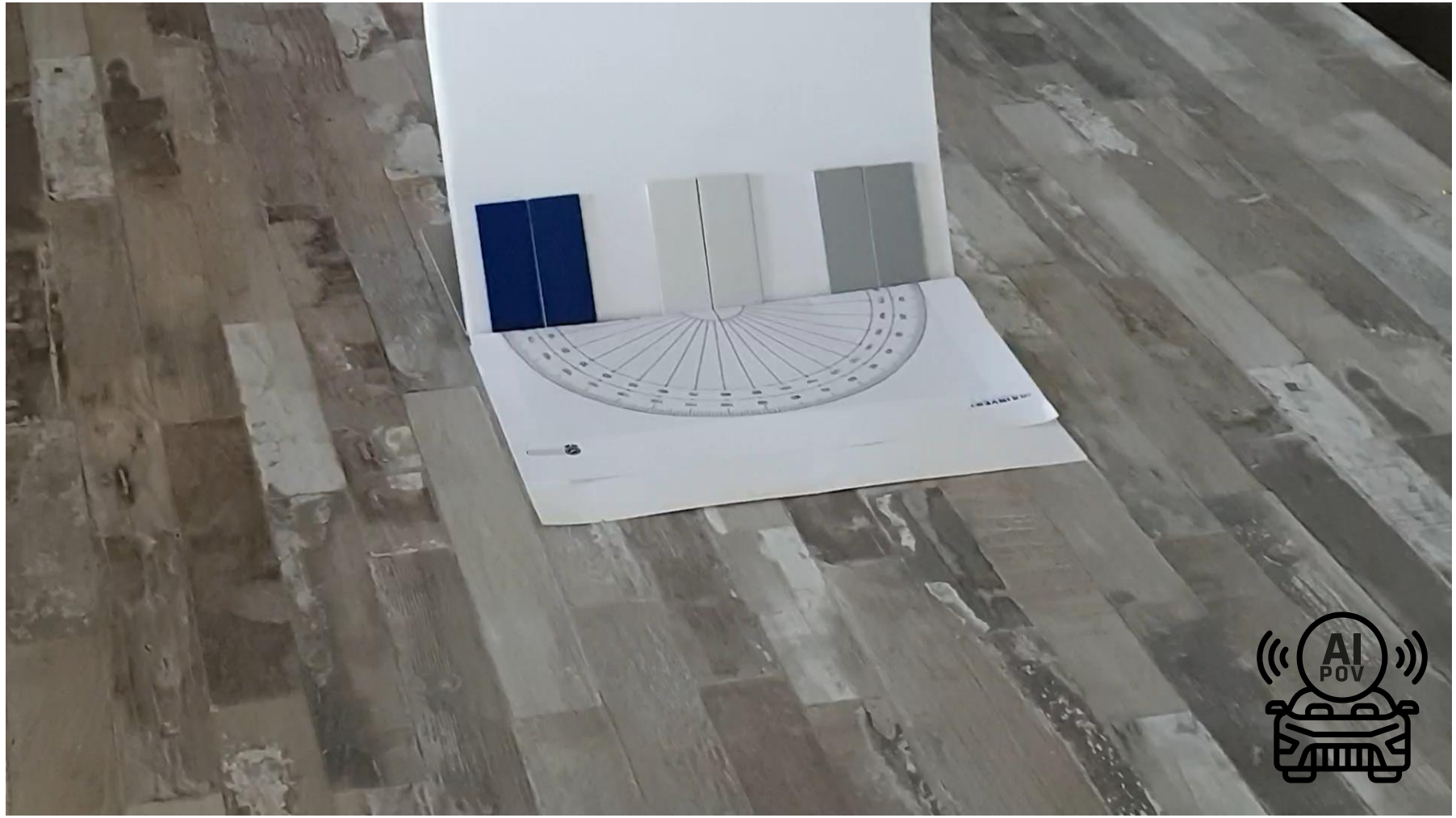


High % Crystal Glass Pigments

Increasing AIPOV-Visibility
By adding larger Crystal Glass Pigment Concentrations for Vulnerable Road Users (Bikes)

Crystal Glass Pigments increases AIPOV Visibility

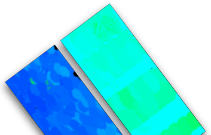
Under increasing angles of surface orientation – Angular Independent Point-of-View Visibility (AIPOV)

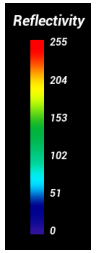


Blue, white and grey panels: left without Crystal Glass Pigments and right with Crystal Glass Pigments

Increased AIPOV Visibility - in contrast to Perpendicular **Single** Point-of-View Visibility of effect pigment colors: **Crystal Glass Pigments support Full Object Visibility**.

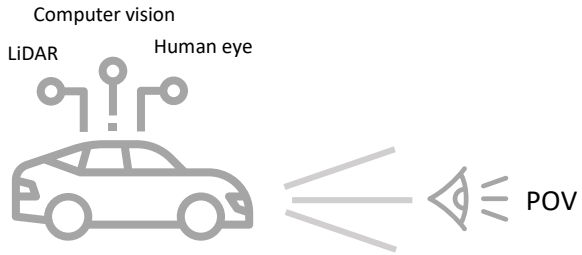
LiDAR Visibility does not need a light source. It sends and receives its own laser signals and sees Crystal Glass Pigment enhanced objects better during day and in the dark.



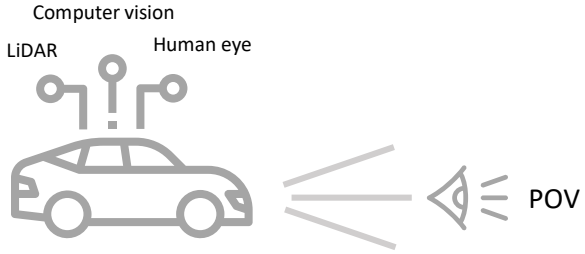


LiDAR

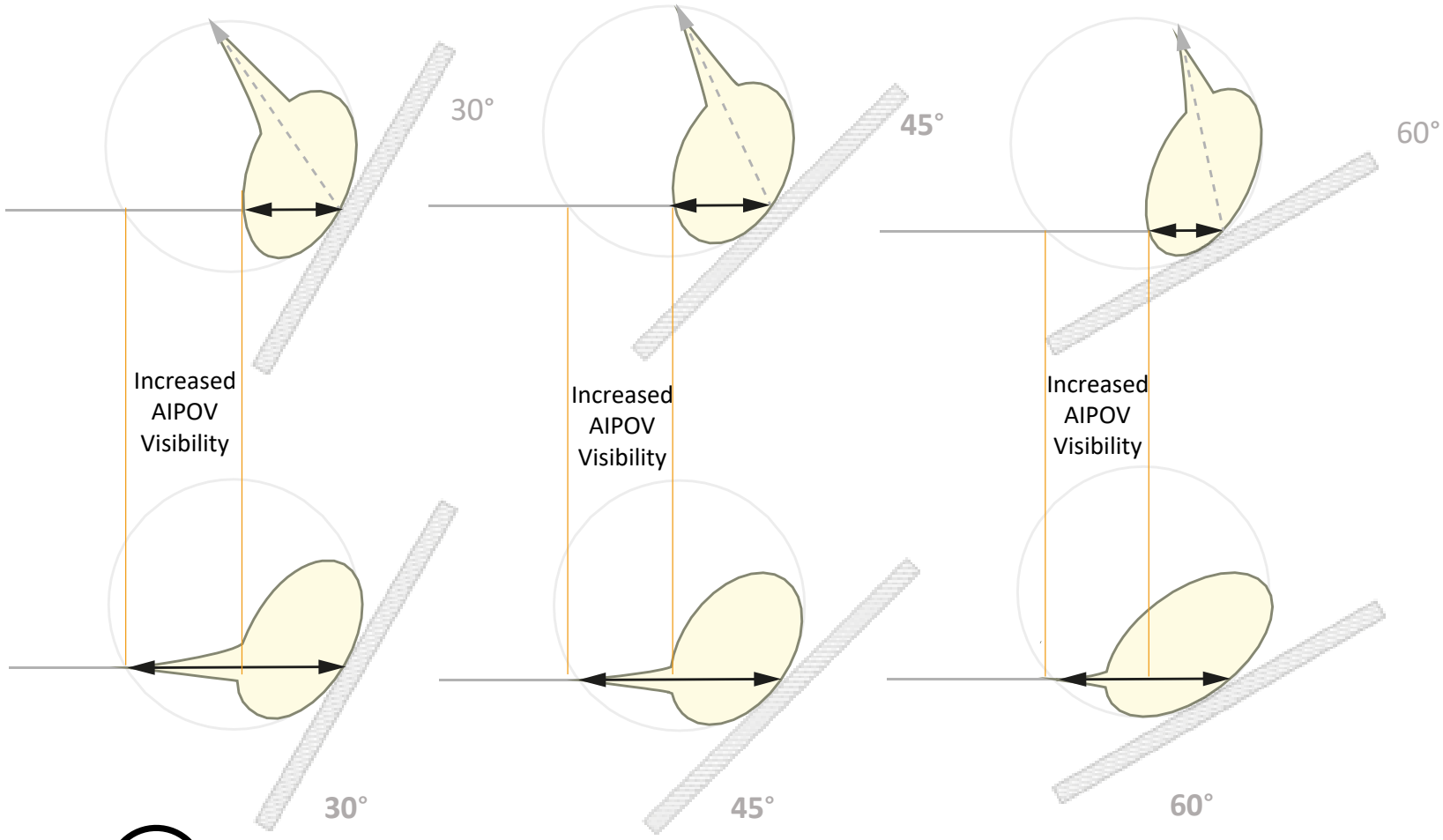
Crystal Glass Pigments Effect: **AIPOV Visibility**

