Coatings Trends & Technologies SUMMIT

Optimizing Paint Appearance through Imaging-Based Measurement Systems

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- Surface Quality Technologies for 35 years

About Rhopoint Americas, Inc.

- RAI is part of a UK-based company providing instruments for measuring coatings quality and surface appearance since 1986.

Optimizing Paint & Coating Appearance with Imaging-Based Measurement

Achieving a flawless finish in paints and coatings requires alignment between technical measurements and human visual perception. A cutting-edge camera-based system, *developed with KU Leuven University*, introduces perception-driven metrics that replicate how people see gloss, haze, waviness, and surface effects.

Using unified imaging hardware, the technology enables fast, multi-metric assessments — from visual gloss and waviness quantification to haze visibility, effect pigment evaluation, polishing quality, and digital cross-cut adhesion testing.

The technology bridges the gap between objective data and subjective visual standards, improving quality control, consistency, and efficiency in coatings development and production.

What is “optimized paint appearance”?

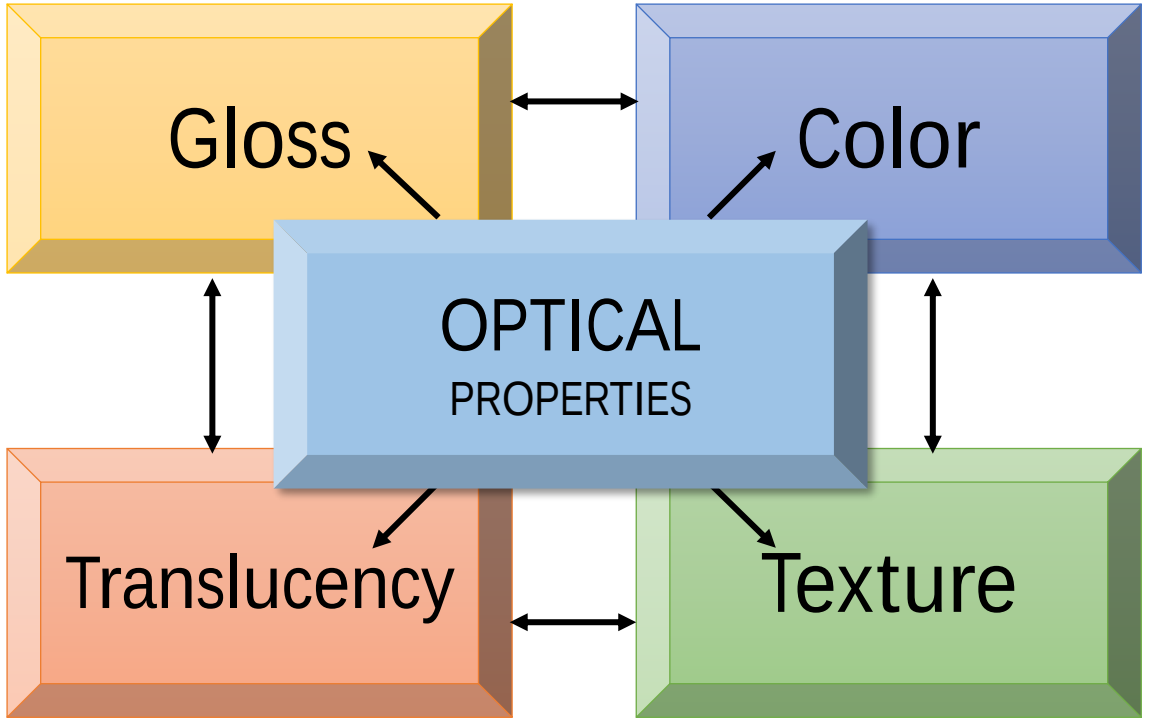
… It’s got *the look*.

appearance, <perceptual>

aspect of visual perception through which an object is perceived to have attributes such as size shape, color, texture, loss, transparency, and opacity

- According to the CIE*, there are four areas in which to measure: Color, gloss, light transmission and texture.

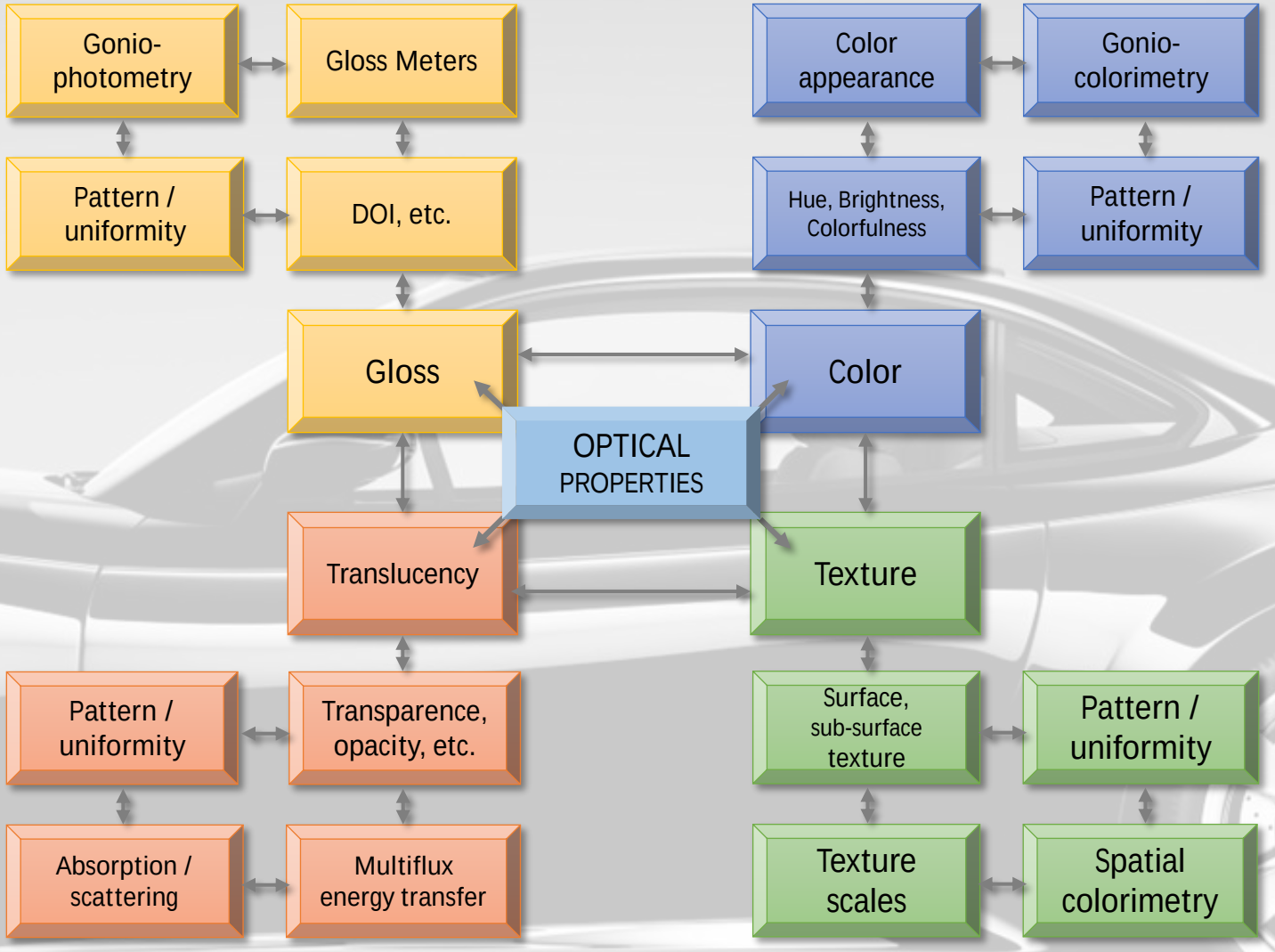
* *The International Commission on Illumination - also known as the CIE from its French title, the Commission Internationale de l´Eclairage*



Source: CIE 175:2006

Appearance Parameters

Many parameters.
Much interplay.

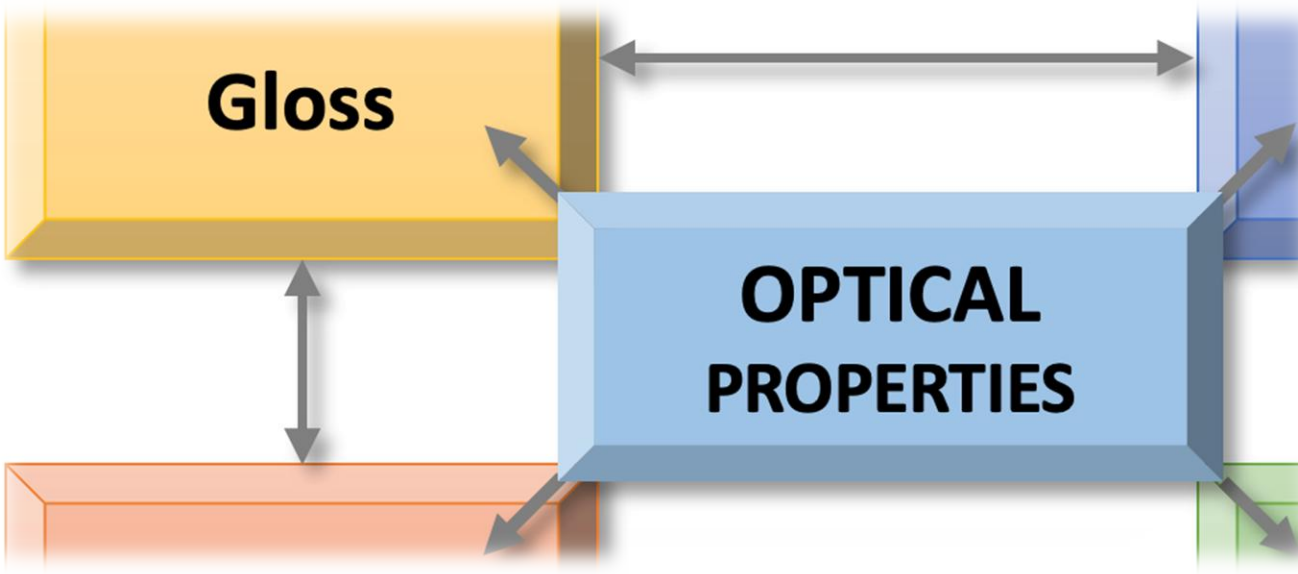


Source: CIE A Framework for the Measurement of visual appearance

GLOSS

Is traditional “Gloss” measurement enough?

