Multi-layer Film Thickness Measurements

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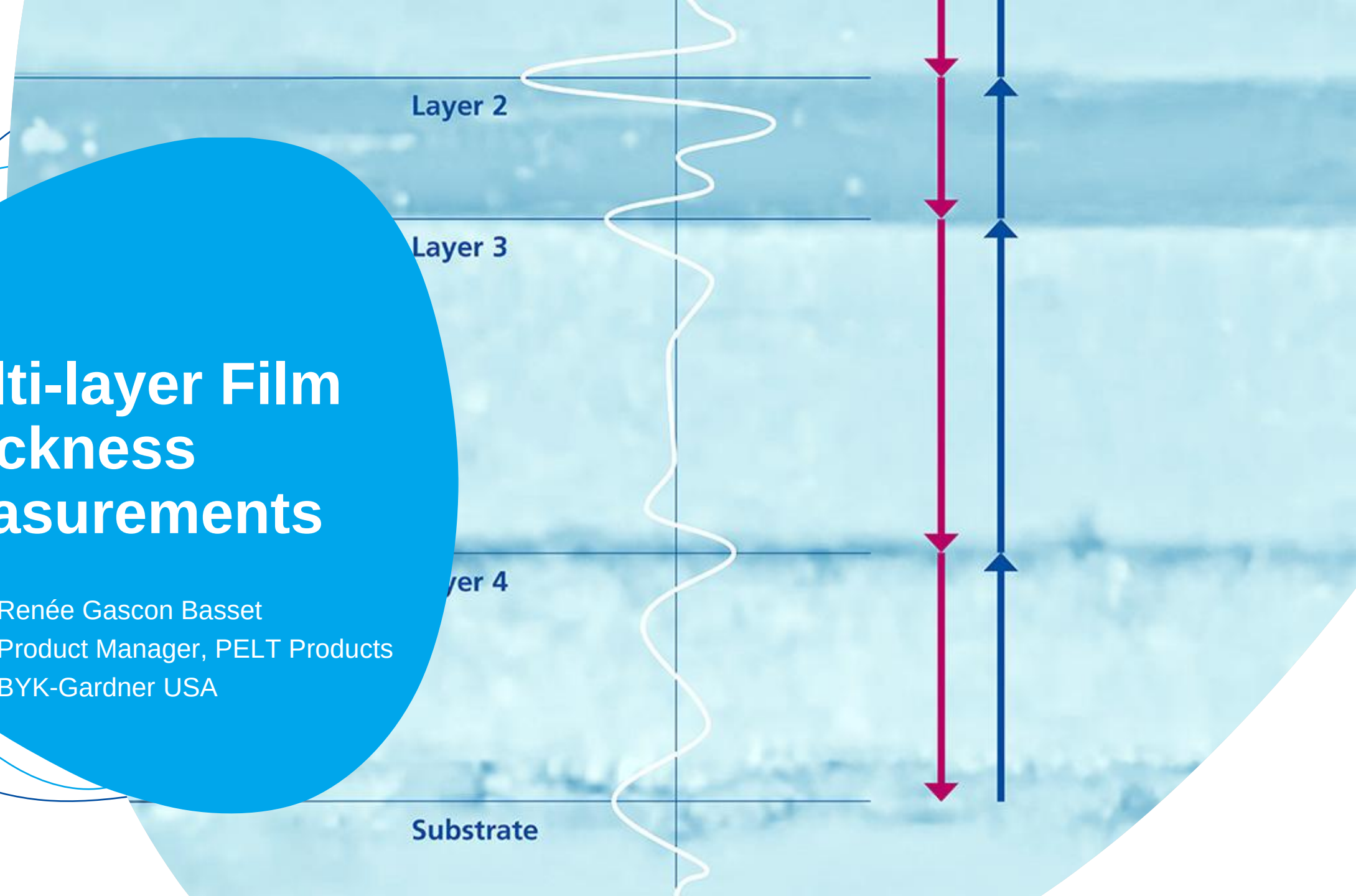
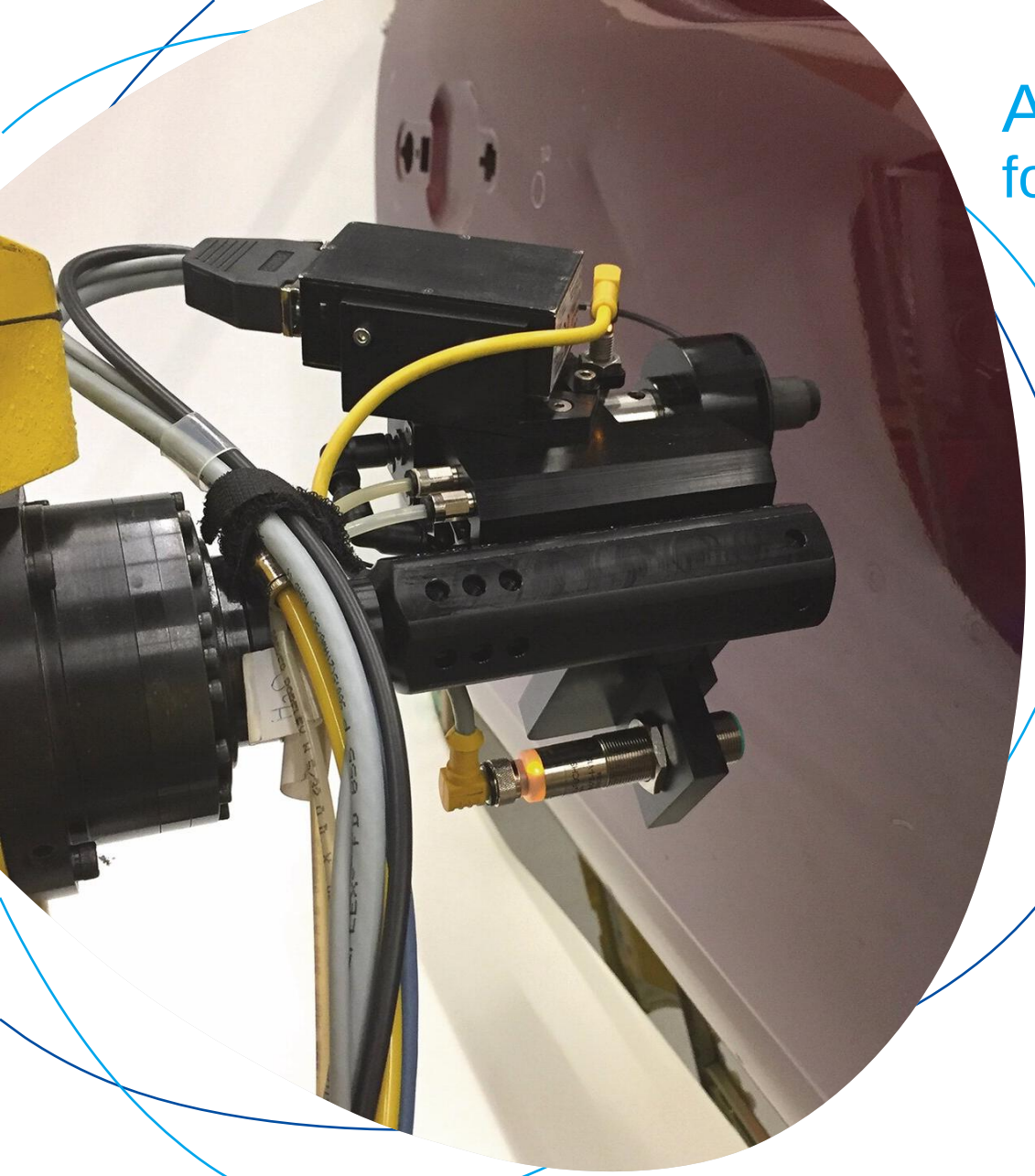
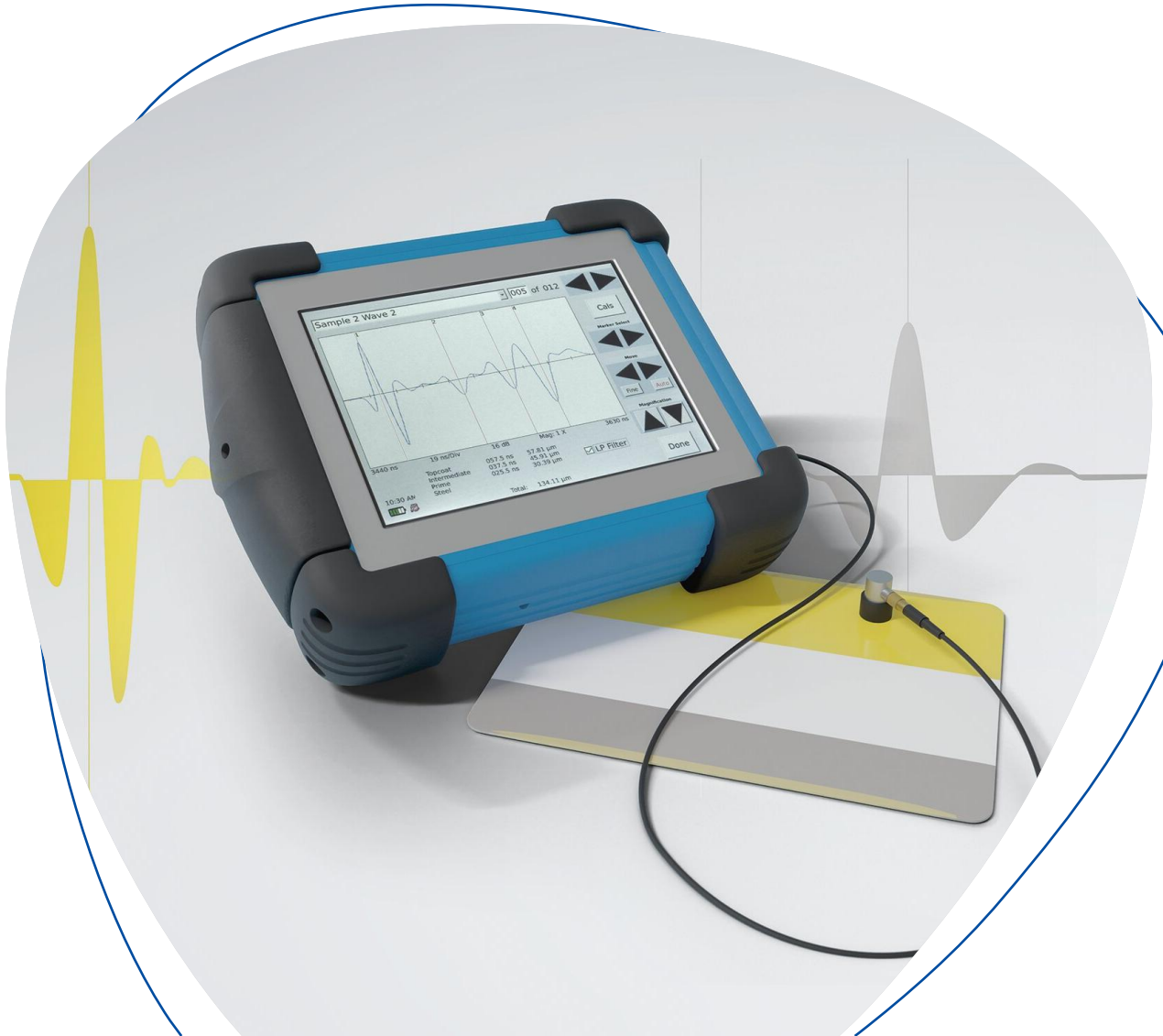