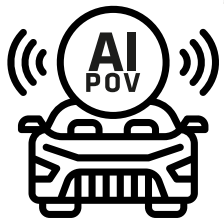


Mode of Action:
High Flop-Index colors



Crystal Glass Pigments
Enhanced colors



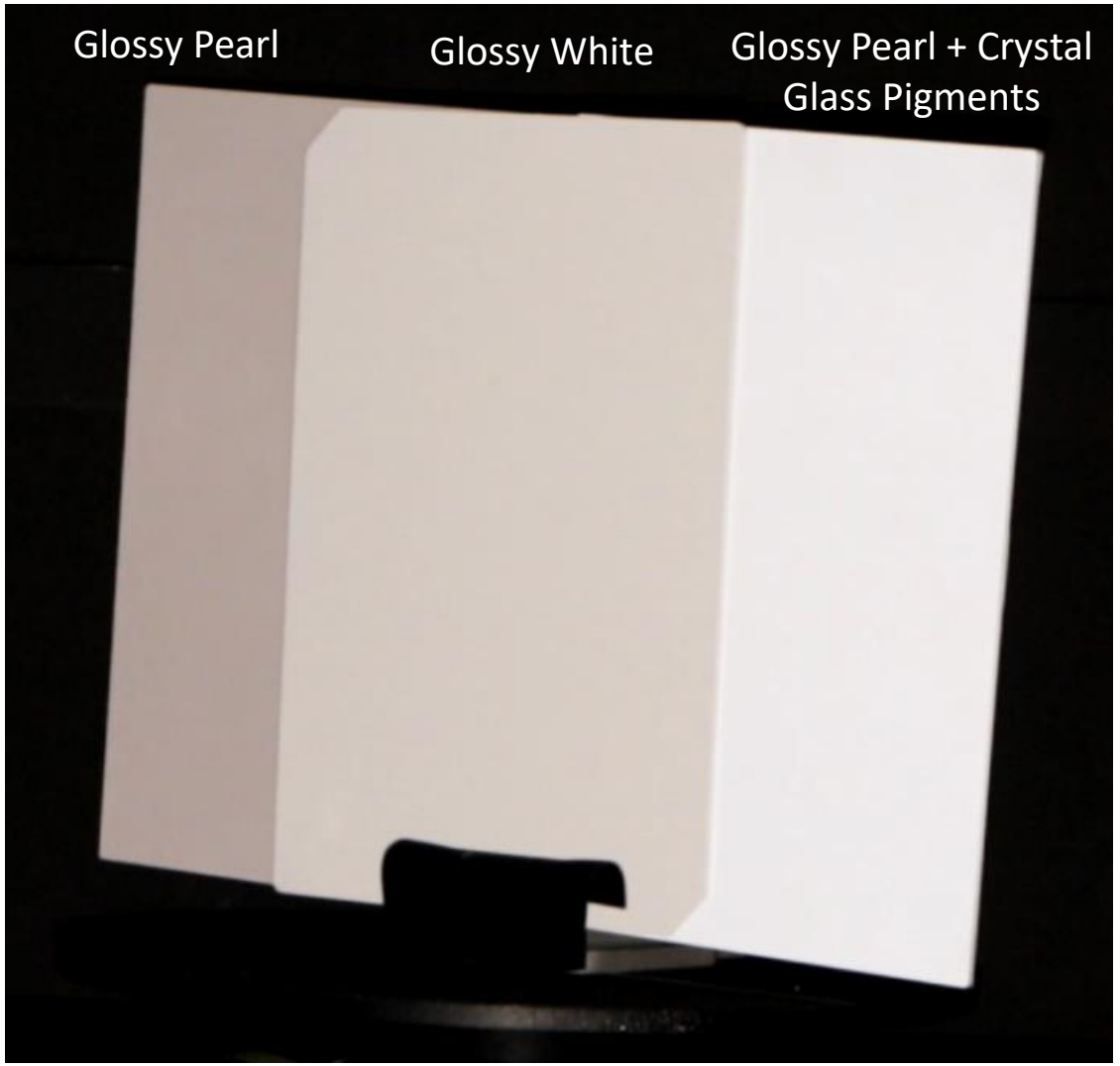


Angular **I**ndependent **P**oint-**o**f-**V**iew
(AIPOV) Visibility

Crystal Glass Pigments Color Development

The world's Whitest White with Crystal Glass Pigments

Three different white panels under an angle with camera and light source aligned.



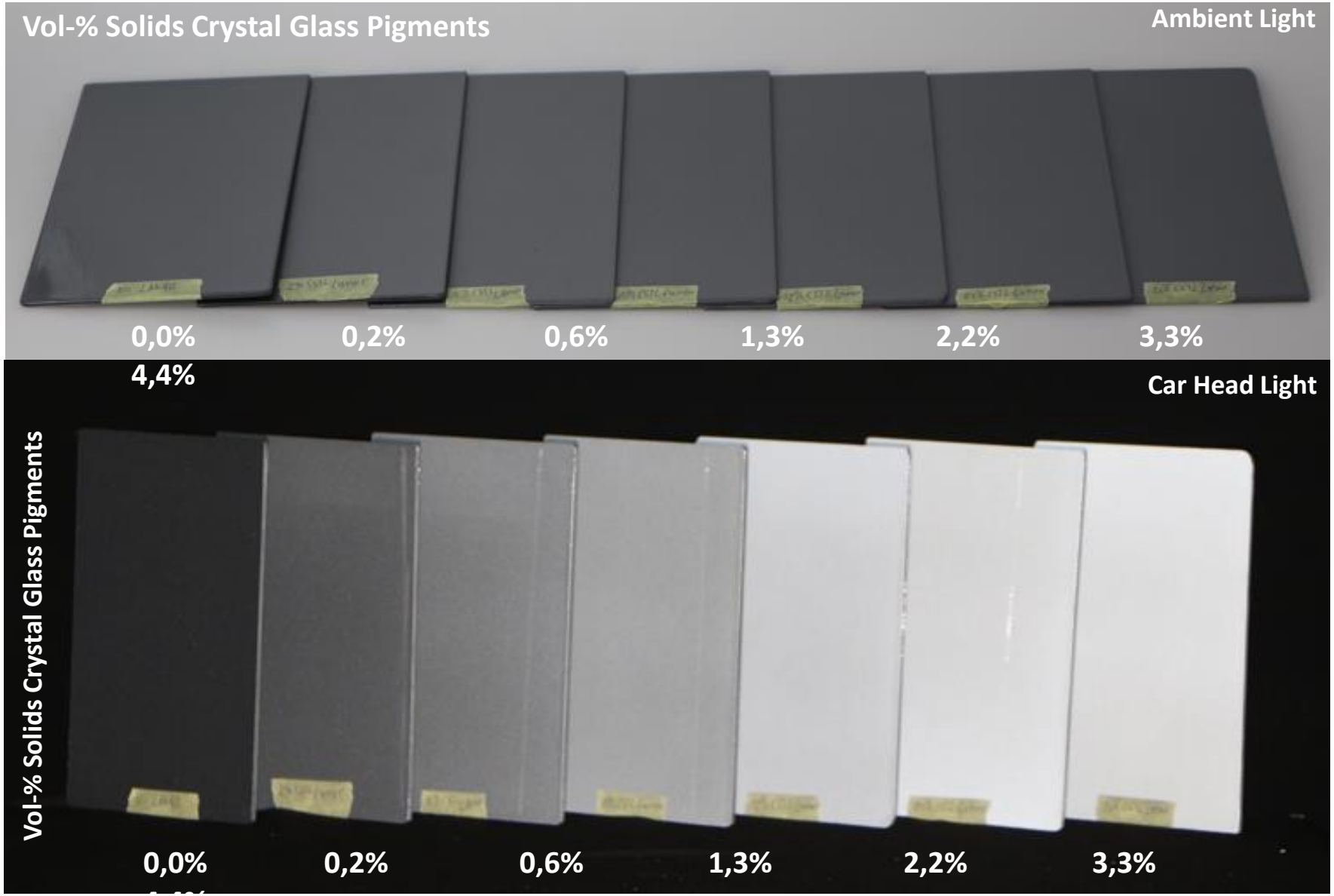
Crystal Glass Pigments create a new aesthetic effect a new color emotion:

Emboldened by a 'Visual Soft Touch'

Once you've seen it, you want to see it again and again:

'Addictive Beauty'

Increasing Crystal Glass Pigments % - Silver Metallic



OEM Grade: average particle size <5 micron.