‘Total appearance combines a description of the appearance of each element of a scene… with a personal interpretation of the total scene in term of its recognition and expectation.’ [1]



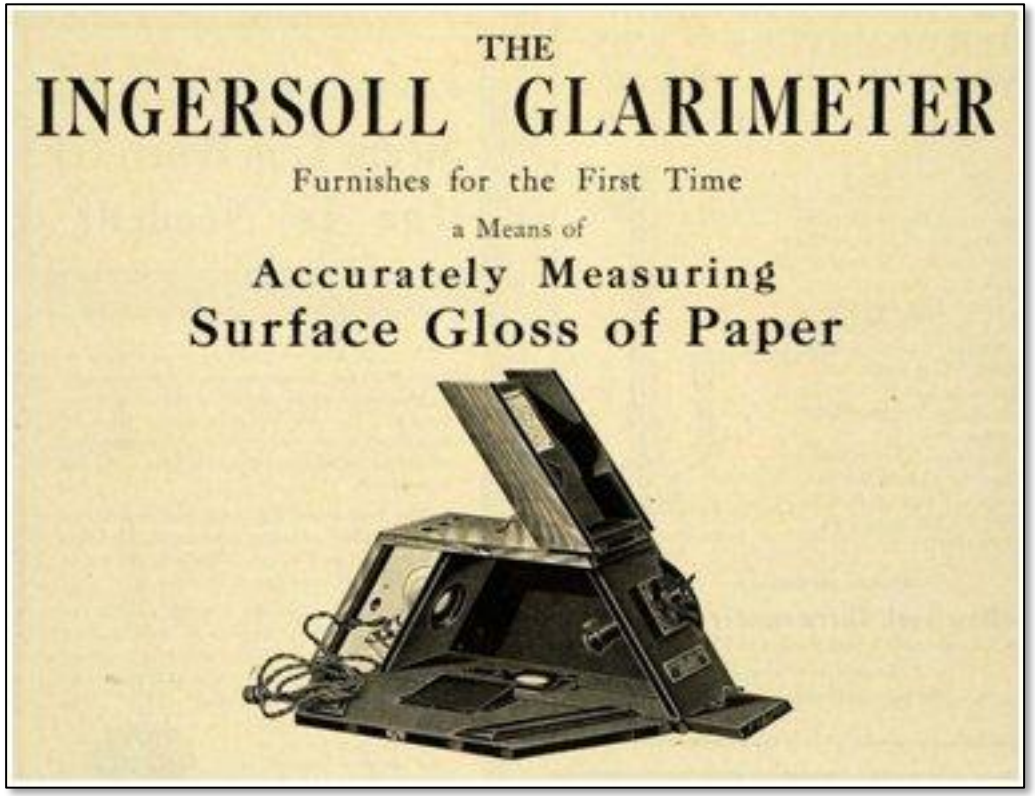
1. Hutchings, J.B. Food color and appearance, 2d edition. Aspen Publishers, New York, 1999

What is Gloss?

ASTM D523

DIN EN ISO 2813

1st Gloss Instrument: Introduced over 100 years ago!



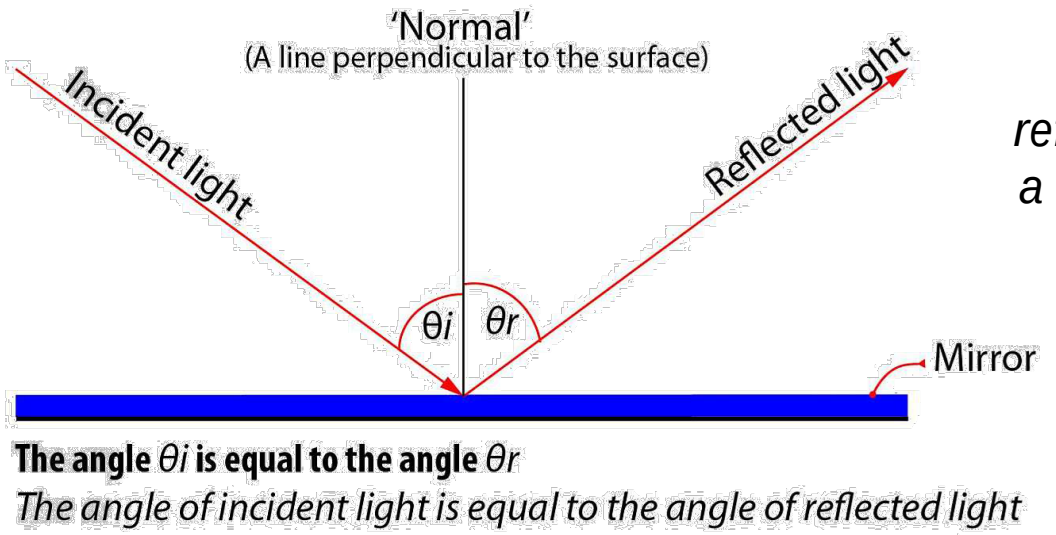
- 1914: Leonard R. Ingersoll pioneered gloss evaluation with the "Glarimeter" to measure paper glare.
- First known instrument for gloss measurement; based on polarization of light in specular reflection.
- Used incident/viewing angles of 57.5° and a contrast method with a polarizing element.
- 1917 Patent granted.

Basic Gloss Measurement Standards

These Standards describe use of integrating photodiodes to collect the *specularly** reflected light.

ISO 2813, ISO 7668, ASTM D523, ASTM D2457, DIN 67530, JIS K5600-4-7, JIS Z8741, etc.

Most important for industry: ISO 2813 and ASTM D523 (as reference for other standards).



** "Specularly" means in a way that is like a mirror, reflecting light or radiation in a single direction. It describes a type of reflection where the angle of incidence equals the angle of reflection, typical of smooth, polished surfaces.*

Defining New Gloss Measurement Standards

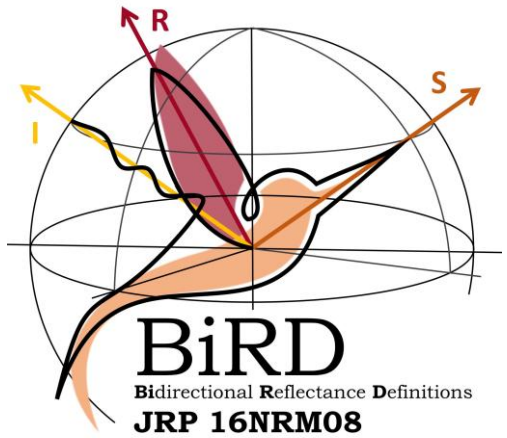
Joint Research Project Bidirectional Reflectance Definitions (BiRD)

- Project Goals: Improve primary goniospectrophotometers for better BRDF measurement and reduced uncertainty.
- Data Management: Develop models for compressing, representing, and handling BRDF measurement data.
- Visual Appearance Correlation: Investigate the relationship between visual appearance and BRDF.
- Propose new Visual Gloss technology to correlate to human perception.

BiRD
Bidirectional Reflectance Definitions
JRP 16NRM08

*Bidirectional Reflectance Distribution Function (BRDF), that is the ratio of the radiance in one given direction to the irradiance coming from another direction, at a given wavelength.

Appearance measurement based on industry needs*



In 2020, Rhopoint Instruments and KU Leuven University undertook a joint PhD program to develop a research-based, next generation imaging-based measurement technology.

A new technology is based on needs identified in BiRD (2017)

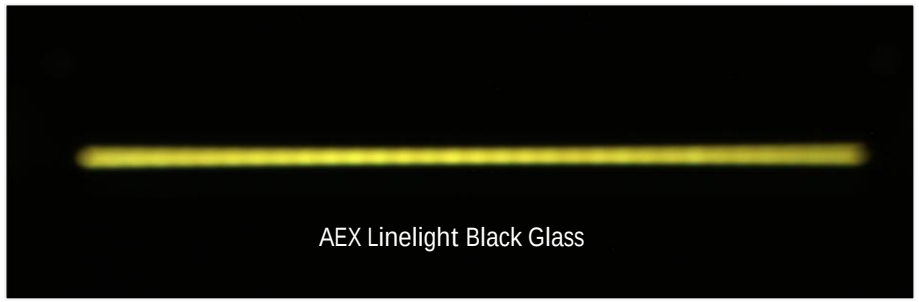
analysis of academic research on gloss perception and new psychometric testing

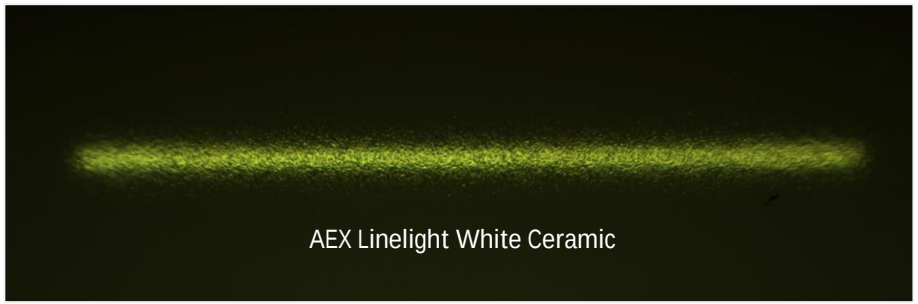
of human gloss and haze response, and now embodied in the commercialized instrument.