Automated or Handheld Models
for Accurate Echoes from Layer to Layer





Multi-layer film thickness measurements

Non-destructive – repeatable – reliable – highest precision

Coating Thickness Technology:
Offering Precision Control of Exacting Coating Applications

Non-destructive measurement of **multiple layers** individually and simultaneously

Measures all types of cured coatings – powder, 3-wet systems, conventional electrostatic layer systems

Measures film thickness on virtually any substrate:

- Automotive steel and aluminum body panels
- Automotive plastic bumpers and auto trim parts
- Primer and topcoat systems for construction equipment, railroad locomotives and rolling stock, and high-speed railway equipment
- Wind turbine blade coatings, shipping container anti-corrosion and topcoat coatings, and marine coatings
- Paint coatings and lacquers on wood such as cabinetry, furniture, musical instruments, and flooring
- Laminate coatings and layers

Ultrasonic
Technical performance

High resolution and accuracy

- Resolution: 0.5 - 0.33 µm (0.02 - 0.013 mils)
- Calibrated Accuracy: ± 1.3 µm (+/- 0.05 mils) or ± 2% of the coating thickness, whichever is greater

Measure true film build

- Unlike gauges that utilize magnetic induction, ultrasonic gauges exclude zinc galvanization thickness, allowing for direct measurement of the actual coating layer thickness.

No influence by magnetic fields:

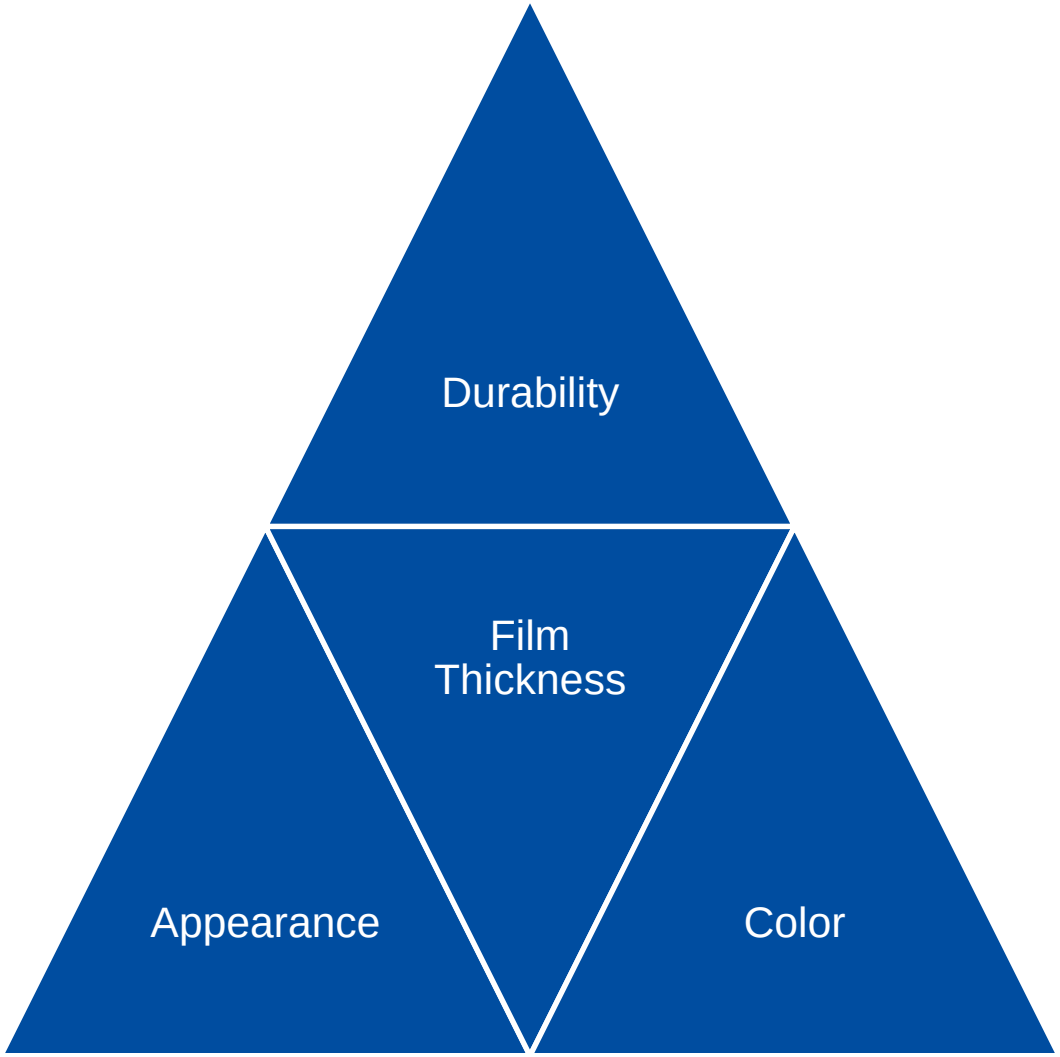
- The measurements are not influenced or affected by differences in substrate magnetic properties or thickness.

Film Thickness
Monitoring and Control

Film thickness is a key process output with a significant impact on paint durability, appearance, and color.

Accurate film thickness monitoring can help in the following ways:

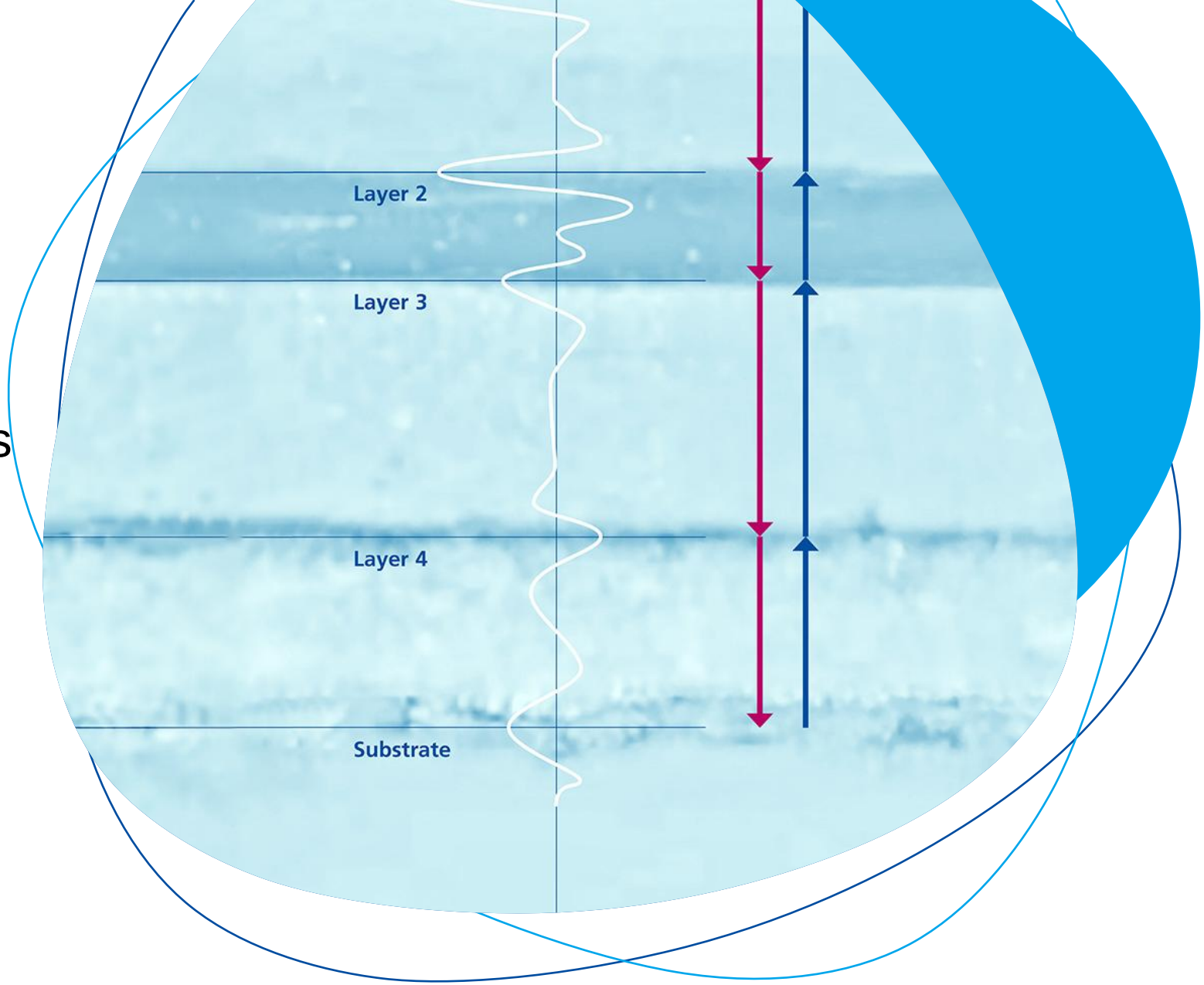
- Ensure paint finish durability
- Avoid excess material usage
- Improve appearance
- Maintain color consistency
- Minimize film build related defects



Multi-layer film thickness

Multi-layer coating systems could only be measured accurately using destructive methods combined with a high-cost microscope which is time consuming and requires expert knowledge.

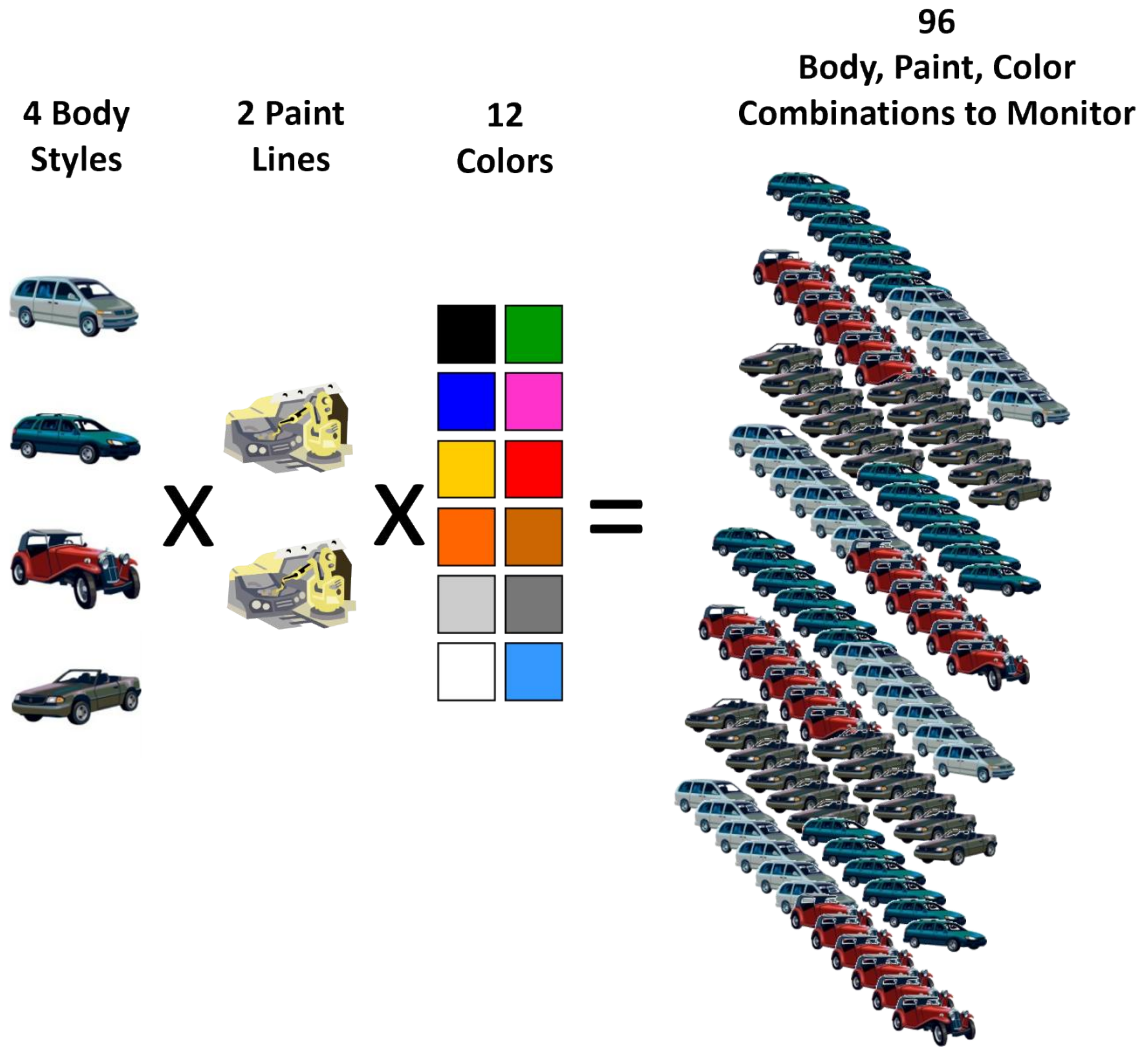
With a single measurement the thickness of each layer in a multi-layer stack is measured.



Automated Thickness Measurement

One of the many advantages that presents is the speed of measurements:

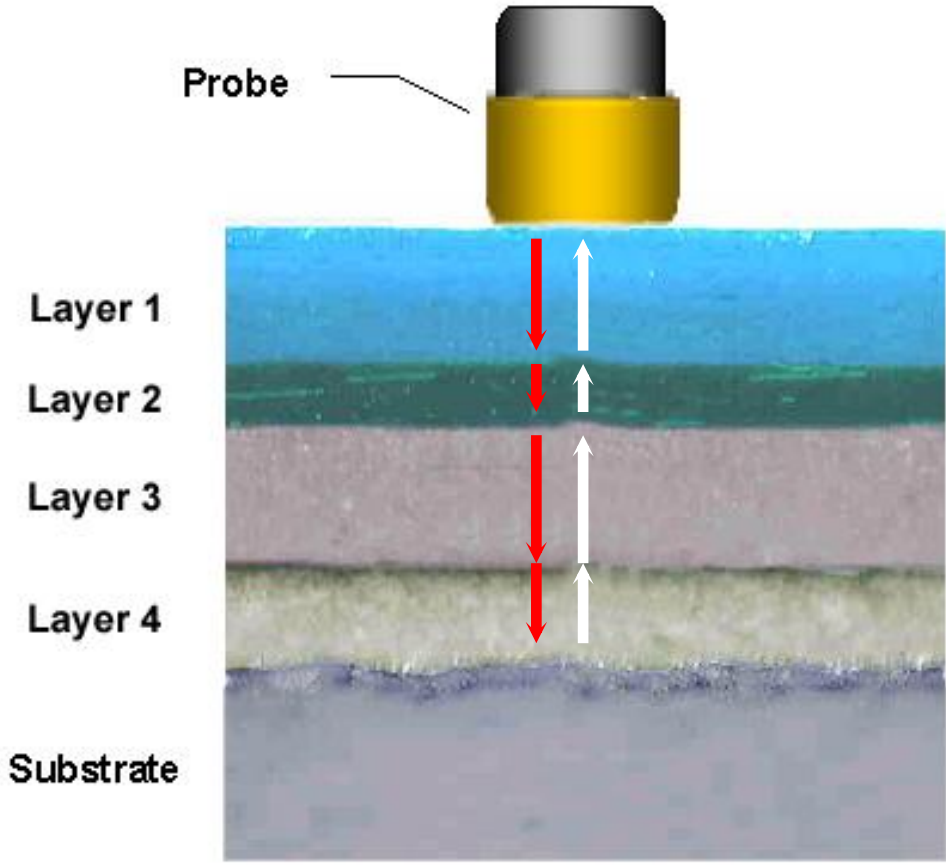
- Approximate time required for Robot to determine spatial orientation and distance to measurement surface: 3 seconds.
- Approximate time required to acquire thickness measurement: 3 seconds.
- With manual measurements of 8 units a day, it would take 12 days to sample 4 body styles, 2 paint lines, and 12 colors.
- With automatic measurements, the same amount could be done in several shifts.