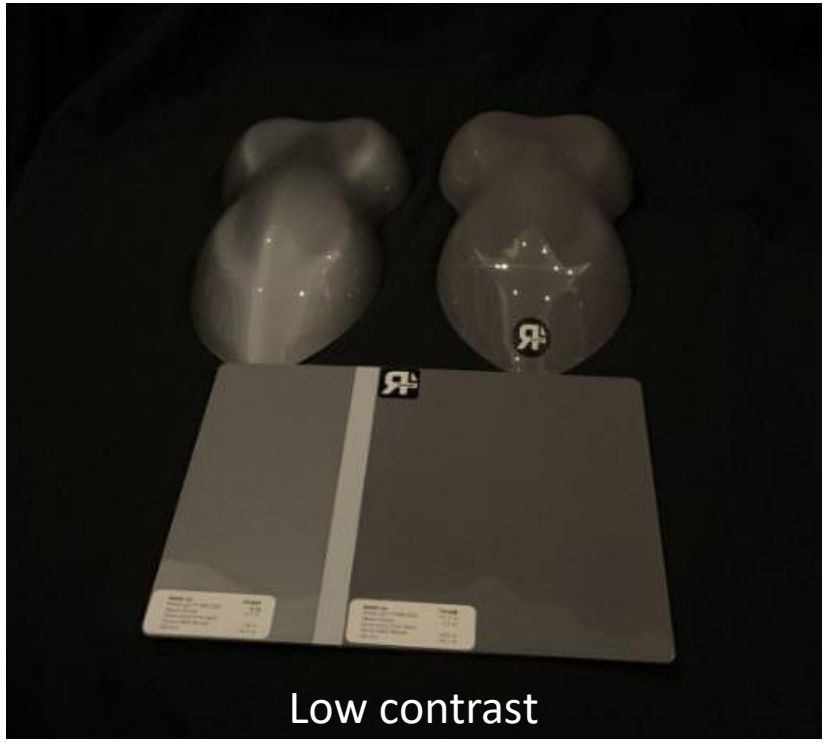
Under ambient diffuse lighting conditions Visibility the same?

Under focused lighting conditions visibility very different

Crystal Glass Pigments Color Development

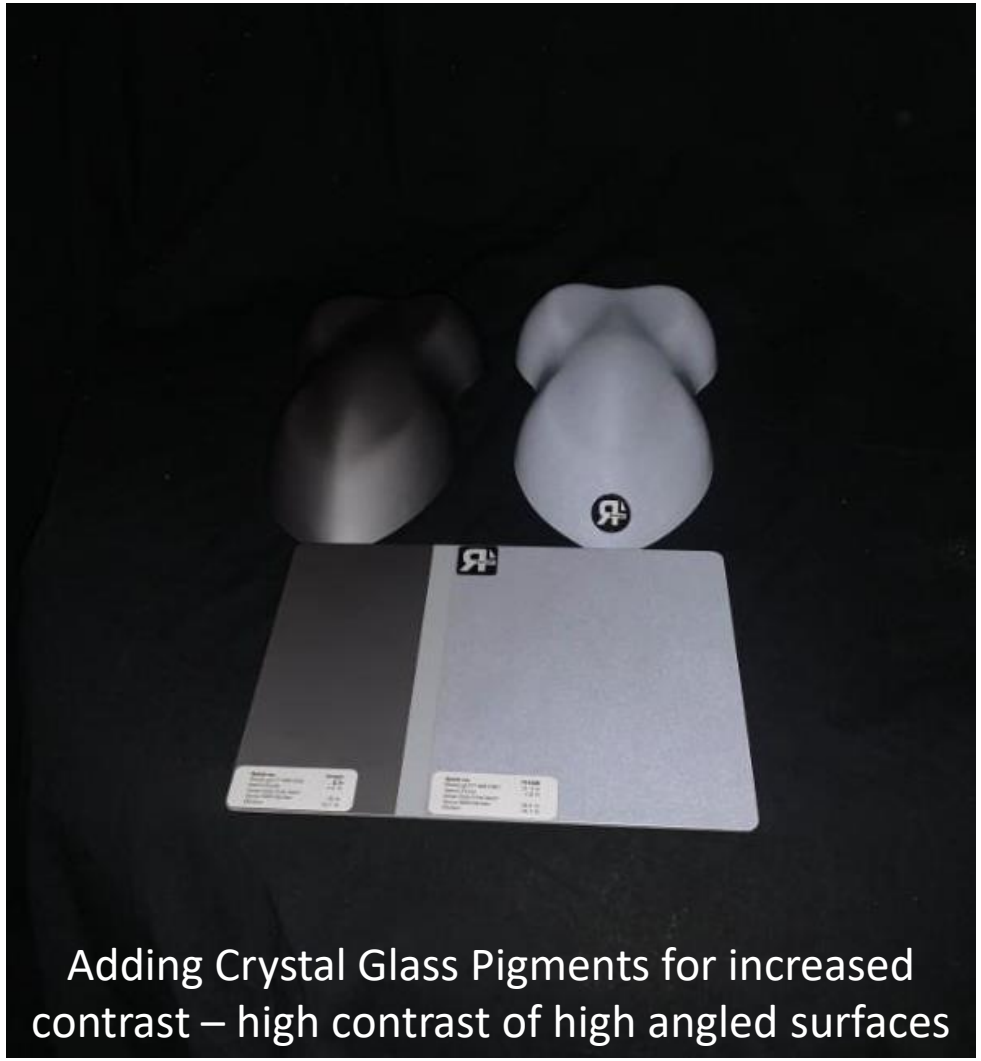
Sparkly Silver – POV Contrast Improvement

No focused Light



Low contrast

In the Sun or Focused Headlights



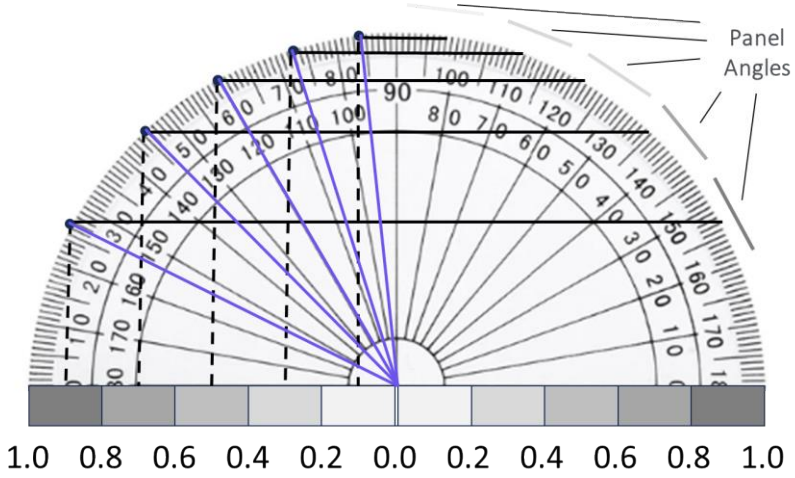
Adding Crystal Glass Pigments for increased contrast – high contrast of high angled surfaces

Five steps to calculate 3D PoV Visibility Label

Of complex shapes

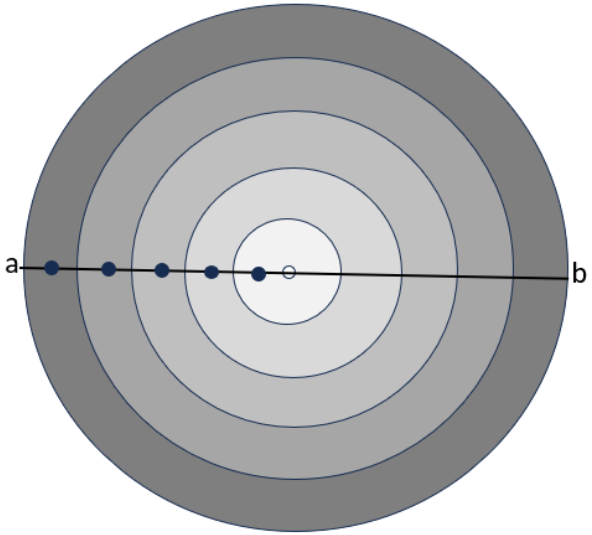
1. Complex Shape

2. Representative shape



3. Measure Visibility of flat panel under angles

4. Correct for ring area reflecting that visibility



Concentric Ring	Area of Concentric Ring
0.0-0.2	4%
0.2-0.4	12%
0.4-0.6	20%
0.6-0.8	28%
0.8-1.0	36%
Total	100%