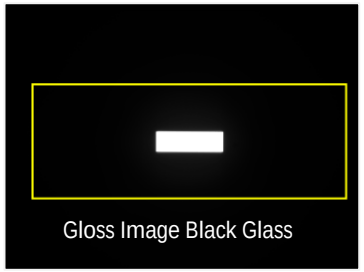
** BiRD identified needs by surveying industry leaders.*

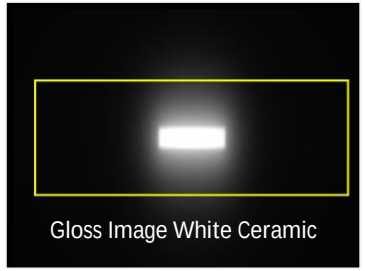
All relevant measurements at once with one instrument

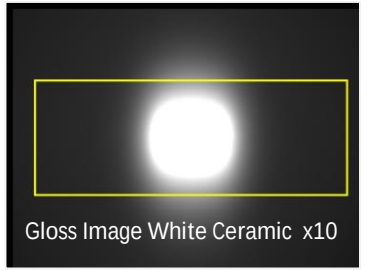
Sample	60° [GU]	60°V [P-GU]	S [%]	MC H [HU]	LogH C [logHU]	VisH-Out [VHU]	Waviness [WU]	DOI [%]	Red	Green	Blue
Black Glass	98.70	91.53	96.37	1.71	0.00	99.93	0.00	97.46	38	36	42
White Ceramic	89.89	59.18	11.66	55.92	206.36	792.88	6.60	60.96	244	243	243











Black Coupon

White Coupon

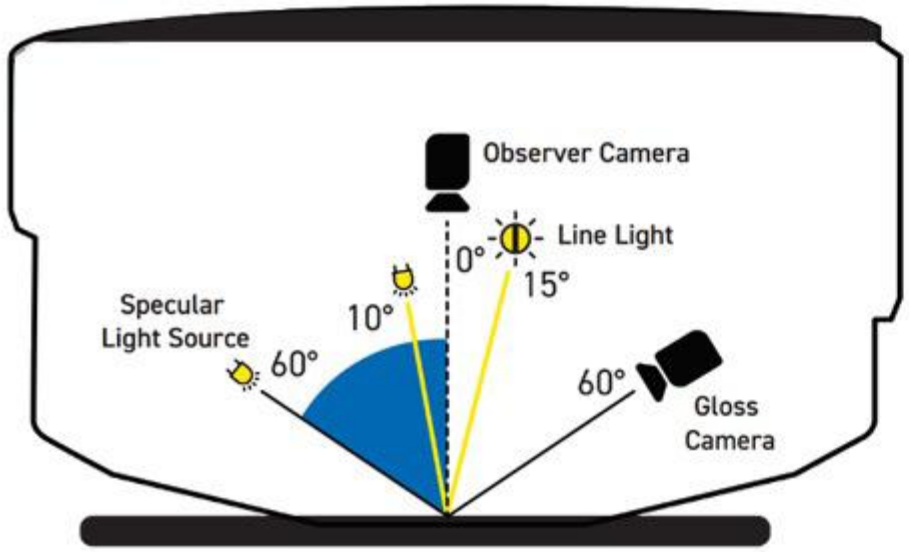
Gloss - Haze - DOI/Sharpness - Visual Gloss - Visual Haze – Waviness Gloss - Haze - DOI/Sharpness - Visual Gloss - Visual Haze – Waviness

A dual camera sensor that can be used to measure multiple aspects of surface appearance and functional quality.

Optical Setup

Cameras (CMOS)

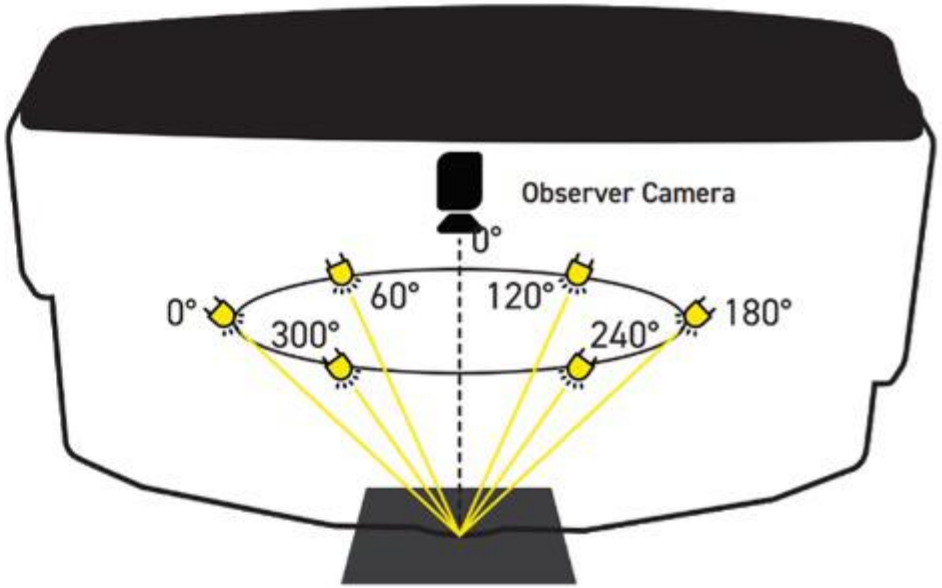
w/ 10µm/pixel resolution:



- 60° specular
- 0° normal

Light Sources

(LEDs):

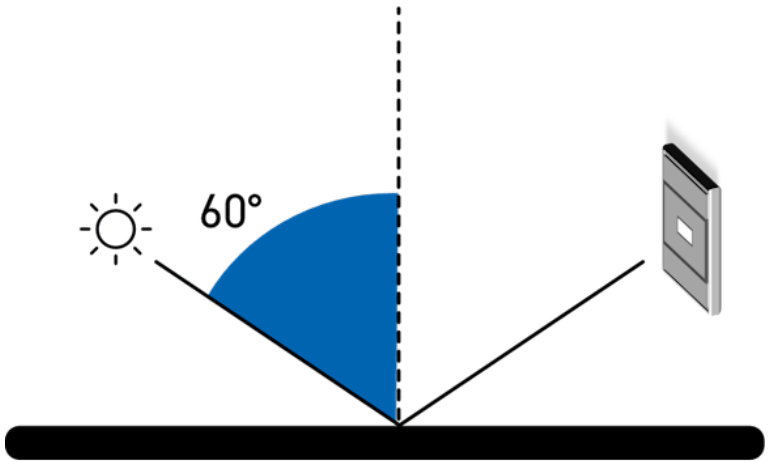


- 10° spot
- 15° line-light
- 60°
- 45° x 6

20 mm

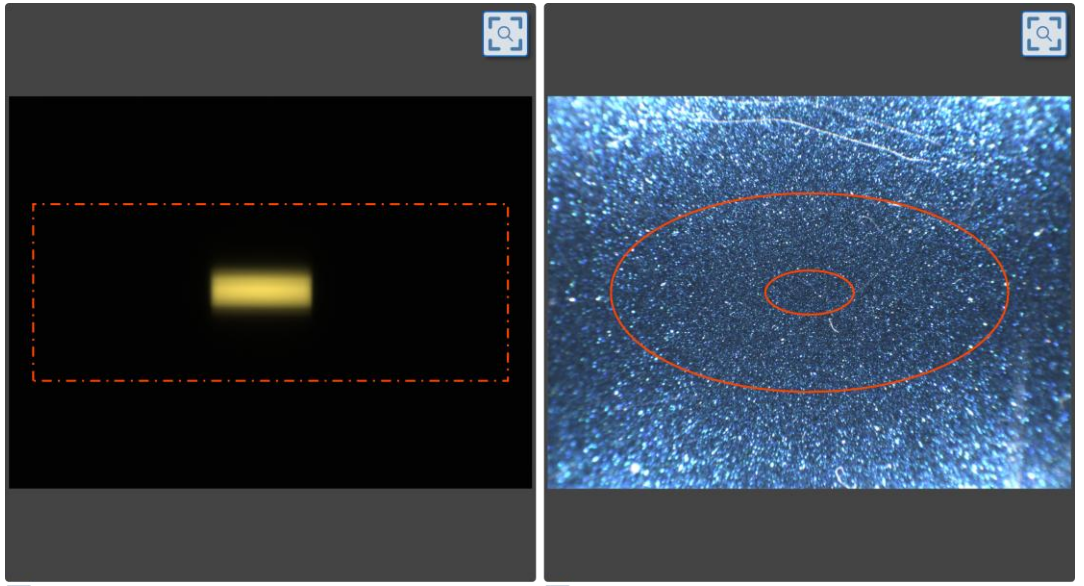
Gloss Measurement by Imaging

An Emerging Imaging Technology is able to completely characterize all important effects that define gloss perception, but it is built in compliance with ISO 2813 and ASTM D523, using a camera instead of a photodiode.

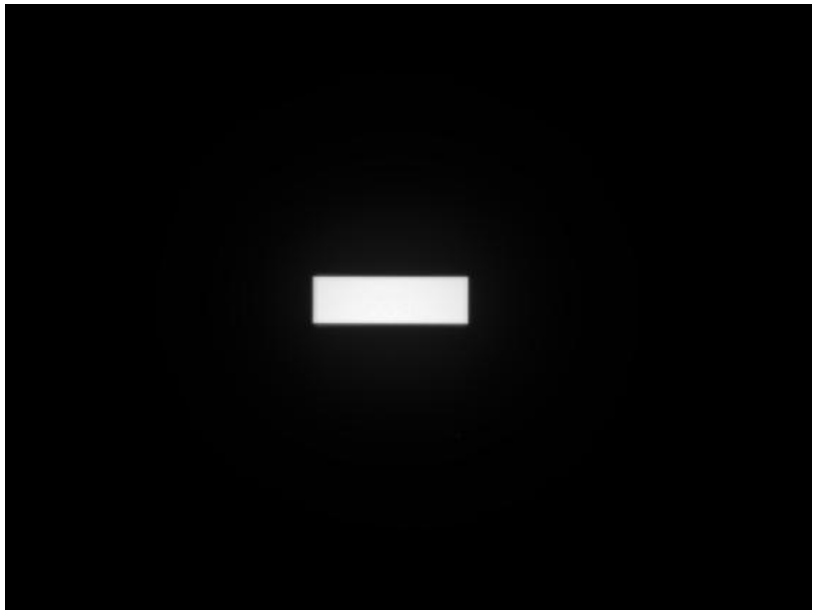


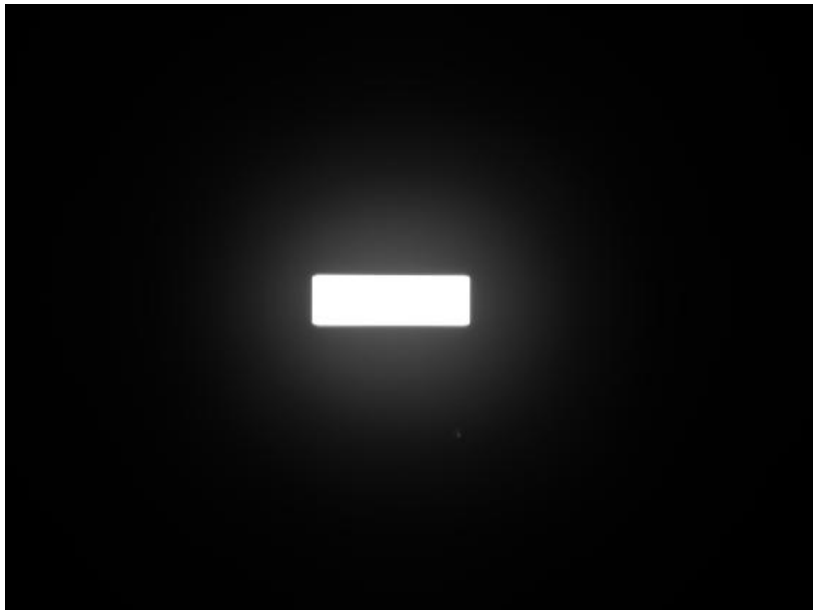
Left live view: Red rectangle
Area on the camera to be integrated according to ISO specification