Ultrasonic Measurement Principle

Measurement Principle
Pulse Echo Layer Thickness

- Water is sprayed on the surface to act as a couplant.
- The transducer is placed on the wet surface and the ultrasonic signal penetrates the paint layers.
- Echoes are generated at each layer boundary/interface.
- The return echoes are digitized and displayed on display screen.



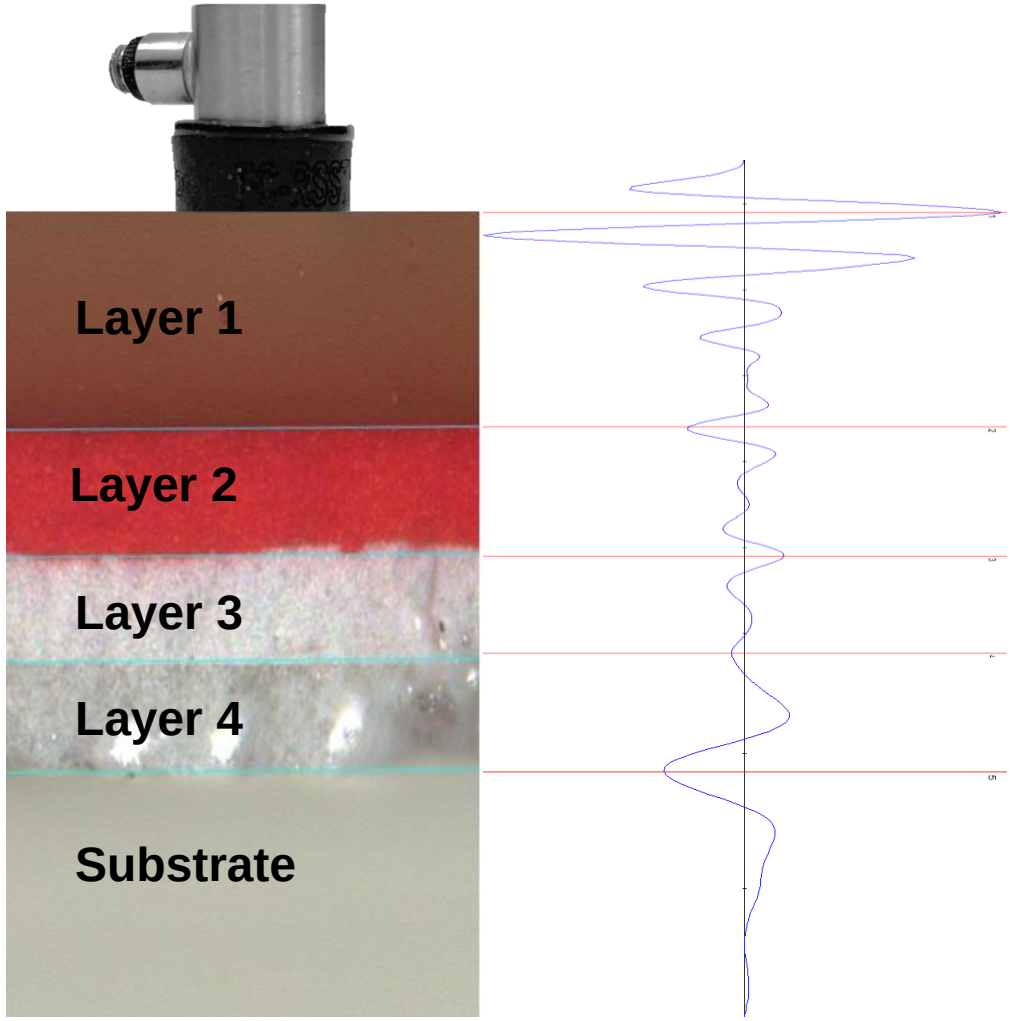
Measurement Principle
Pulse Echo Layer Thickness

Ultrasonic gauges are essentially acoustic microscopes – the gauges “see” the same layer boundaries an optical microscope would see.

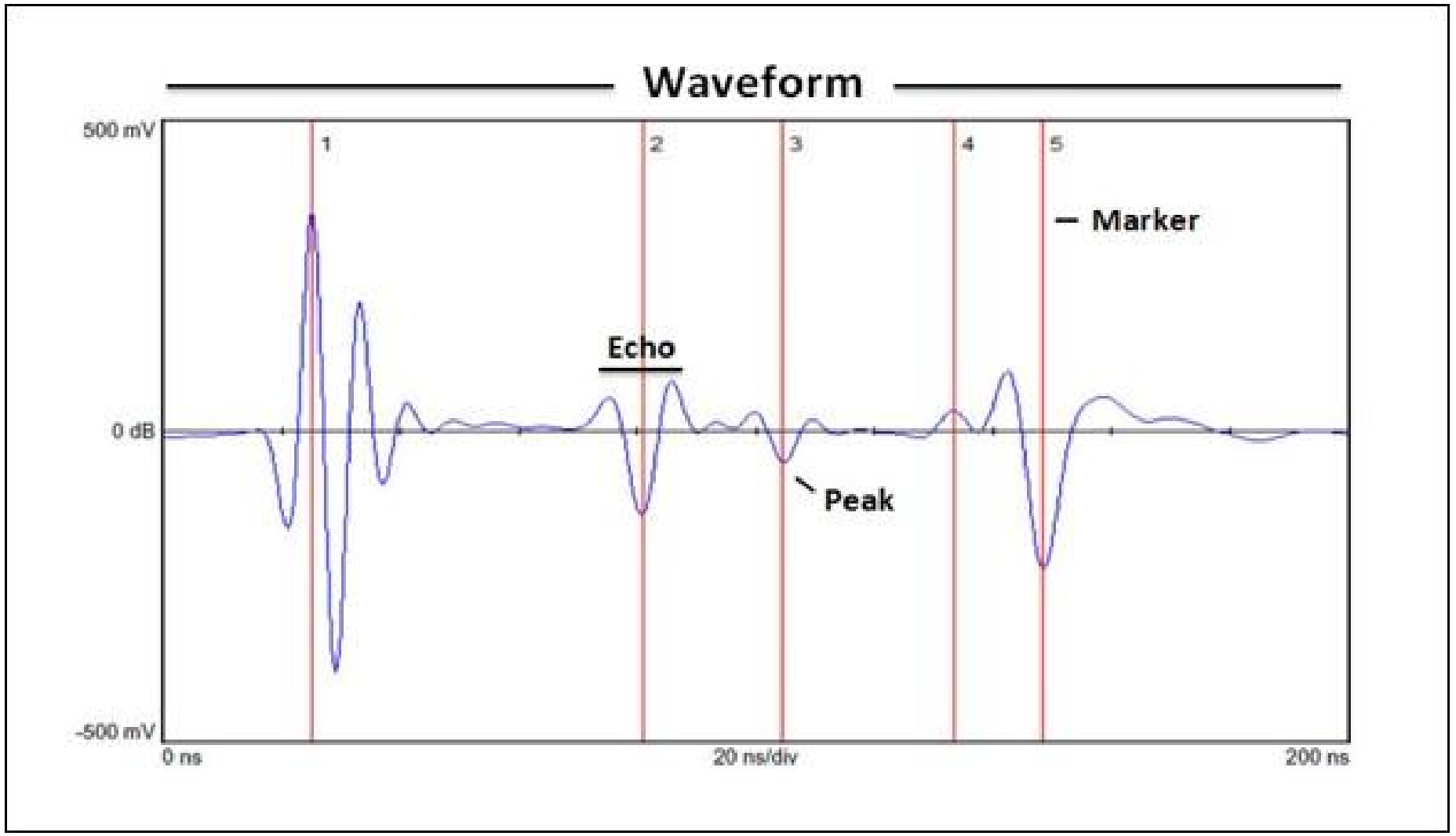
Differentiation or contrast between layers is a function of the differences in the mechanical or acoustic properties between adjacent layers.

Transducer technology advances can be used to improve visualization of low contrast layers or difficult to resolve layer boundaries.