5. Calculate Visibility Parameters for:
- Human Vision
- Computer Vision
- LiDAR Visibility

AIPOV Visibility base for 3D PoV Visibility Label

VisibilitySavesLives.org

Voluntary Visibility Label

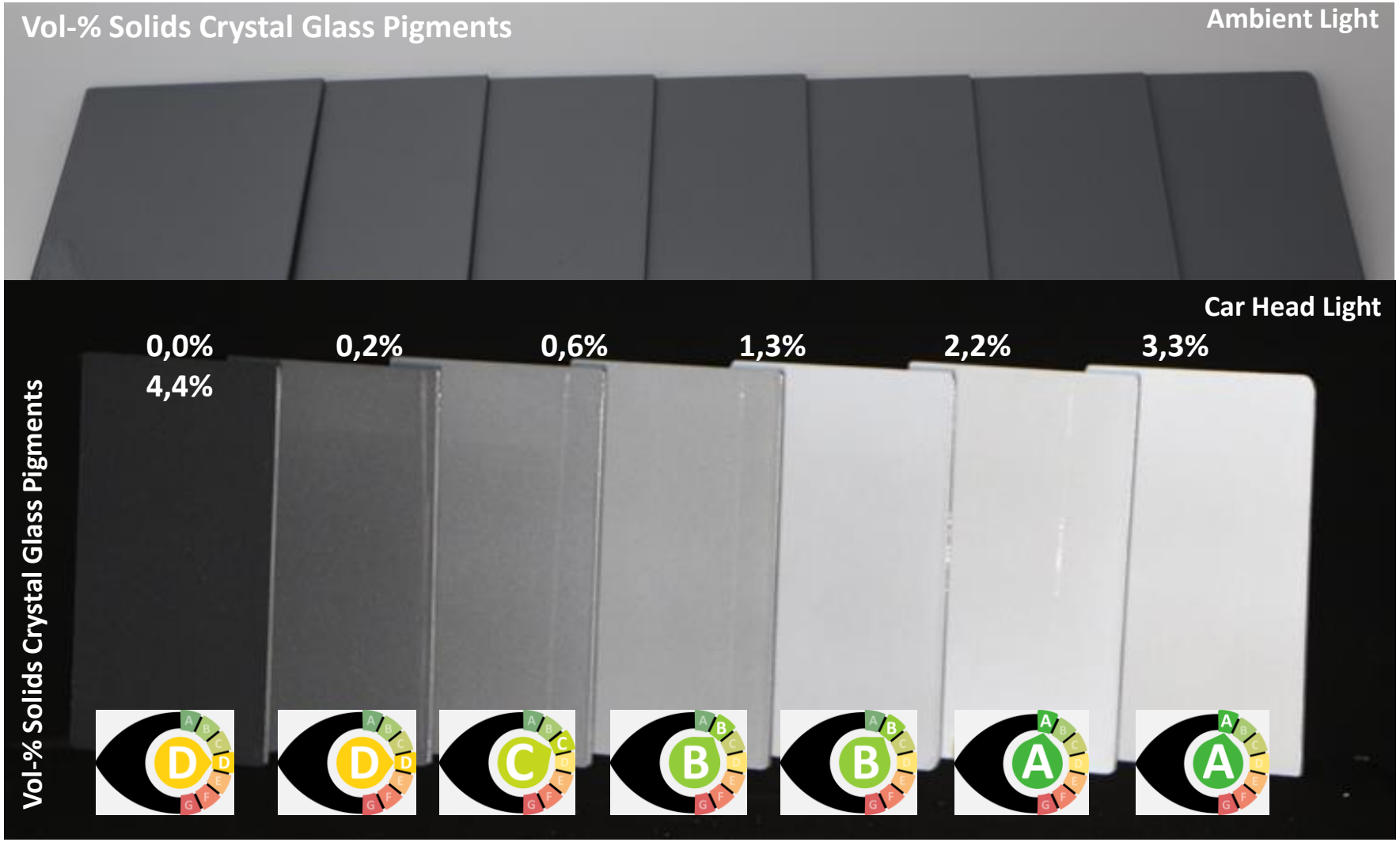
EU-Style for Road Users

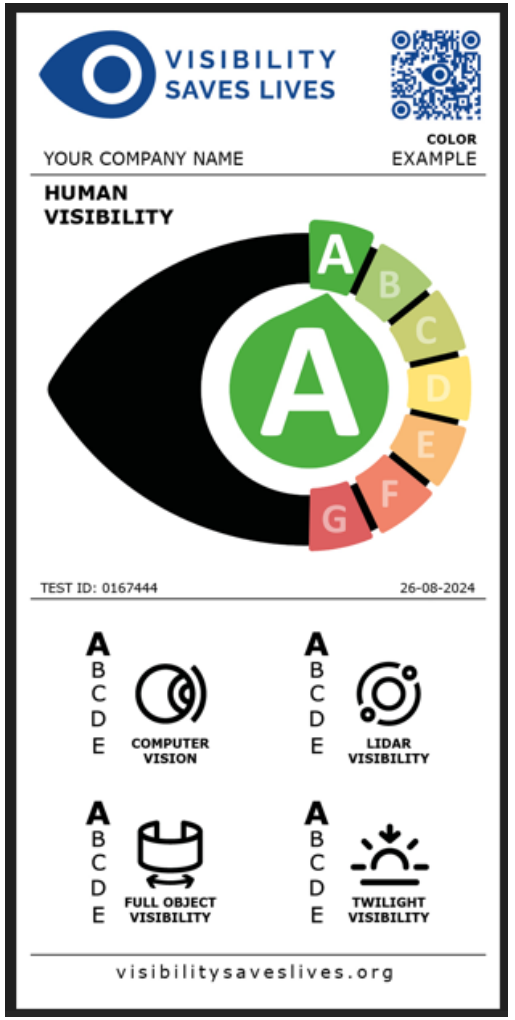
Minimum ‘F’-grade

Target ‘D+’