Right live view: Red Ellipses
Areas on the sample that will be measured
Standard spot 18x9mm / Small spot 4x2mm



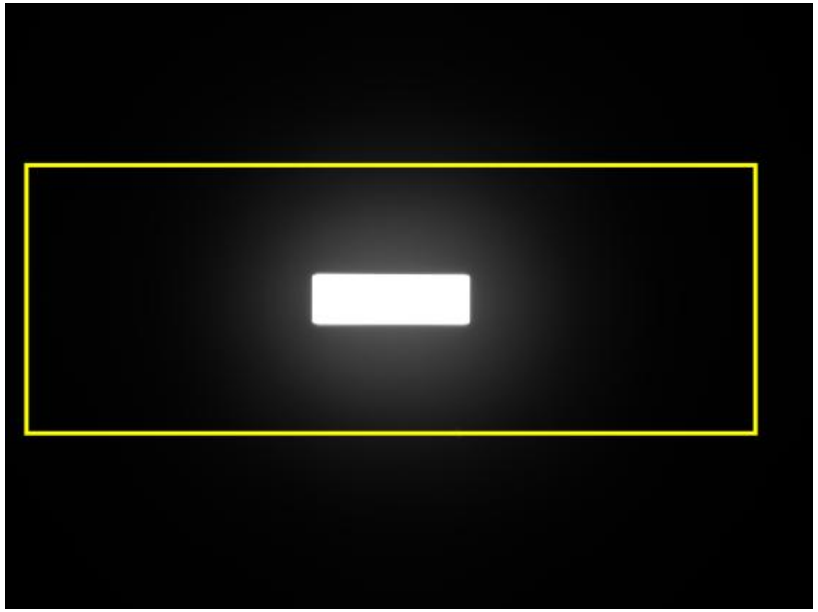
Three images with different exposure times to grab the slightest diffusion...



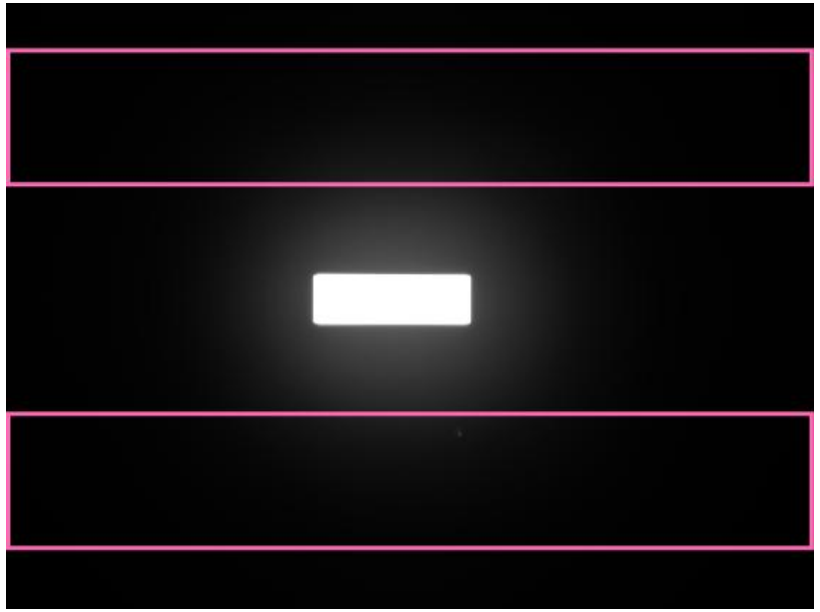


Gloss measurement with advanced imaging

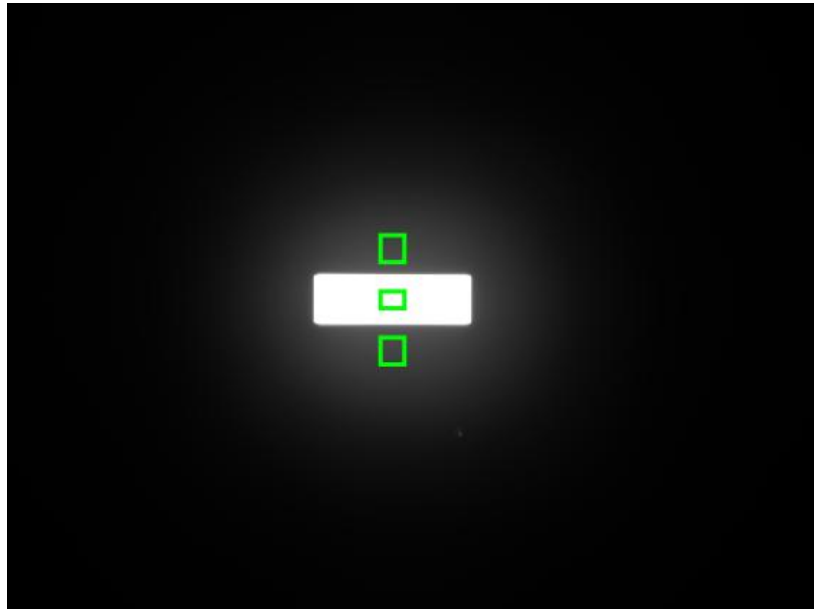
... then analyze different regions for gloss and near gloss information.



ISO 2813 / ASTM D523 Gloss



Haze ASTM E430 Compatible



Michelson Contrast (MC) Haze

QC as a Human Sees it.

Gloss - Standard Values Compared To Perception

Standard gloss is OK for monitoring consistency but understanding the way the eye perceives contrast and brightness as essential for developing products and explaining human visual experience.

Contrast Gloss Measurement by Imaging

Measured values compared to human visual experience

- QC report tells us the gloss is the same.
- Our eyes tell us the dark blue paint is glossier than the white paint.

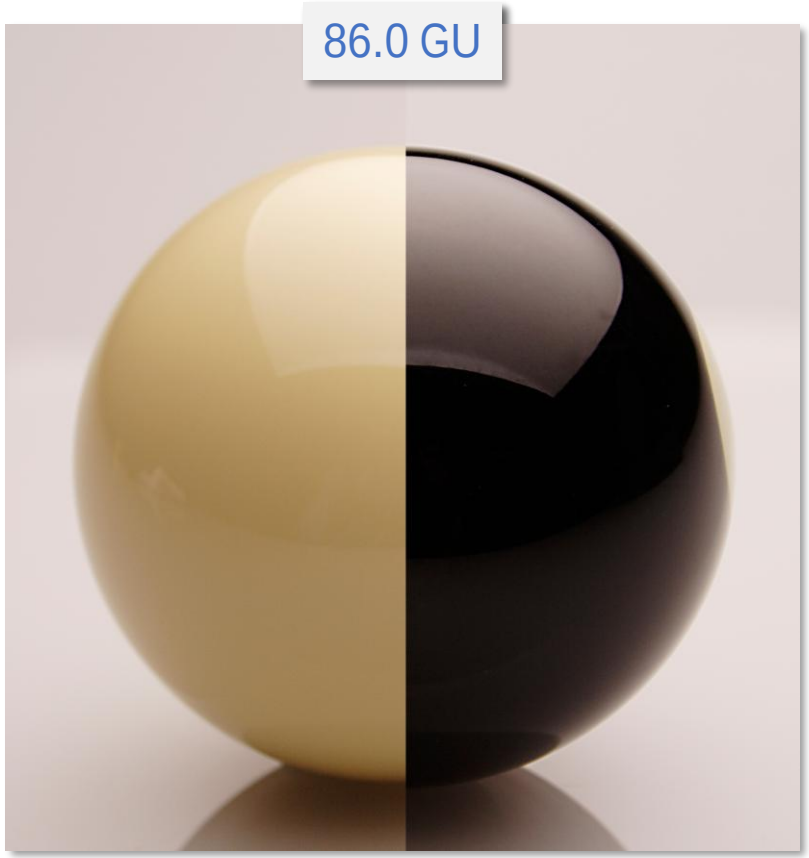
Perception does not match measurement for different colors side by side.

The Color Factor

When judging surface reflection effects like Reflection Haze or Waviness, the background color has an important influence.

Human gloss perception is strongly influenced by background color.
If the surface color is different, we also perceive the gloss as being different.

Together with the team from KU Leuven, this concept was fine-tuned with Perception Studies and developed for industrial usage.

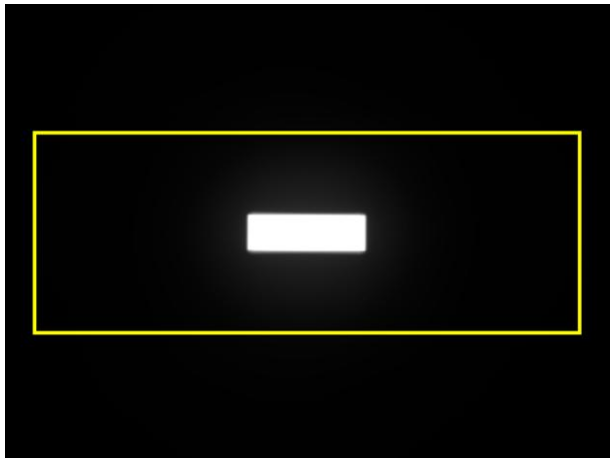


Contrast gloss evaluation by use of a camera-based gloss meter
Stijn Beuckels*, Jan Audenaert, Peter Hanselaer, Frédéric B. Leloup Light&Lighting Laboratory, Dept. of Electrical Engineering (ESAT), KU Leuven,

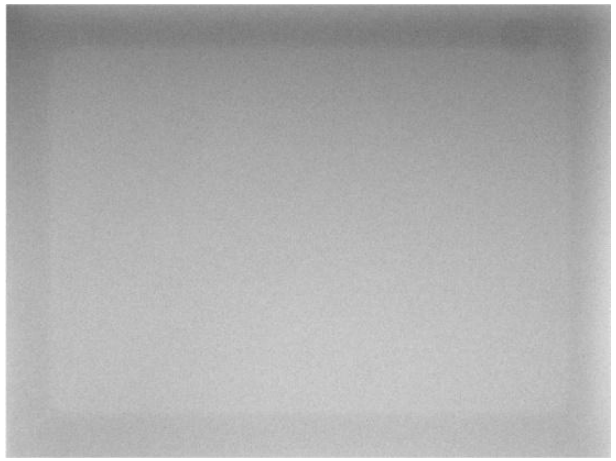
Visual Gloss Concept

Using its 0° camera, the device can “see” (measure) the surface color (background) of the sample to calculate “perceived brightness”.