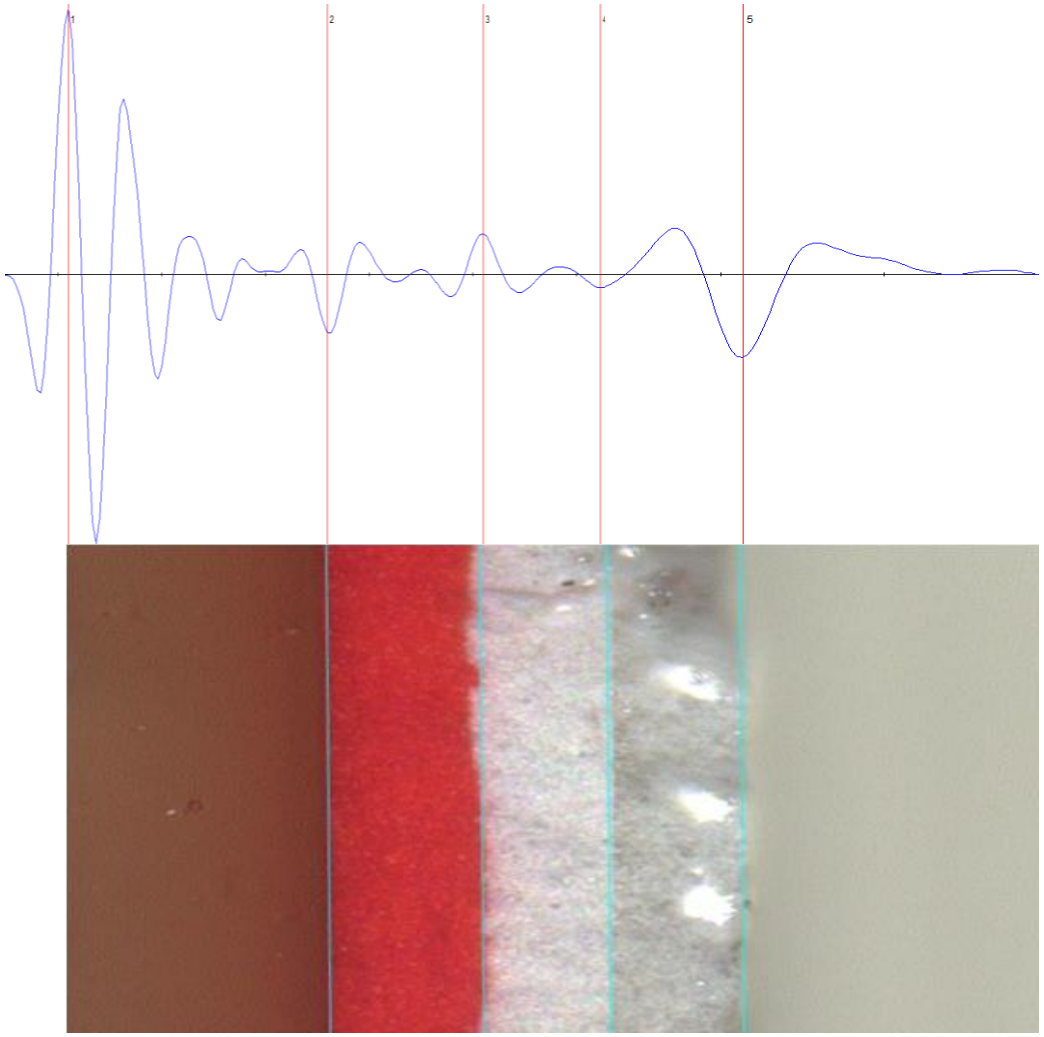
Resolution of thinner coating layers can be achieved by utilizing higher frequency transducers and ultrasonics.



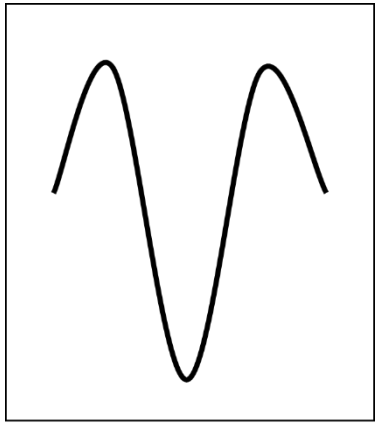
Measurement Principle
Terminology



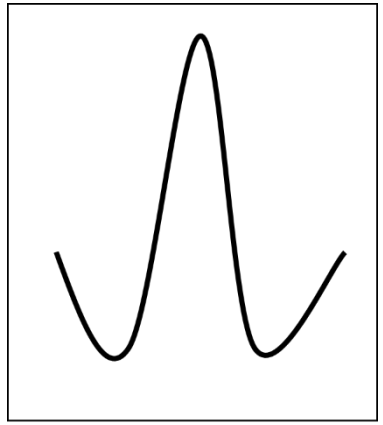
Measurement Principle
Echoe types



Typical ultrasonic echoes generated by paint layers:

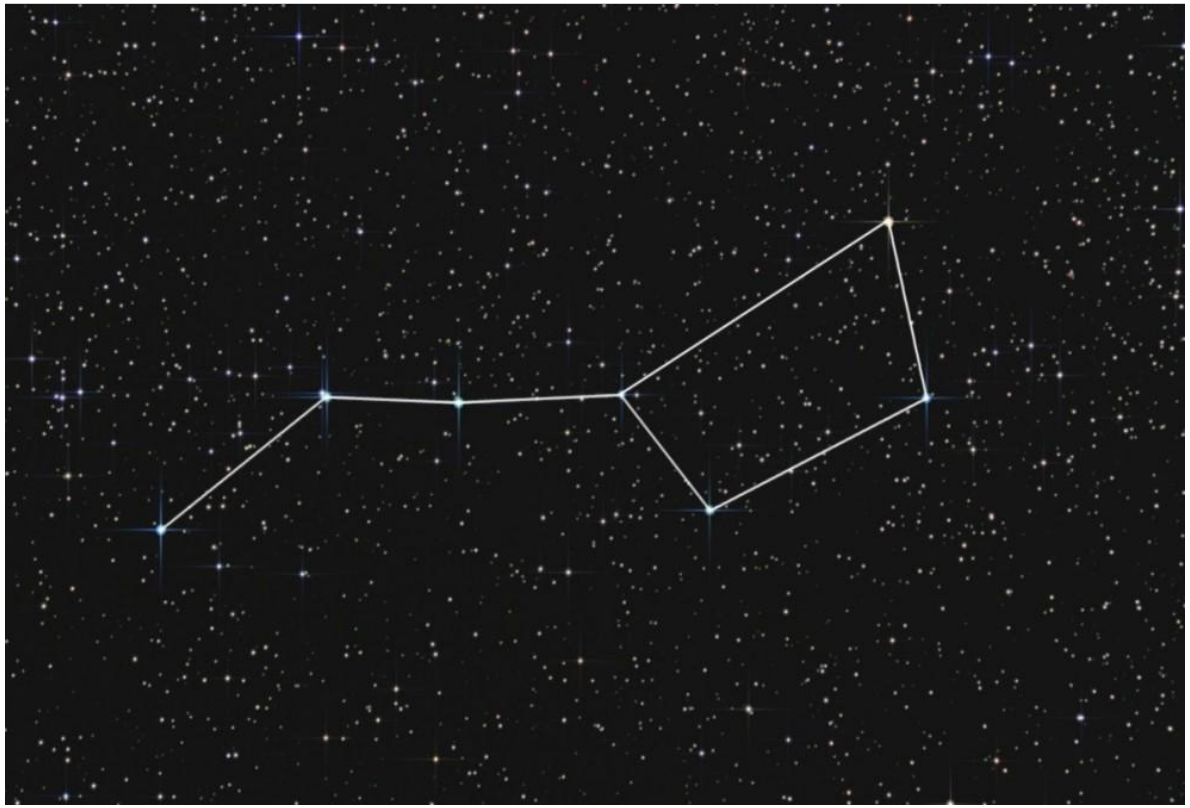


“M”



“W”

Measurement Principle
Waveforms and Pattern Recognition

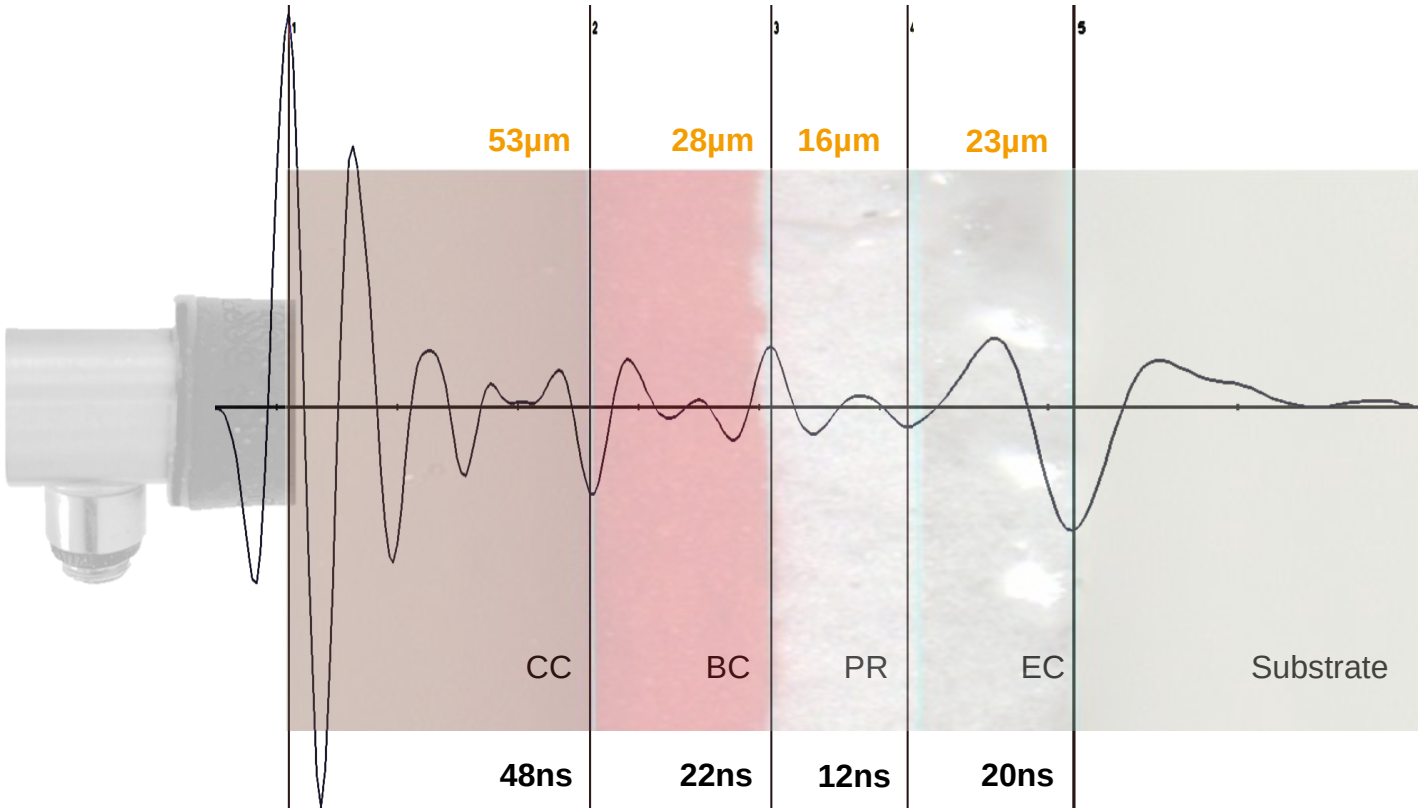


The key to waveform interpretation is pattern recognition

Calibration of Sound Velocities

Measurement Principle

Auto OEM 4-layer coating system



Layer thickness

Velocity x time

2

- **Time of flight** is measured by Ultrasound Instrument
- **Velocity** is determined by calibration record

Measurement Principle

Measurements through Calibration of Sound Velocity

The accuracy of this technology is enhanced by the coating calibration process.