‘A’-grade highest 3D PoV visibility

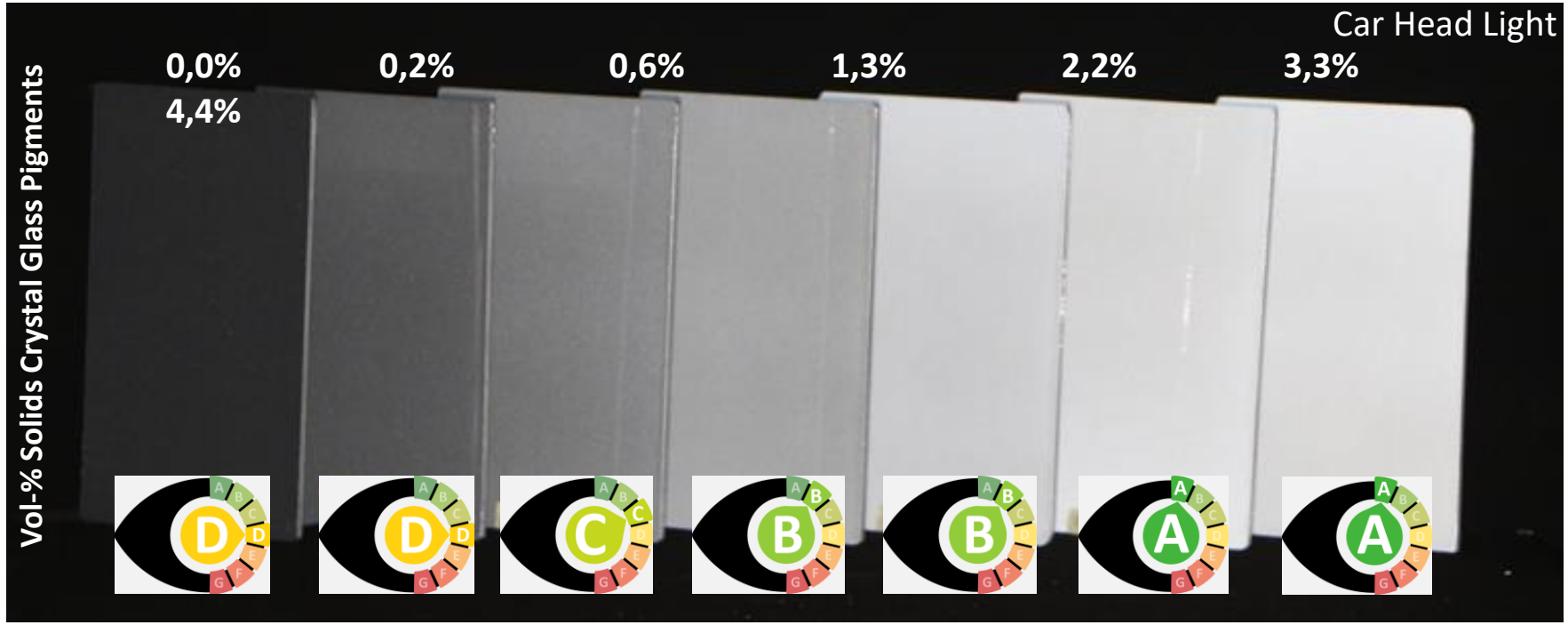
Increasing Crystal Glass Pigments %

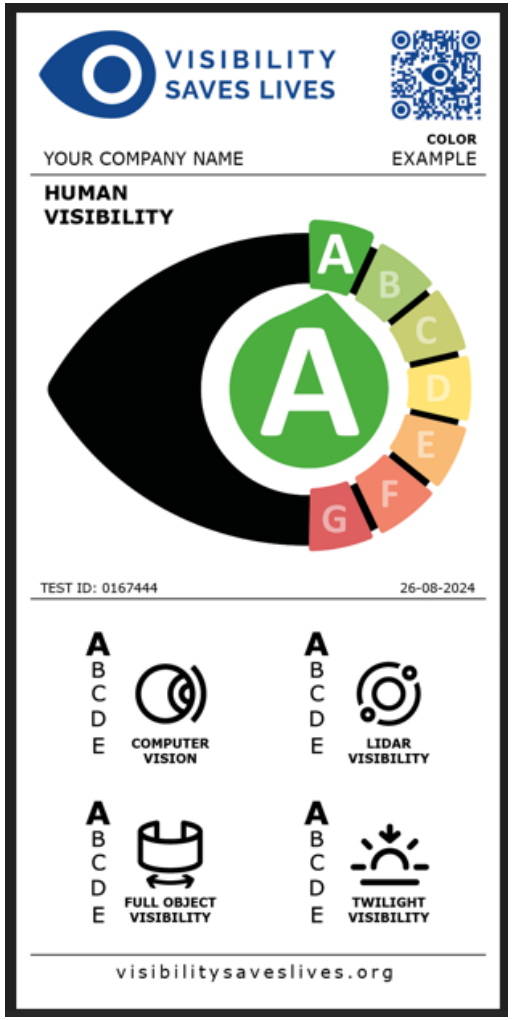




AIPOV Visibility Label: 5 parameters

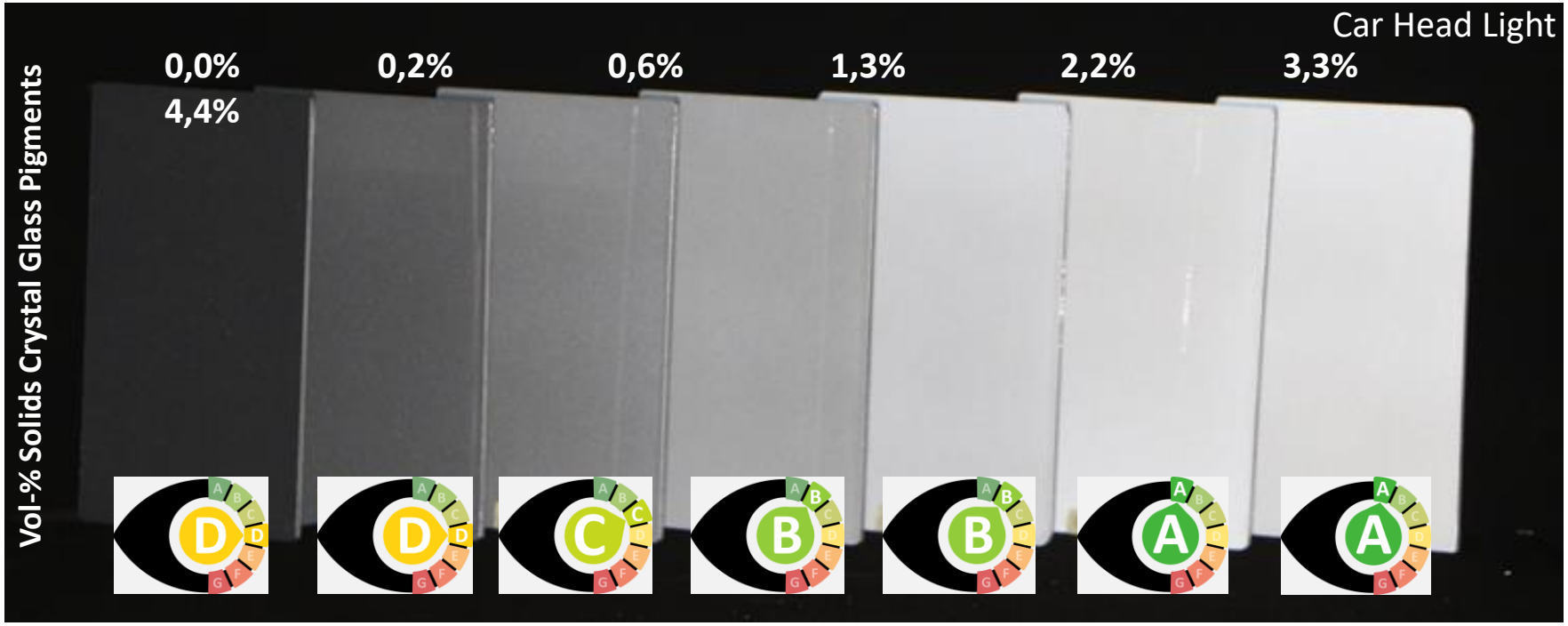
Visibility Label (100 LUX)	Reference White Gloss xtra topcoat	Lunar Silver	Lunar Silver RL	Lunar Silver RL	Lunar Silver RL	Lunar Silver RL	Lunar Silver RL	Lunar Silver RL
%RheoLight	0	0	2	5	10	17	24	31
hum 100 5r	A	D	D	C	B	B	A	A
Cam avg 100/3.2 5r	A	C	C	C	B	B	A	A
LiDAR 5r	A	B	B	B	B	A	A	A
HAC avg 100/3.2 3r	A	D	C	B	B	A	A	A
Low Light 3.2 4r	A	C	C	C	B	B	A	A

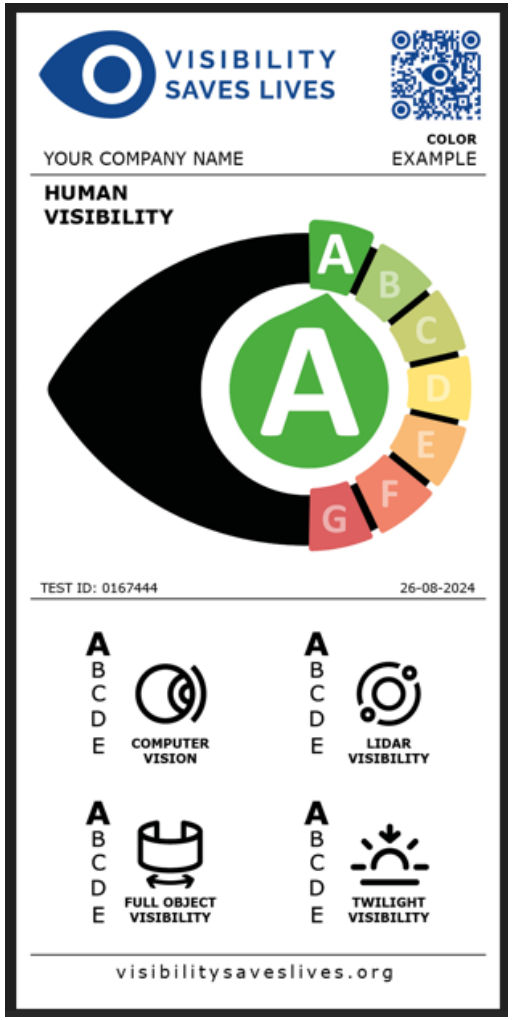




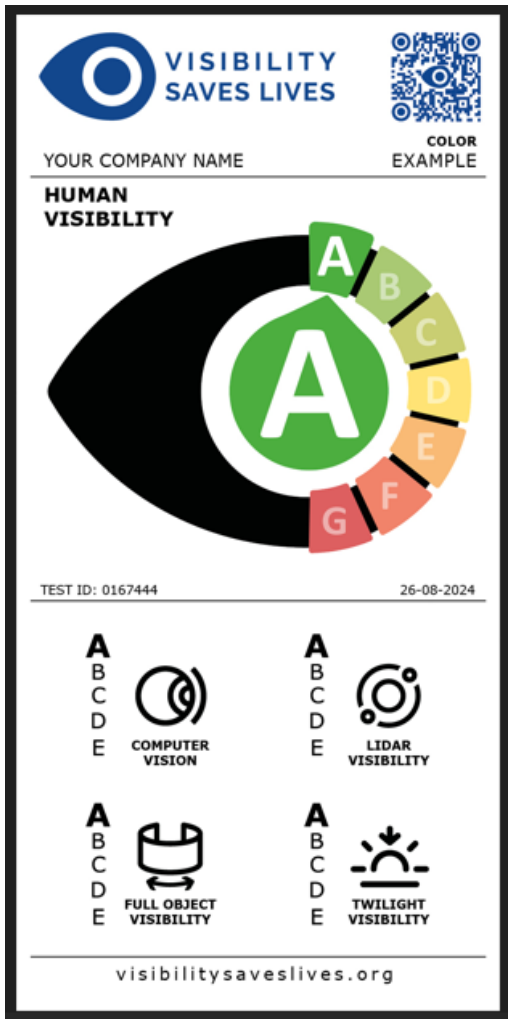
AIPOV Visibility Label: 5 parameters

Visibility Label (100 LUX)	Reference White Gloss xtra topcoat	Lunar Silver	Lunar Silver RL	Lunar Silver RL	Lunar Silver RL	Lunar Silver RL	Lunar Silver RL	Lunar Silver RL
%RheoLight	0	0	2	5	10	17	24	31
hum 100 5r	13,6	1,0	1,3	1,9	3,0	4,9	6,5	8,3
Cam avg 100/3.2 5r	5,7	1,0	0,9	1,2	1,7	2,6	3,2	4,2
LiDAR 5r	3,4	1,0	0,9	1,1	1,4	1,9	2,0	2,5
HAC avg 100/3.2 3r	12,9	1,0	2,1	3,6	5,6	7,1	7,9	8,7
Low Light 3.2 4r	9,1	1,0	0,9	1,5	2,6	4,2	5,2	7,0