The new parameter “Visual gloss”, aka “Psychometric contrast”, describes the perceived glossiness [p-GU] of samples with varying contrast (e.g., for designing surfaces).



Sample Luminance

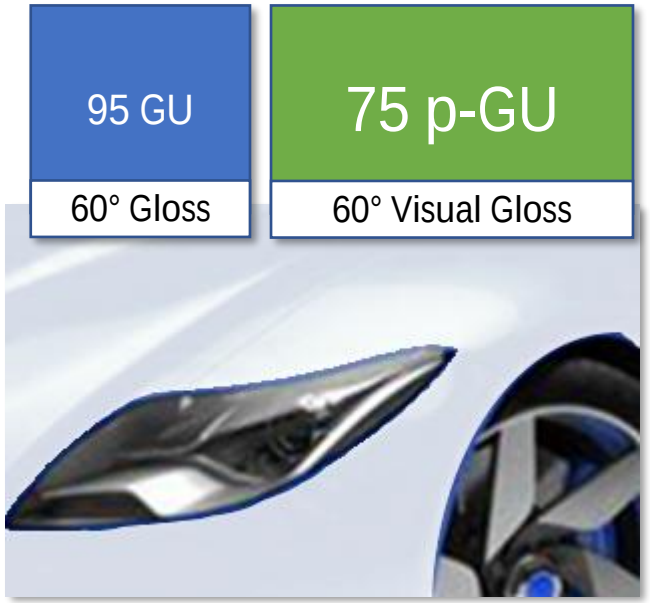


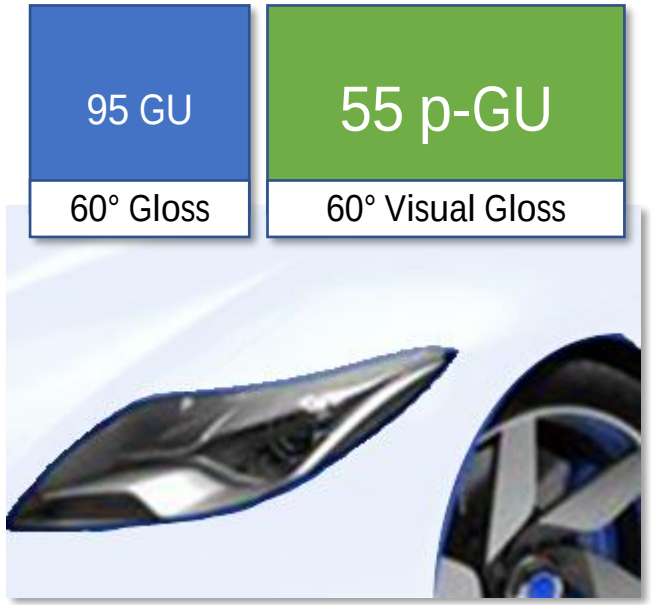
Background color brightness

Visibility

Why Visual Gloss is important for product design

- At certain p-GU levels, differences between parts are less visible – the lighter the color, the higher the tolerance.
- Visual Gloss highlights the visibility of the traditional technical gloss effect.

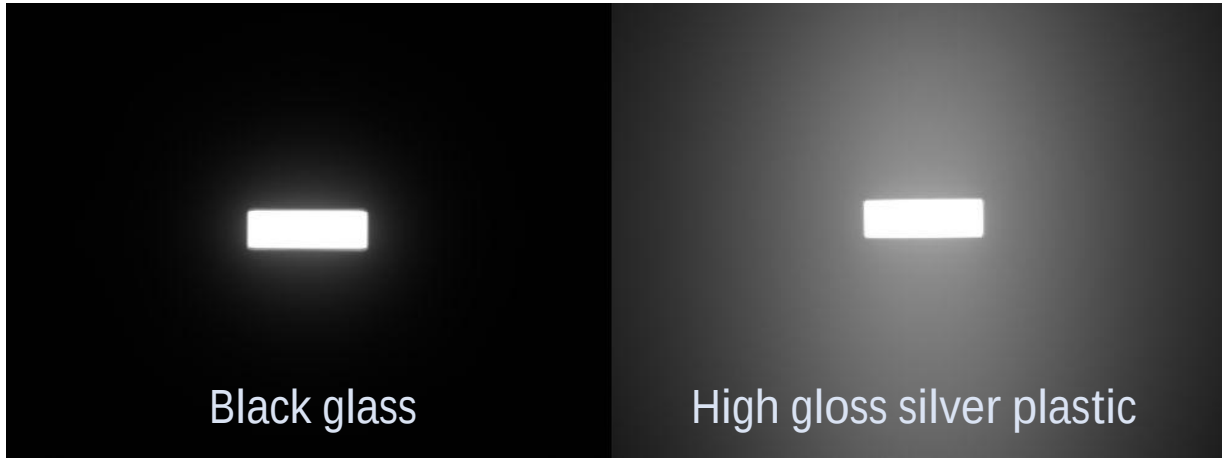




Correlation to human perception

Haze [HU]:

Scattering of light at the glossy surface of a specimen responsible for the apparent reduction of contrast of objects viewed by reflection at the surface.

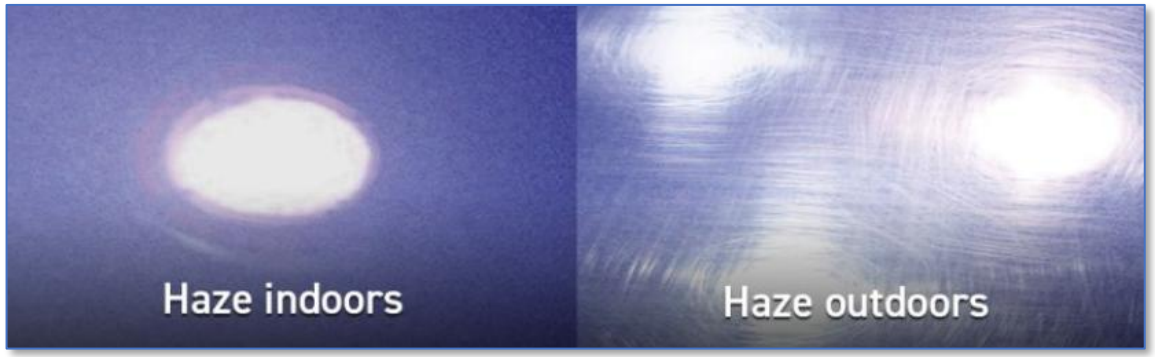


The visual concept extended to Haze

Visual Indoor and Visual Outdoor Haze

The device uses two viewing conditions that are combinations of the Surface illuminance [lux] and Source luminance [cd/m²] to spot effects not visible otherwise.

	Conditions	Surface illumination	Specular Illumination
VH_{ID}	Standard indoor lighting	0.5k Lux	25k cd/m²
VH_{OD}	Sunny day-clear sky	100k Lux	1.6m cd/m²

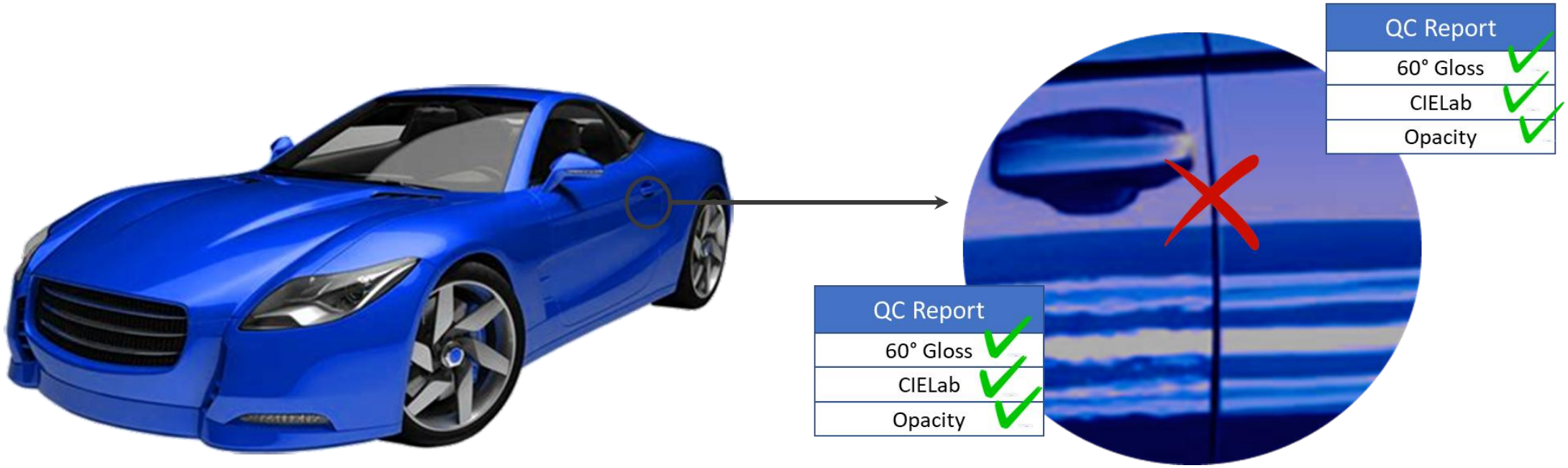


Coatings or materials which are to be viewed in outdoor conditions should be assessed using the Visual Haze Outdoor (VH_{od}) parameter which will quantify the visibility of unwanted haziness in all conditions.

Correlation to human perception

measure orange peel

- Adjacent parts with different levels of orange peel disrupt our feeling of “quality & harmony””
- Consumers associate premium quality with smooth homogeneous surfaces.

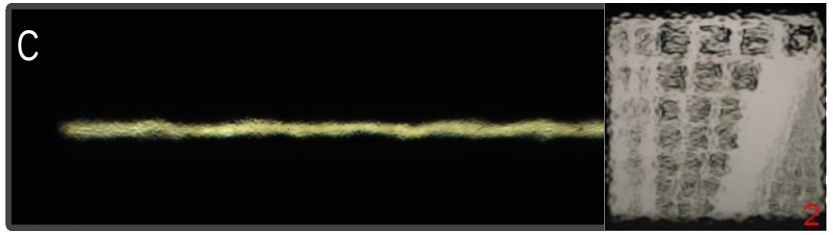


Waviness Measurement by Imaging

AEX Waviness measurements on ACT orange peel standards 10, 5 and 3 vs comments made by untrained consumers.

Waviness (1.3)
"The paint is amazing the surface is perfectly smooth."

Waviness (6.0)
"This paint finish is worse than A, I see some ripples."



Waviness (20.6)
"I don't like this paint- it looks very bumpy and bad quality."

"Waviness" (W) describes the visual impact of "Orange peel" when the surface is viewed from a distance of 1.5m away.