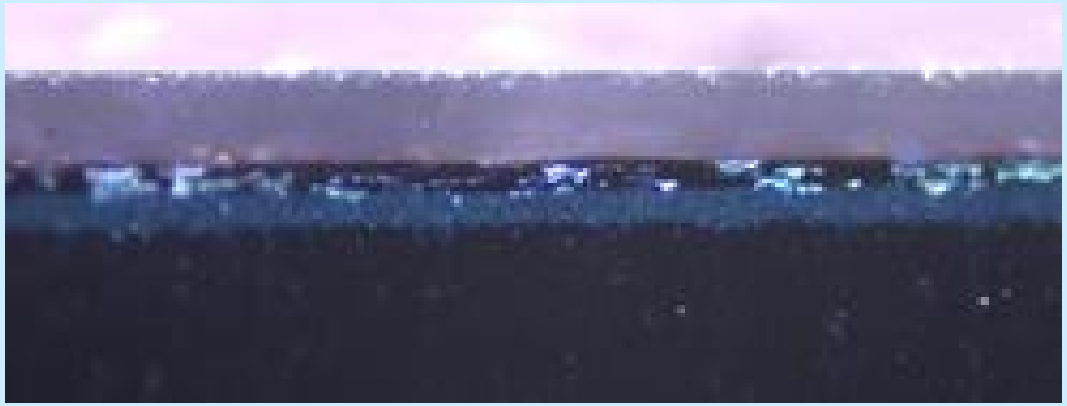
Because different coatings have different material properties, the velocity of sound through each coating will be different.

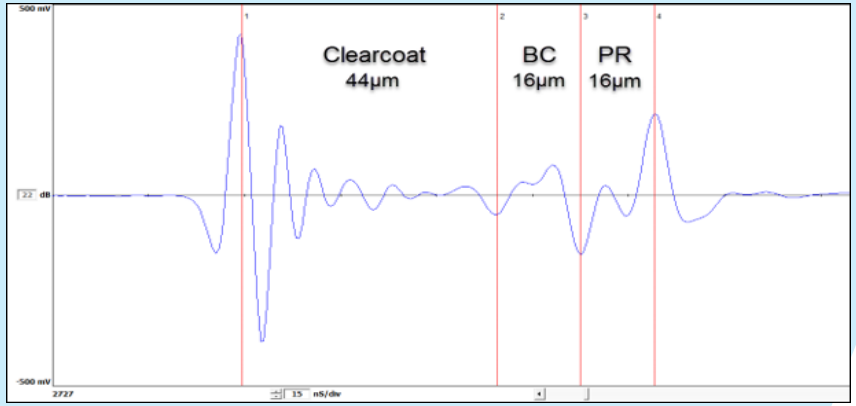
The sound velocity of a given layer is affected by the layers above and below.

For these reasons, the coatings velocities are determined as a system, and not solely by substrate, or as individual layers.

Measurement Principle
Calibration data for highest accuracy

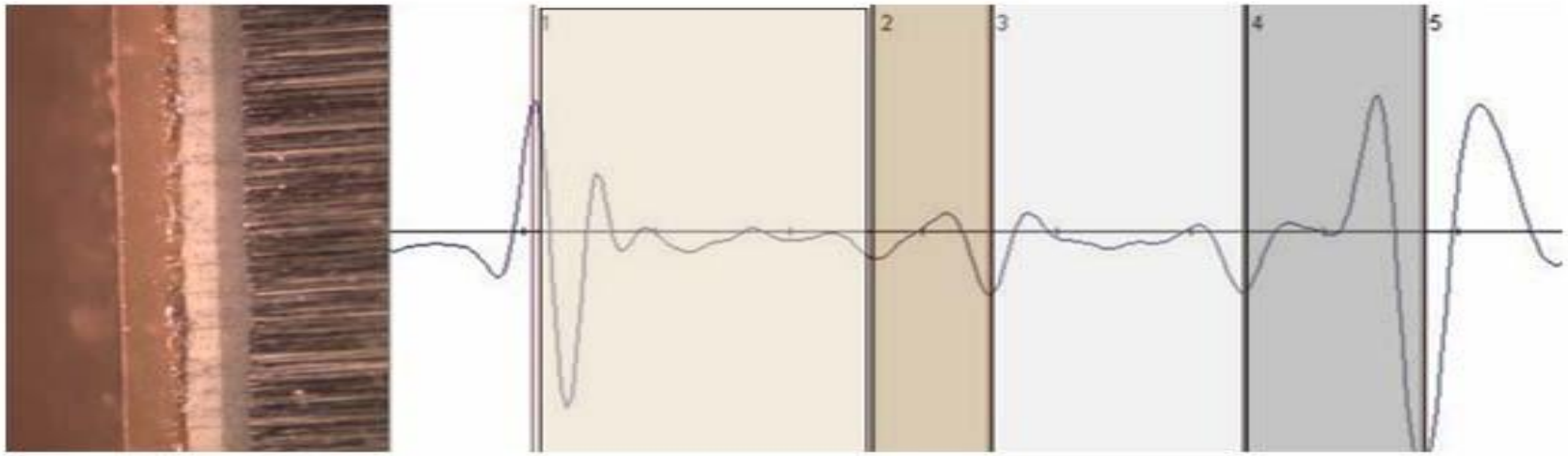
- To guarantee highest precision, calibration of the filmbuild layers are needed.
- Cross-sections from a specific multi-layer finish are cut, polished and measured with a high-resolution microscope.
- The microscope measurements and instrument waveforms are used to generate a calibration file for each layer of the filmbuild.





Measurement Principle
Calibration data for highest accuracy

Recalibration is necessary if coating supplier or coating type changes
or based on your internal quality system requirements.



Industries using High Precision Ultrasound

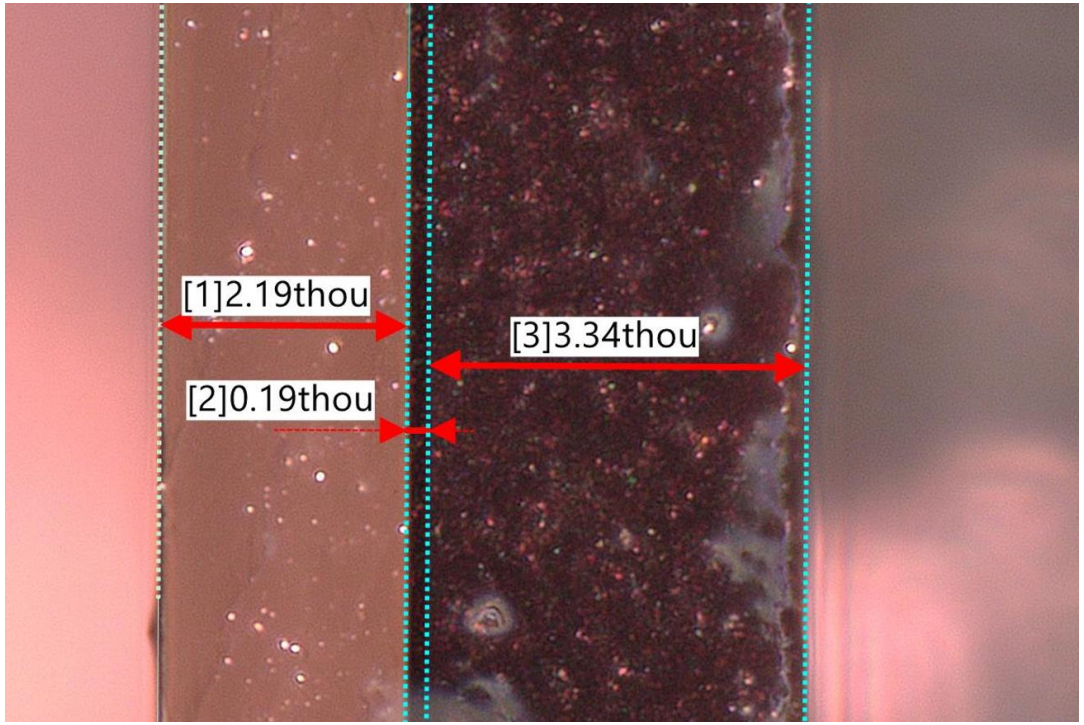
Industries using Ultrasound for Thickness Measurements