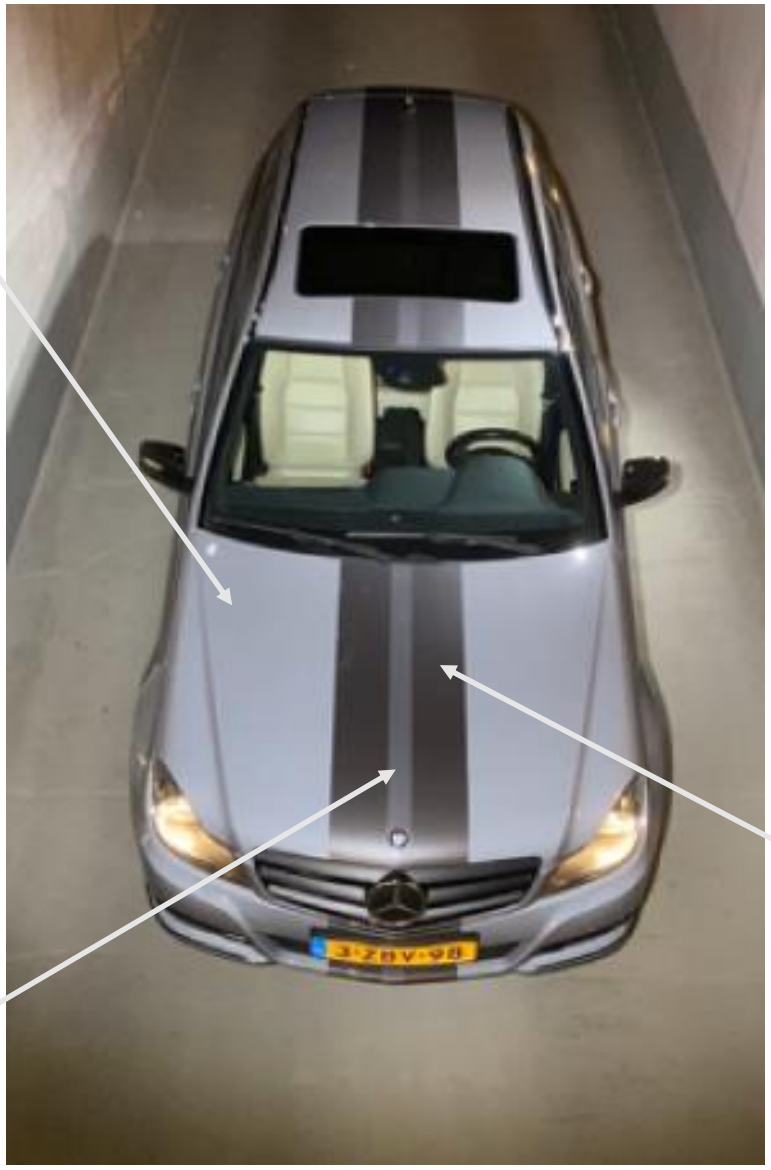
CGP's to help increase visibility by night and day



Influence your 3D PoV Color Visibility

'Addictive Beauty' in Sunlight

Tungsten + 20% Crystal Glass Pigments



Tungsten + 5% Crystal Glass Pigments

Focused Lighting

Daylight Ambient Lighting

Color: Tungsten

Tungsten Original

Crystal Glass Pigments: Safety made Beautiful!

One look is never enough

- Addictive Beauty
- Safety integrated in color design
- Industrially applicable
- Commercially viable
- Including for VRU’s

(Vulnerable Road Users)

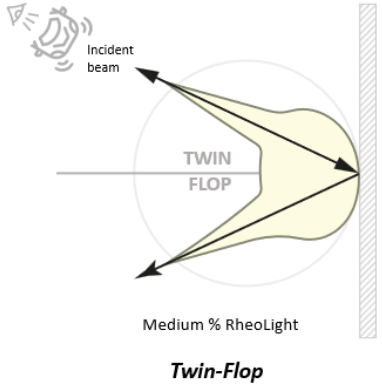
providing

Safety for all

Comparison Automotive with and without Crystal Glass Pigments (high & low)

Which side has Crystal Glass Pigments?

Crystal Glass Pigments: Safety made Beautiful

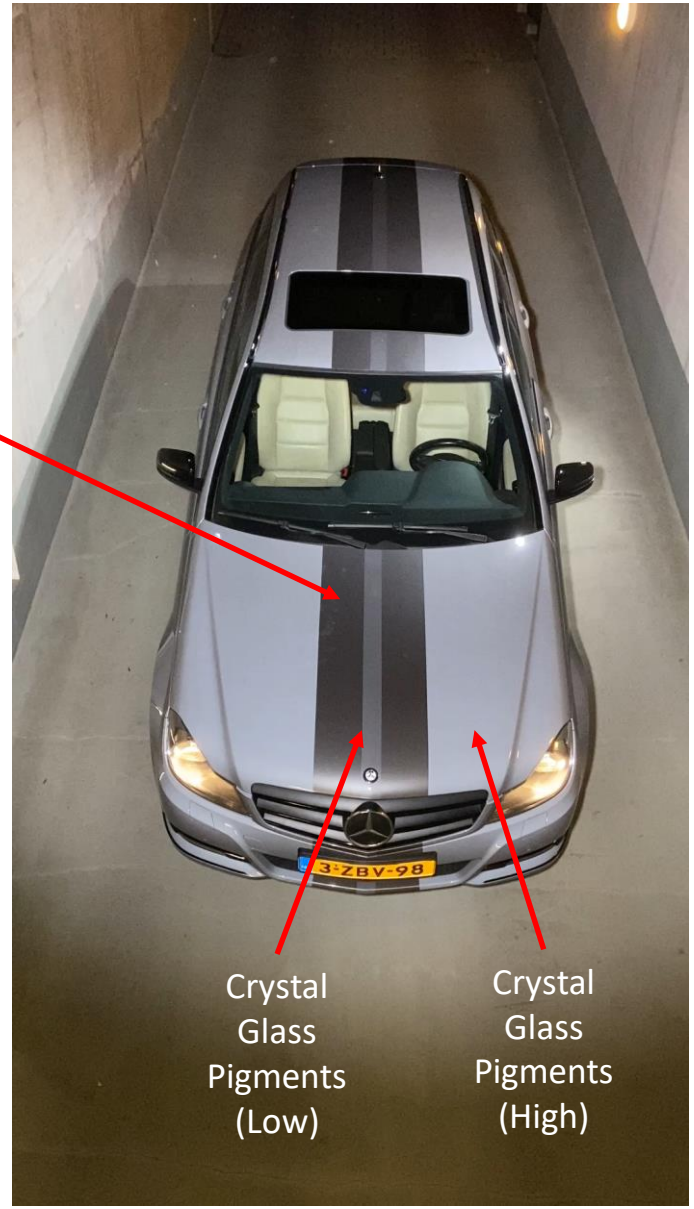


Crystal Glass Pigments (Low %)

Twin-Flop: 'Flop' or Specular Visibility: similar

Original Color

Twin-Flop: Angular Independent Point-of-View Visibility improved



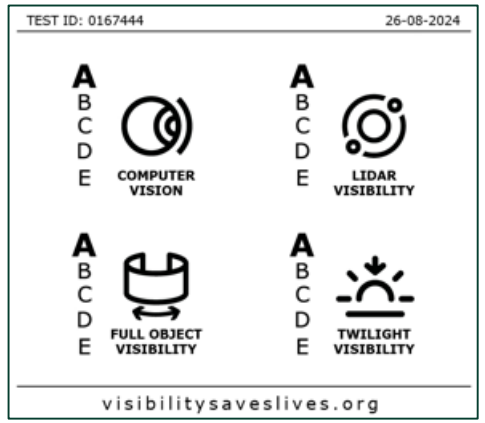
Influence your 3D PoV Color Visibility Label