(based on a German automaker perception study of quality surfaces)

Capturing surface brilliance

	#	Sample	60° [GU]	S [%]	MC H [HU]	LogH [logHU]	Waviness [WU]	DOI [%]	PCI
	35	Black Glass	99.60	99.60	3.75	5.18	0.00	96.08	9.86
	57	ACT 10	94.68	34.63	7.87	25.29	1.32	93.30	8.86
	58	ACT 5	95.41	17.88	9.81	26.78	5.93	92.00	7.40
	61	ACT 3	92.40	10.10	30.17	30.14	20.61	78.30	4.17

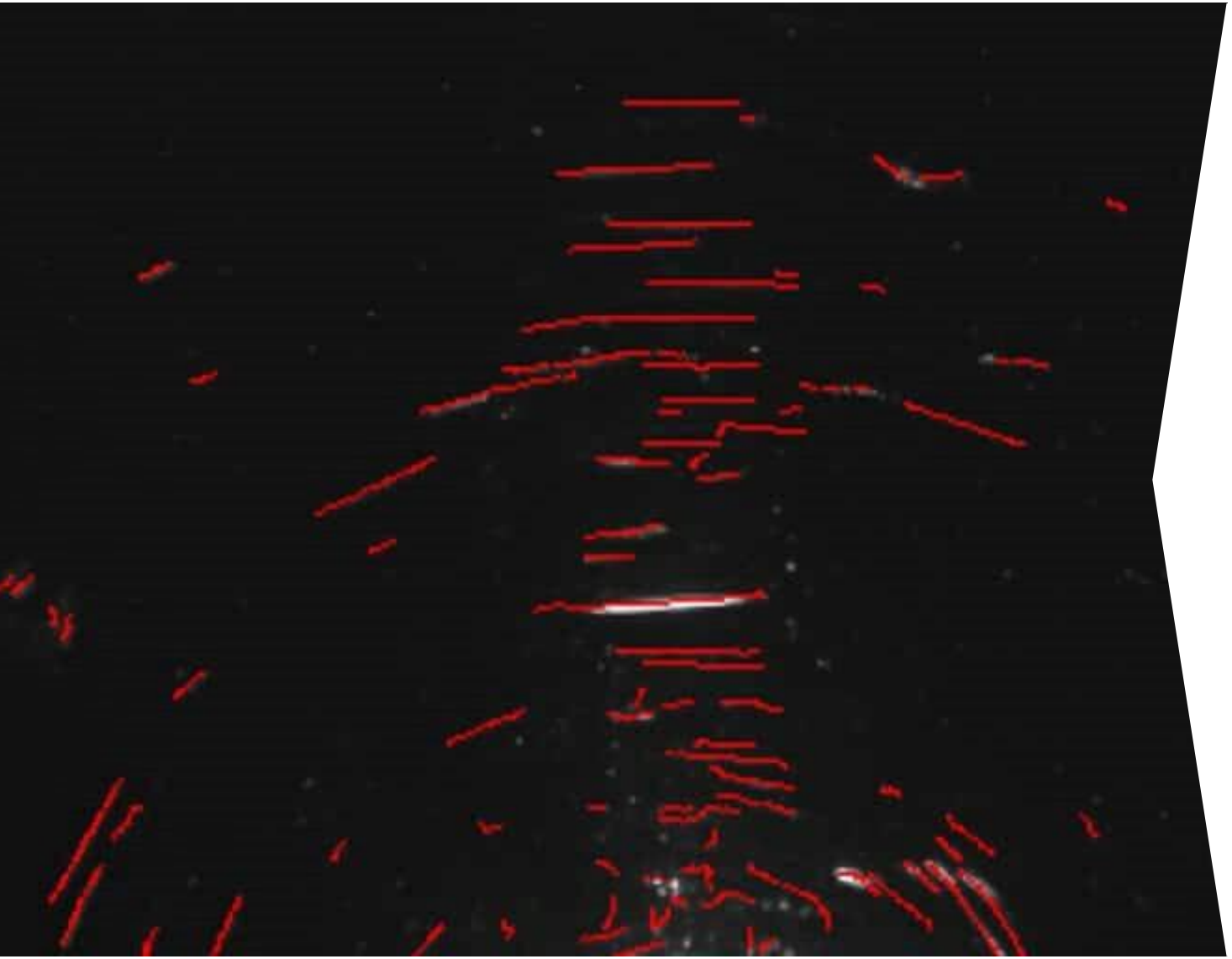
Gloss of curved & small Parts, wet surfaces

“Live View” – reduce spot size by beam adaptors, reducing the measured area down to 2mm

or measures surfaces with curvature >7m^{-1} or cylinders with a radius >11mm with bespoke 3D adaptors

60 [GU] Std Aperture	60 [GU] 2mm Aperture
102.2	102.2
94.2	94.1
92.2	92.3
86.7	87.3
50.8	52.0
33.8	35.4
13.1	14.2
9.2	10.1
7.2	7.9
5.8	6.3
4.0	4.3
1.8	2.0

EFFECT OF SURFACE CURVATURE ON SPECULAR GLOSS EVALUATIONS
Ged, G.1 , Beuckels, S.2 , Bessenay, T1 ., Audenaert, J.2 , Leloup F.B.2 1 EssilorLuxottica / Lens R&D, Créteil, France

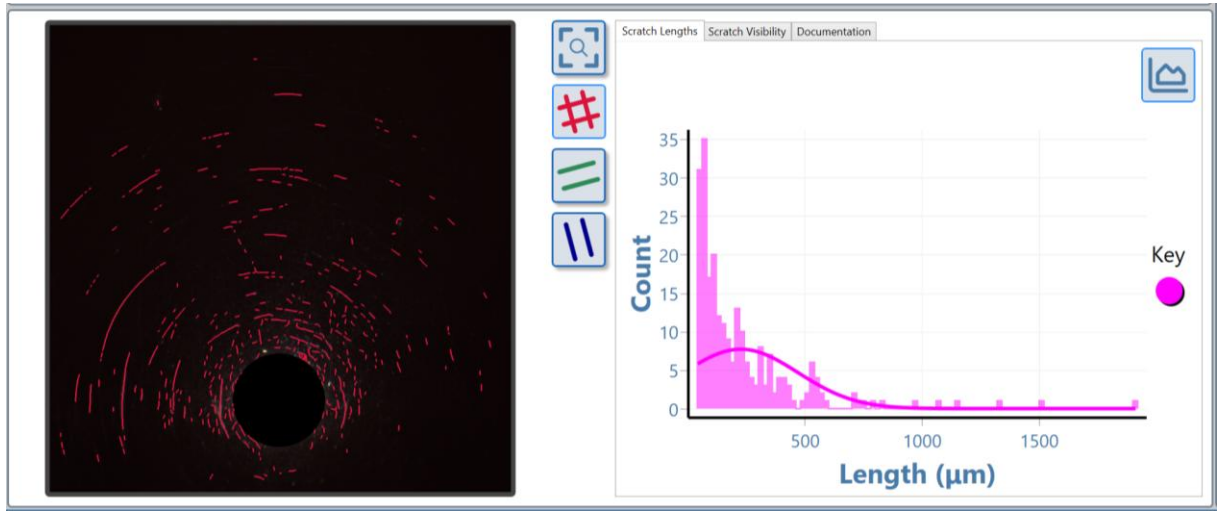


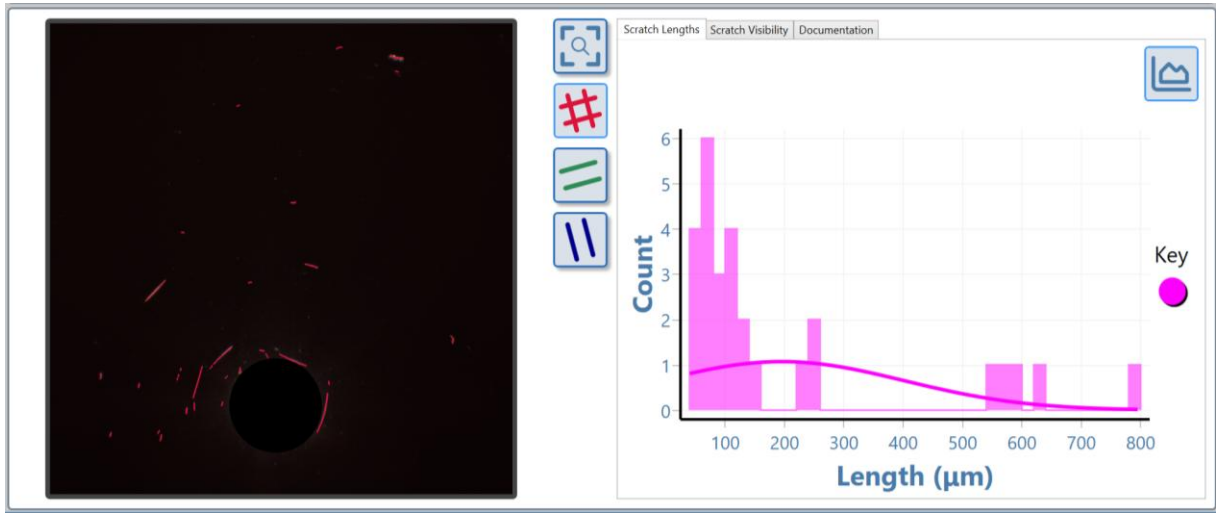
Polishing Quality

(Scratches)

Measure polishing relevant defects

Scratch evaluation and its impact on Gloss and Haze with 10° Spot





Pre-Polish	
Average Scratch Length	231.1 um
Scratch Area	1.54 um
Scratch Count	237.0 um
Visibility	1.79
LogHc	65.0
VHout	123.0

Post Polish	
Average Scratch Length	163.4 um
Scratch Area	0.05 um
Scratch Count	10.0 um
Visibility	0.8
LogHC	21.0
VHOut	40.0

Effect Finish

(Sparkle & Graininess)

Sparkle measurement

What QC parameters are calculated?