Aerospace Paint Coatings

Radar Domes

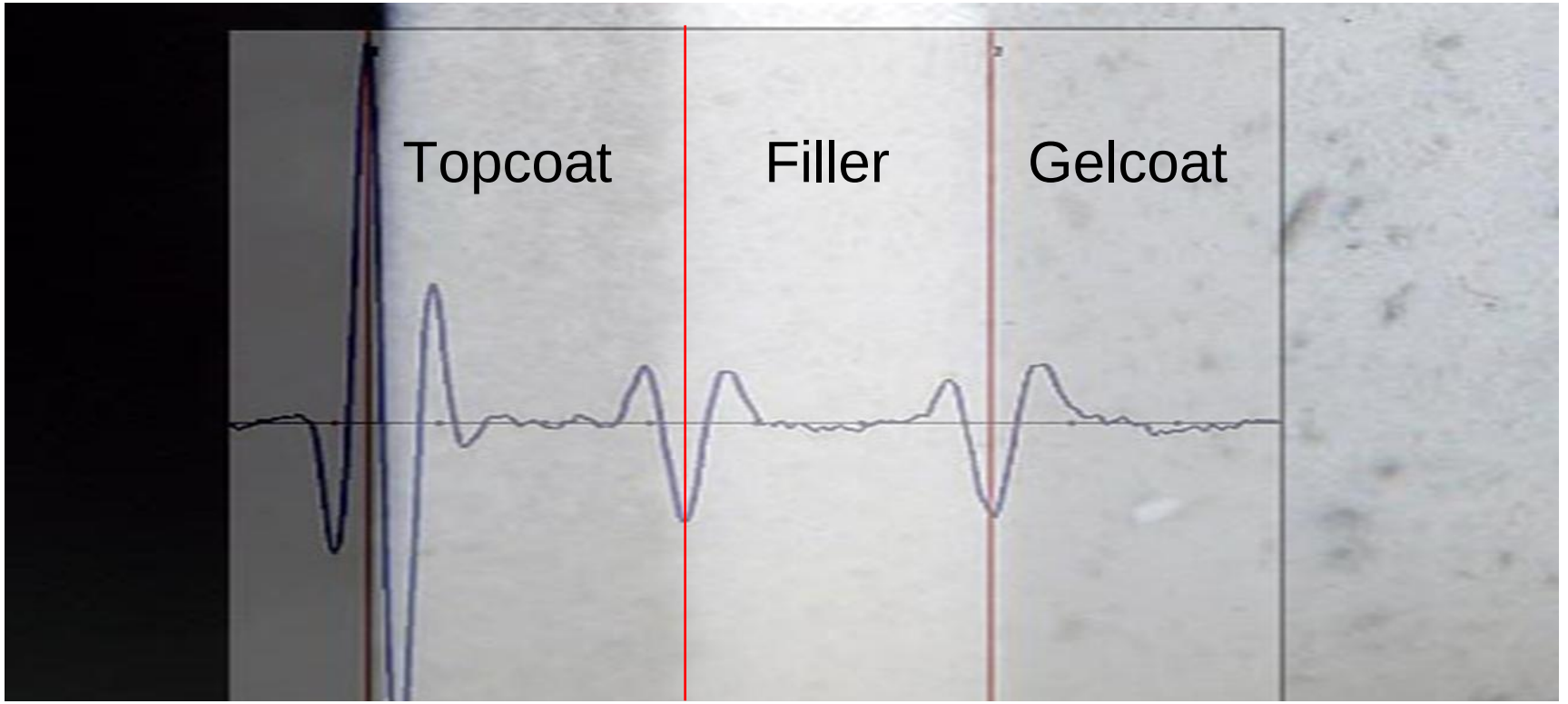
Lightning Protective Mesh composites

Powder Coatings



Wind Turbine Blade Cross Section

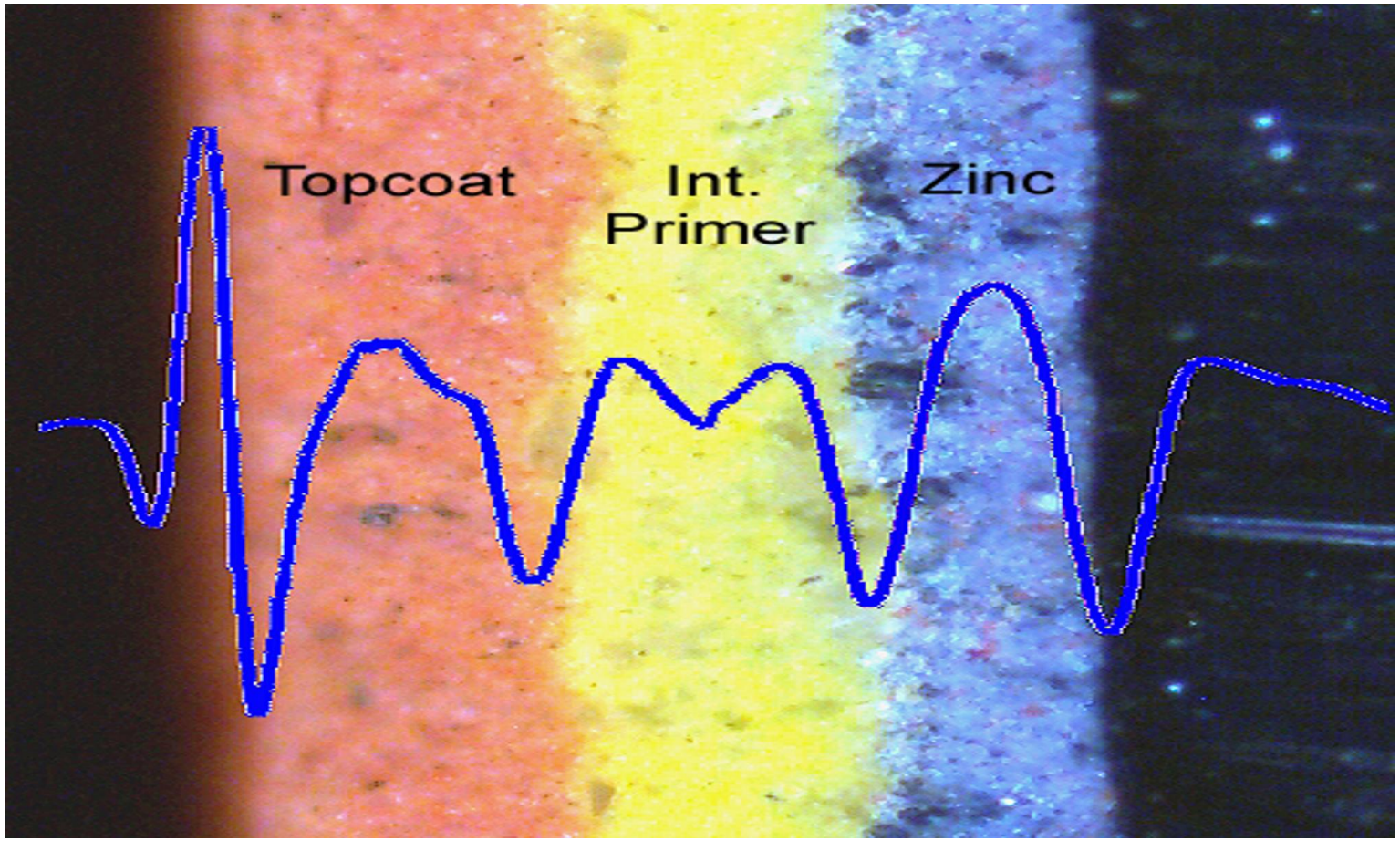
Lower frequency transducers are used for applications that require penetration through thick or lossy layers such as wind turbine blades.



Shipping Containers

Mid-frequency transducers are used for applications with rough or blasted substrates such as the shipping container industry.