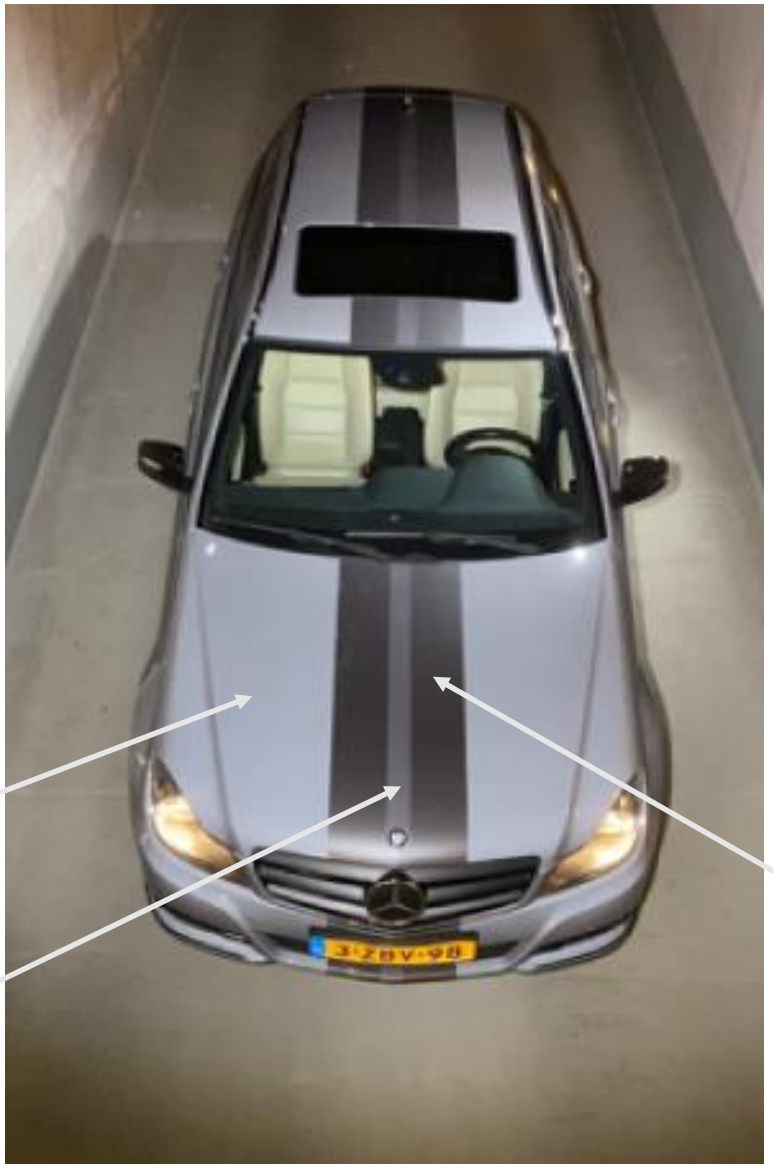
Coatings Trends & Technologies SUMMIT

Visibility Label:

- Human / **Camera** Visibility
- **LiDAR** Visibility
- Full Object Visibility
- Low Light Visibility - 3.2 Lux

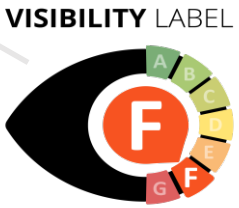
(Reference Color: Glossy Traffic White)

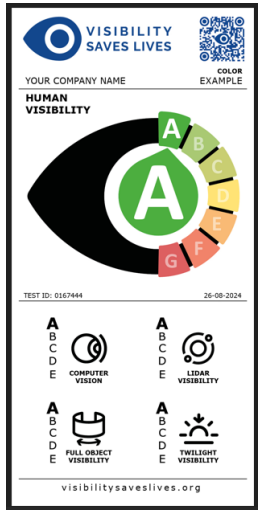




Focused Lighting

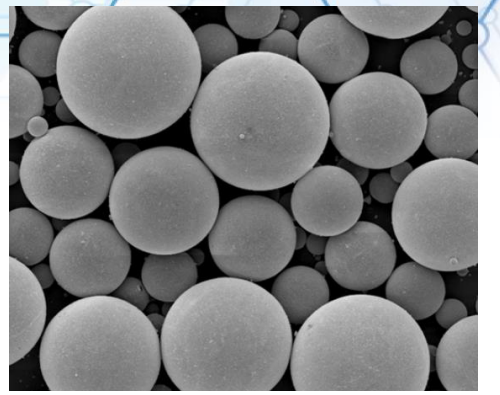
Daylight Ambient Lighting



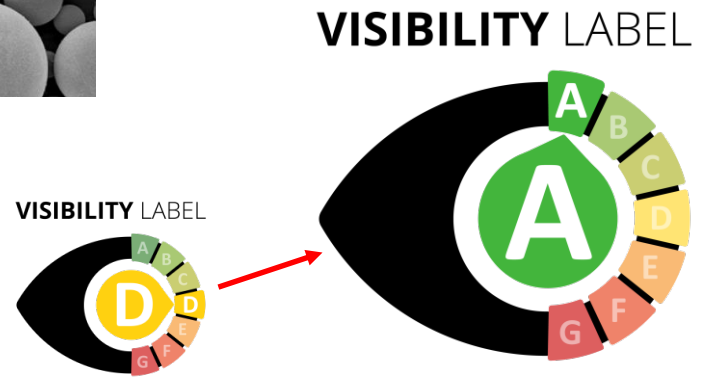


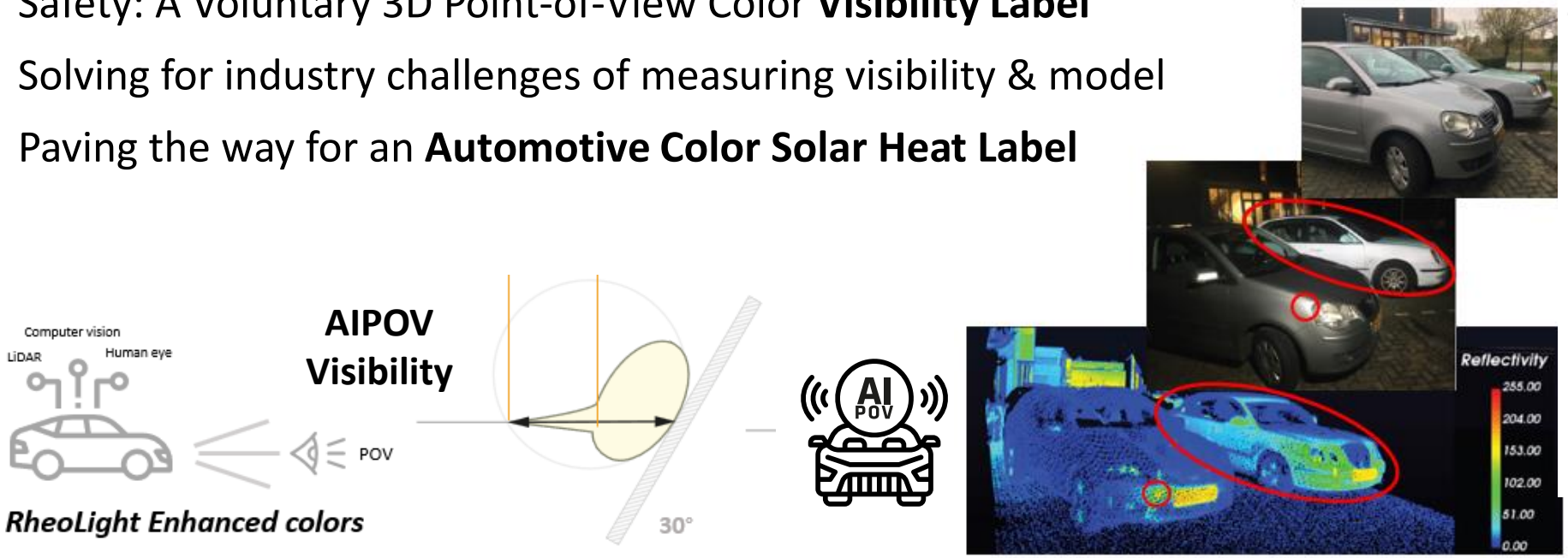
Crystal Glass Pigments

A new class of Effect Pigments

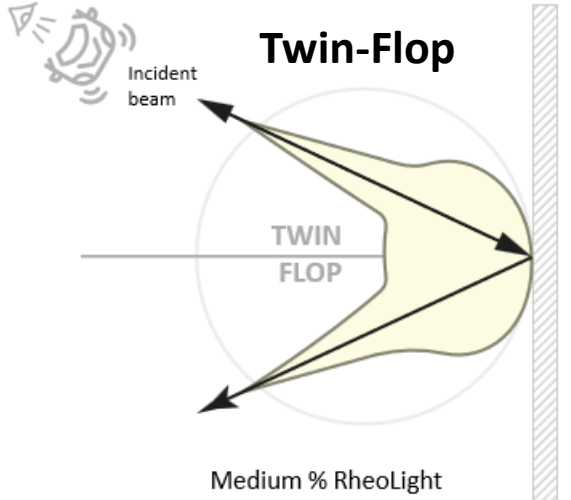


- New pigment morphology for New Colors and Effects
- Crystal Glass Microsphere Dispersions (WB/SB)
- Focus: automotive OEM/refinish and wider mobility industry
- New colors & concepts: '**Twin-Flop**' Effect and '**AIPOV**' Visibility
- Increased ADAS (**LiDAR** & Computer Vision) Visibility
- Safety: A Voluntary 3D Point-of-View Color **Visibility Label**
- Solving for industry challenges of measuring visibility & model
- Paving the way for an **Automotive Color Solar Heat Label**