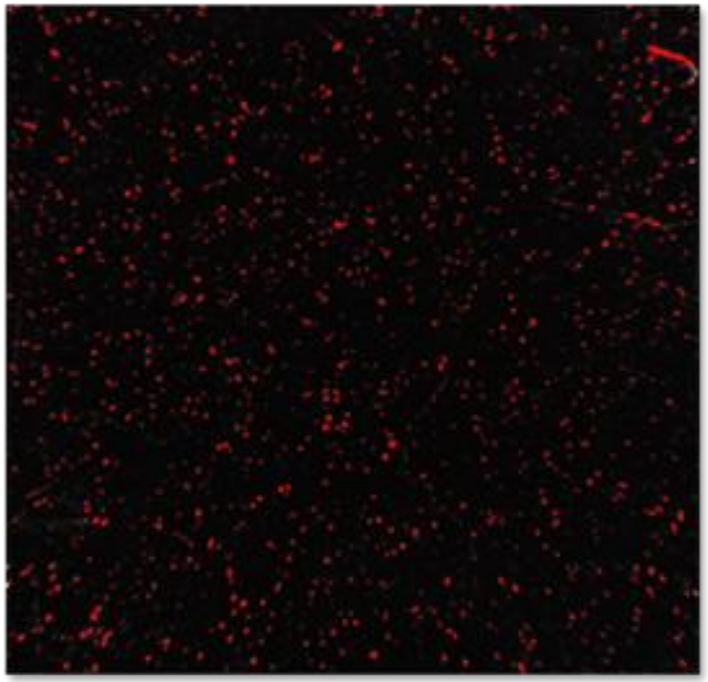
From HDR images at 10° and 45°

Brightness Average Sparkle Element intensity

Visibility $\frac{Average\ Sparkle\ Element\ Intensity}{Background\ Luminosity}$

Density Number of Sparkle Elements per 100mm^2

Area Average Sparkle Element size [µm^2]

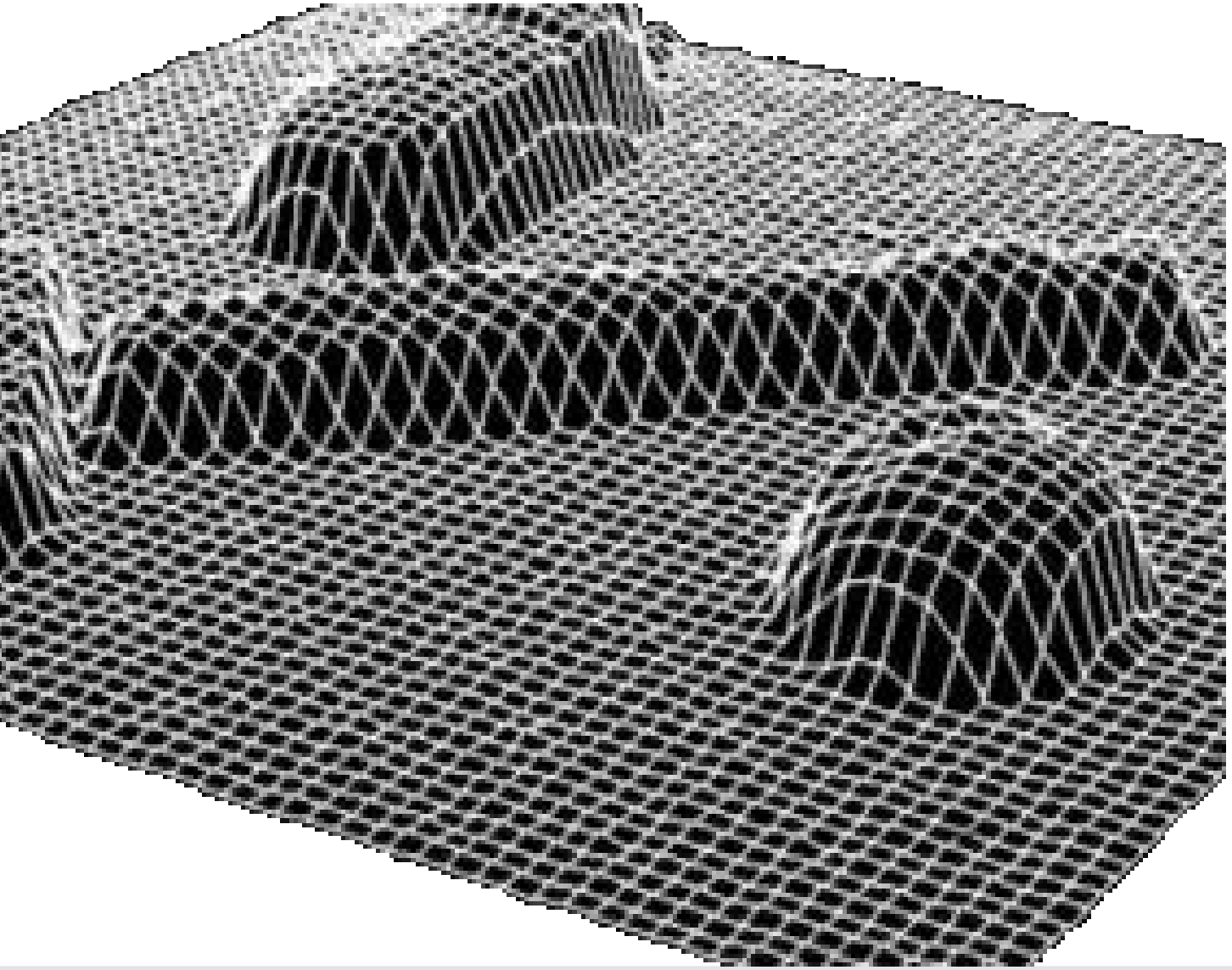


Parameter	Value
Gloss 60°	97.6 GU
Waviness	5.42
Graininess	0.7

Parameter	Value @ 10°	Value @ 45°
Density	855	355
Visibility	1.79	5.12
Brightness	60.90	87.23
Area µm	159	136

Preliminary measurement scales for sparkle and graininess

A. Ferrero, E. Perales, N. Basic, M. Pastuschek, G. Porrovecchio, A. Schirmacher, J. L. Velázquez, J. Campos, F. M. Martínez-Verdú, M. Šmid, P. Linduska, T. Dauser, and P. Blattner

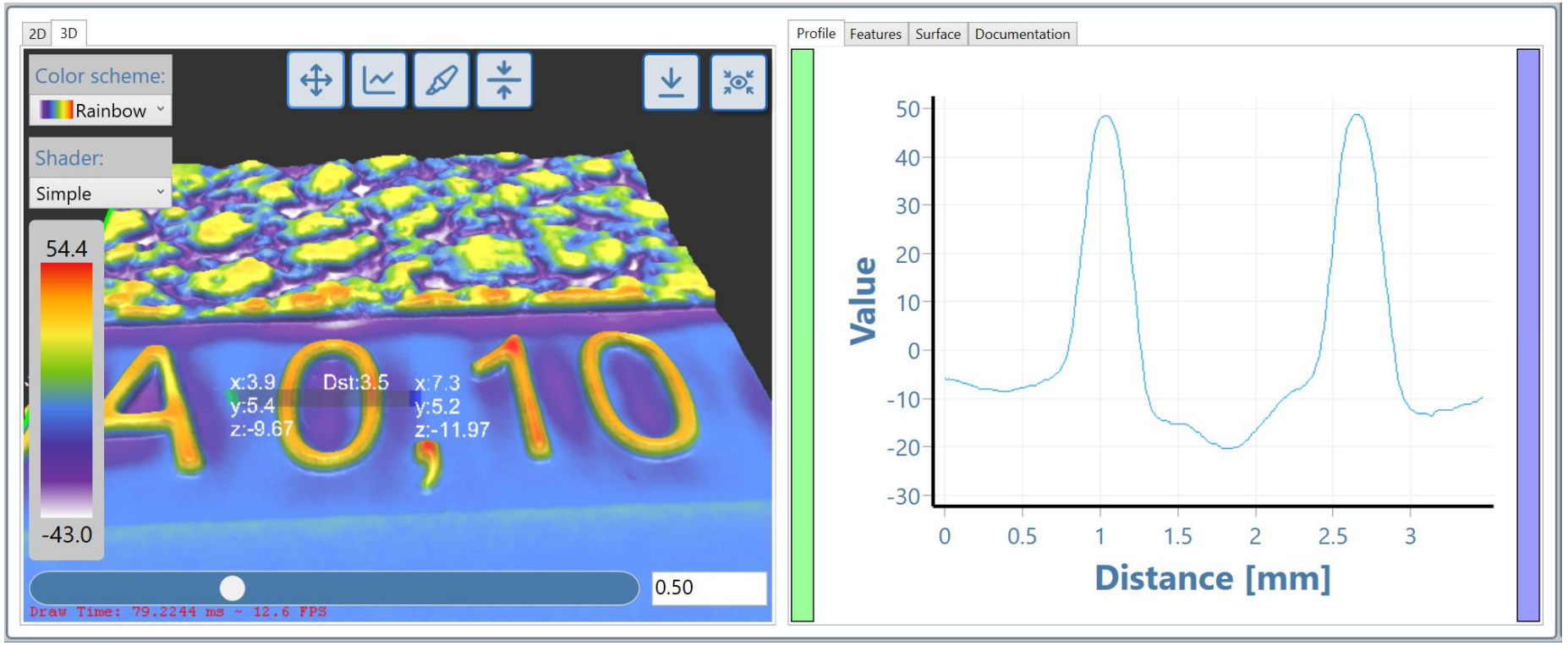


Texture

(Topography)