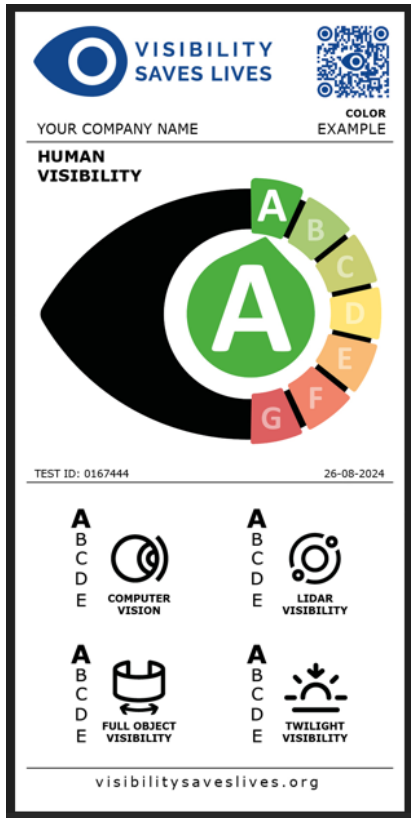
RheoLight Enhanced colors



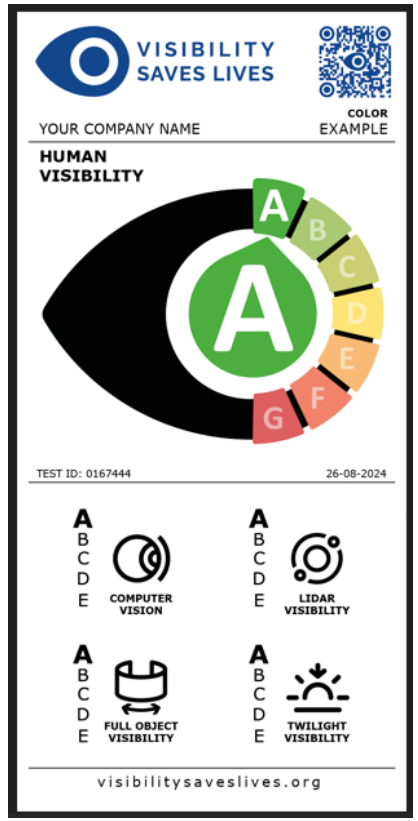
Twin-Flop

'Addictive Beauty'

Crystal Glass Pigments

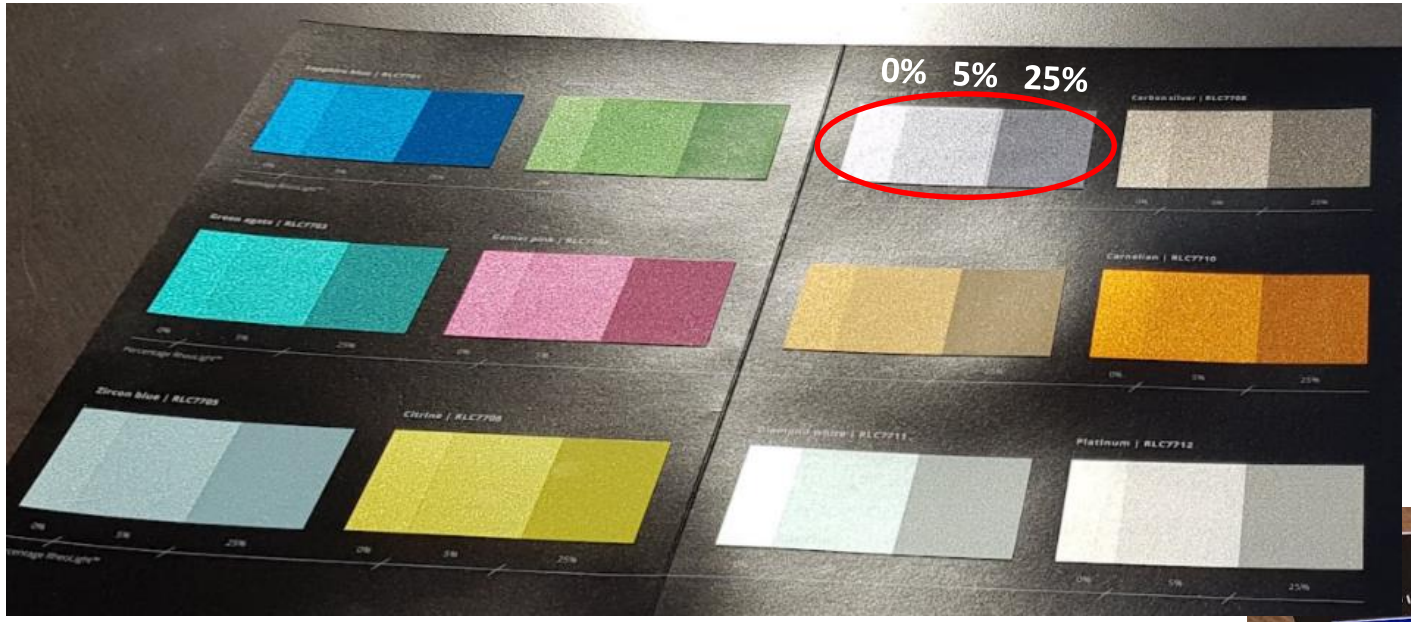


Have the Visibility of your colored coatings measured today for a Brilliant, Beautiful and more Visible & Safer World!



Crystal Glass Pigments Play with Light in a New Way

To provide an innovative & unexpected Twin-Flop Effect & Deep Sparkle



With **sunlight** in front

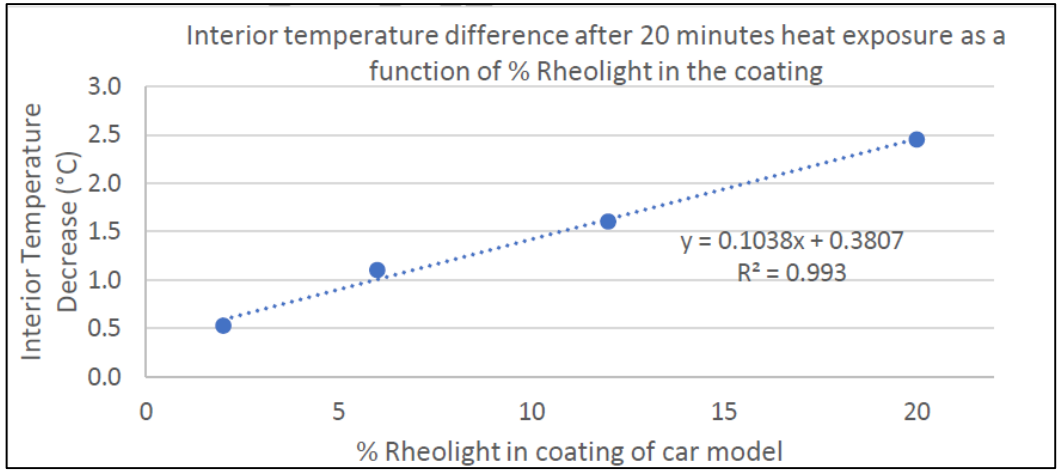
Crystal Glass Pigments Concentrations Per color from left to right:
0% - 5% - 25%
(Crystal Glass Pigments SB D50 7 micron)

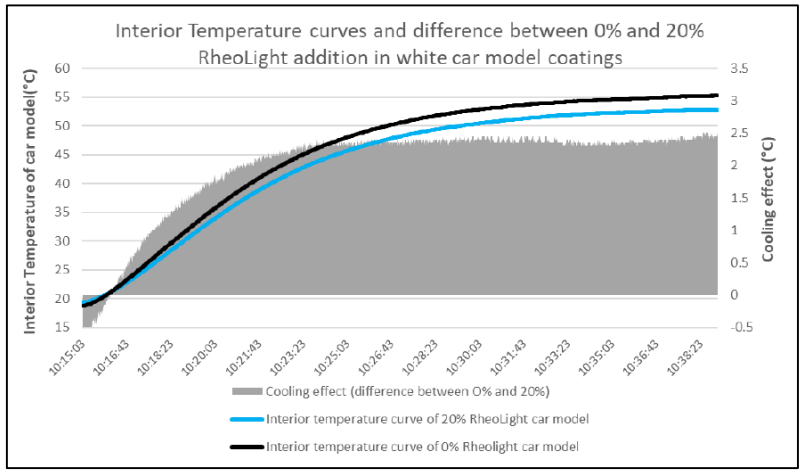
With **sunlight** at your back

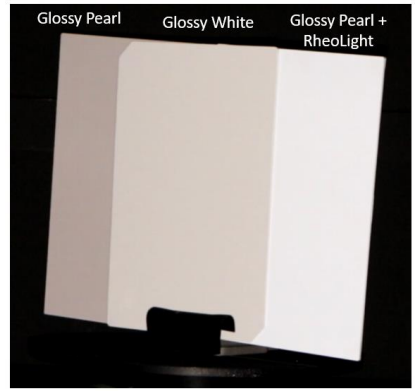
Opposite color lightness and visibility, depending on direction of light source

CGP's: Cool-Colors for thermal comfort

- **Color integrated Heat Reflection** for high-end automotive & mobility applications.
- Improving **fuel economy** by reducing the temperature of the interior.
- No color restriction when choosing for thermal comfort, **energy saving** and personal style.
- **Under construction**: new **Automotive Solar Heat Label**
- Based on 'AIPOV Visibility **3D Solar Reflection Model**' for automotive coating system build-up.
- Current AS-norms ***cannot optimally*** **determine representative TSR** for automotive colors on complex shapes.
- First results on 'Arctic White Color' with **interior cooling: > 2°** (*)
- Crystal Glass Pigments for the world's **'Coolest White'**







(*): IR-heating - study setup to be further refined