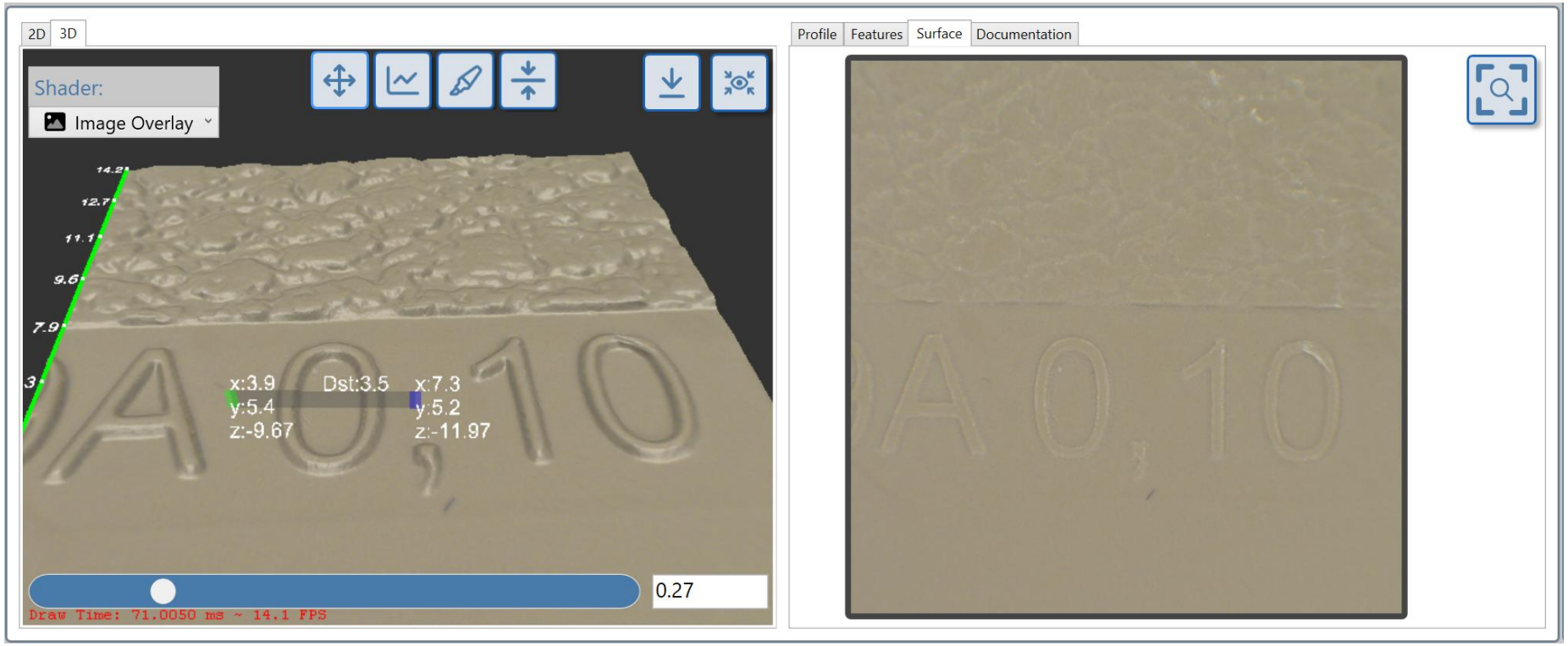
Topographic measurements

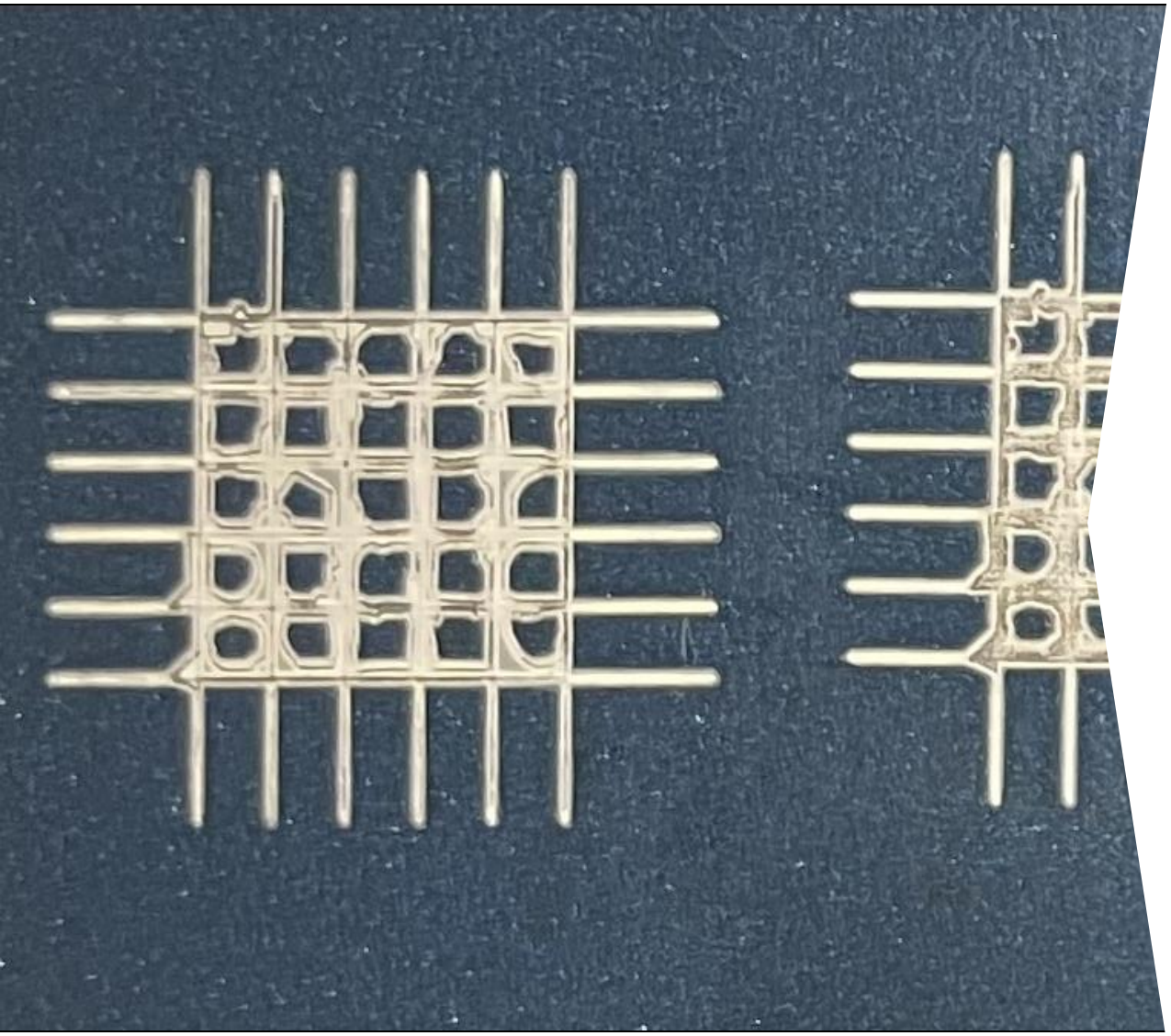
Complete topographic pattern with roughness, profile, cell sizes, cell form, cell numbers, altitudes, etc.



Topographic measurements:

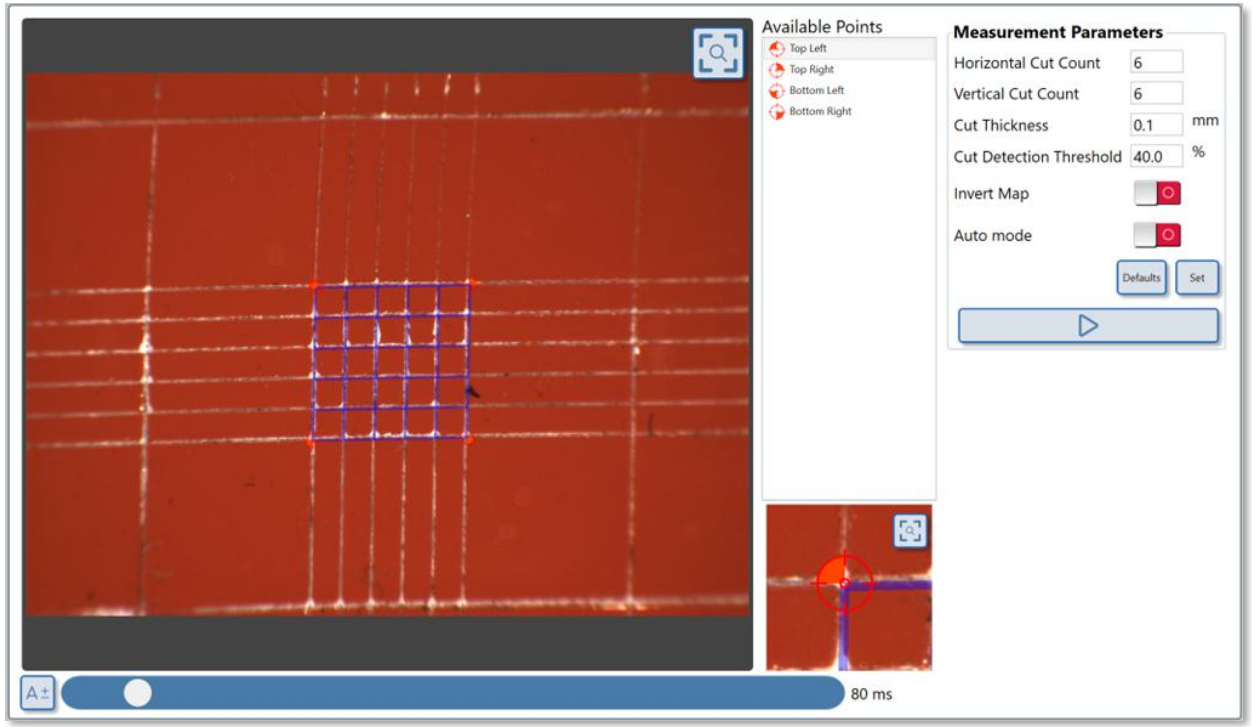
Combine topographic map with color and dimensionally correct surface image

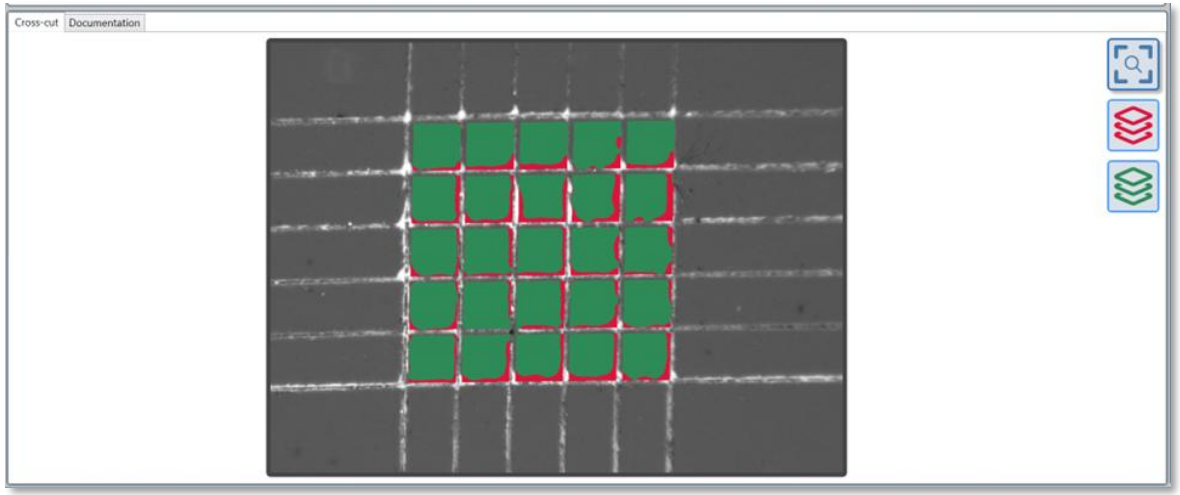




Cross-Cut Adhesion

Cross-cut analysis, to ISO and ASTM standards





Undamaged Area 87.4%
ASTM Class 3
ISO Class 2

Questions?

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Thank you for your attention!