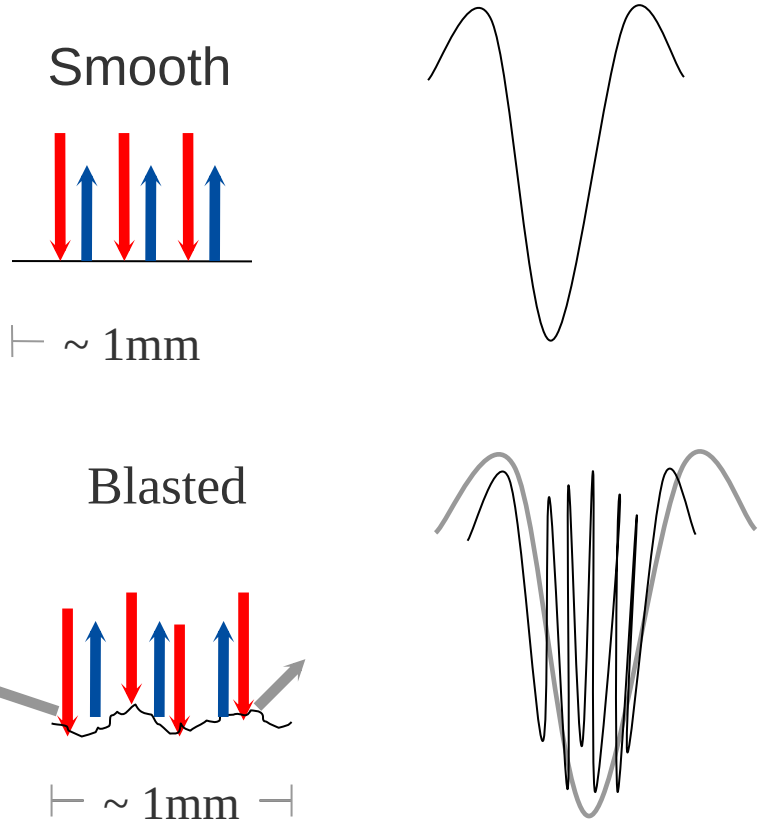
Shipping Container Cross Section



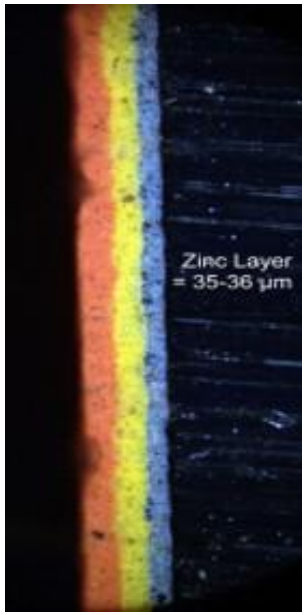
Smooth vs. Blasted Substrates

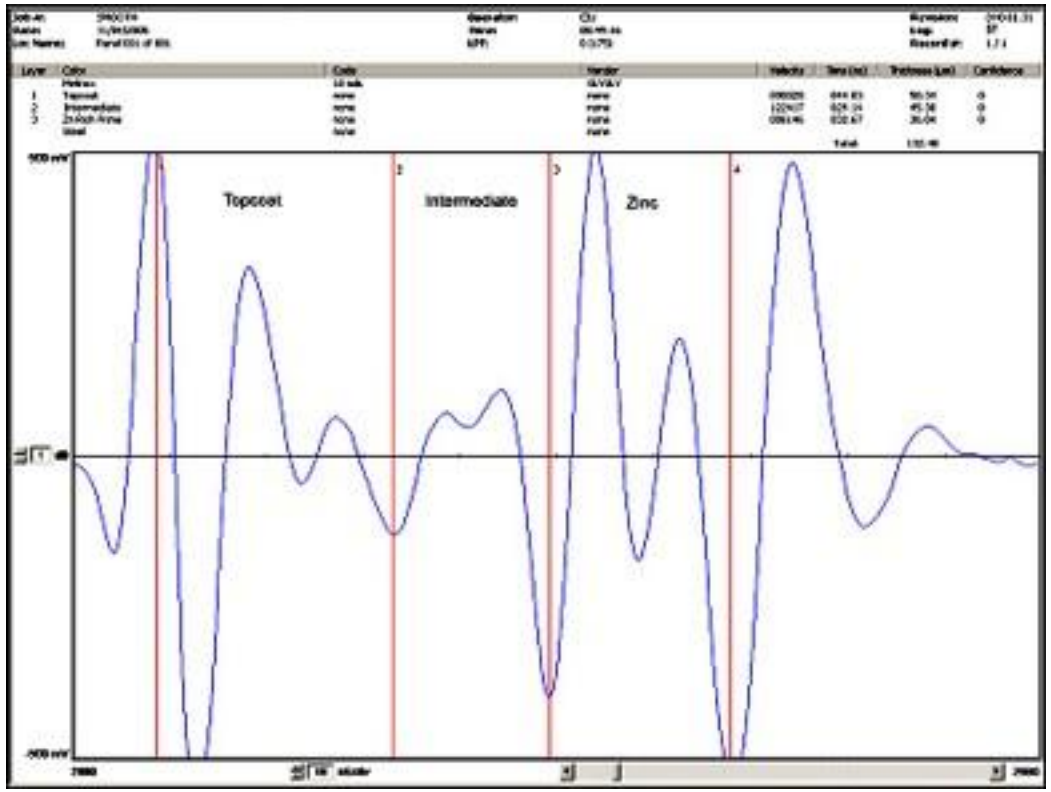
On smooth substrates, the ultrasonic pulse is not scattered, resulting in a clear echo that is each to capture and mark. The ultrasonic pulse is disc-shaped and samples a small area of the coating.

On blasted substrates, the ultrasonic pulse is partially scattered. The technology is still able to generate an echo based on an average.



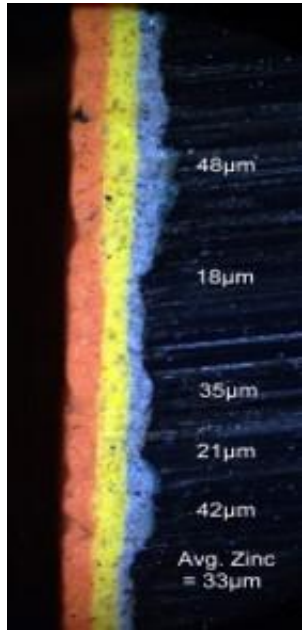
Smooth Substrate

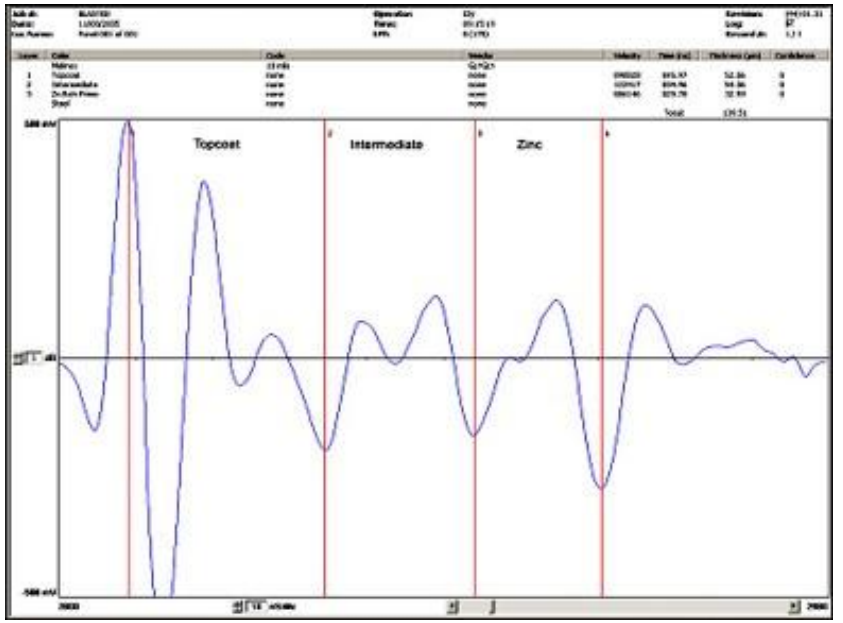




On this sample, the substrate is smooth, and the zinc prime layer is uniform in thickness.

Blasted Substrate

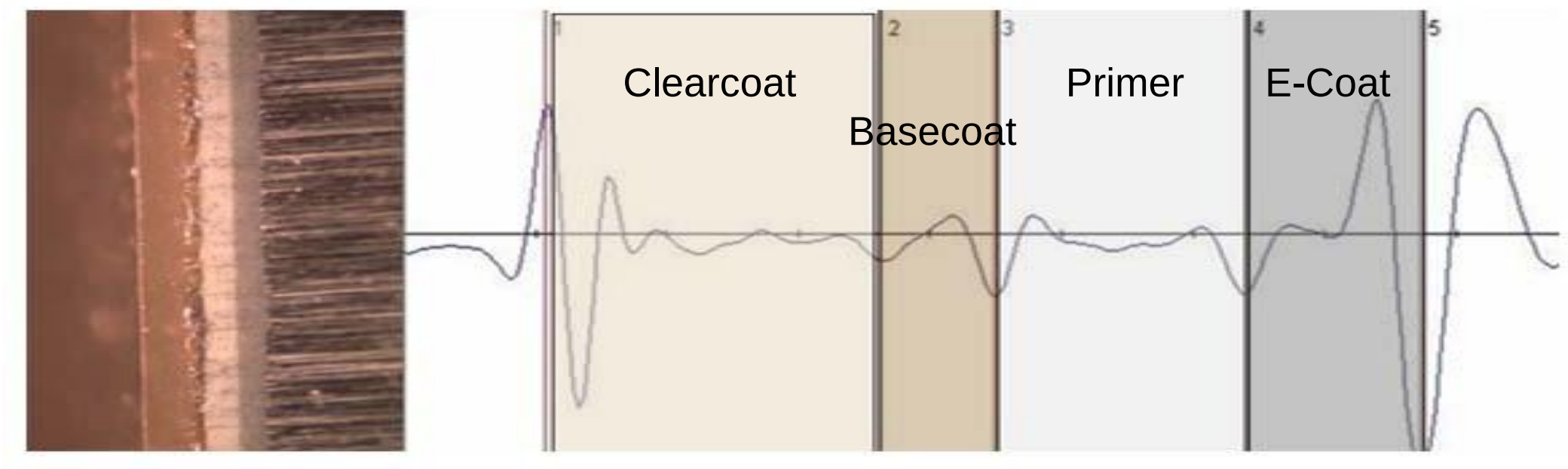




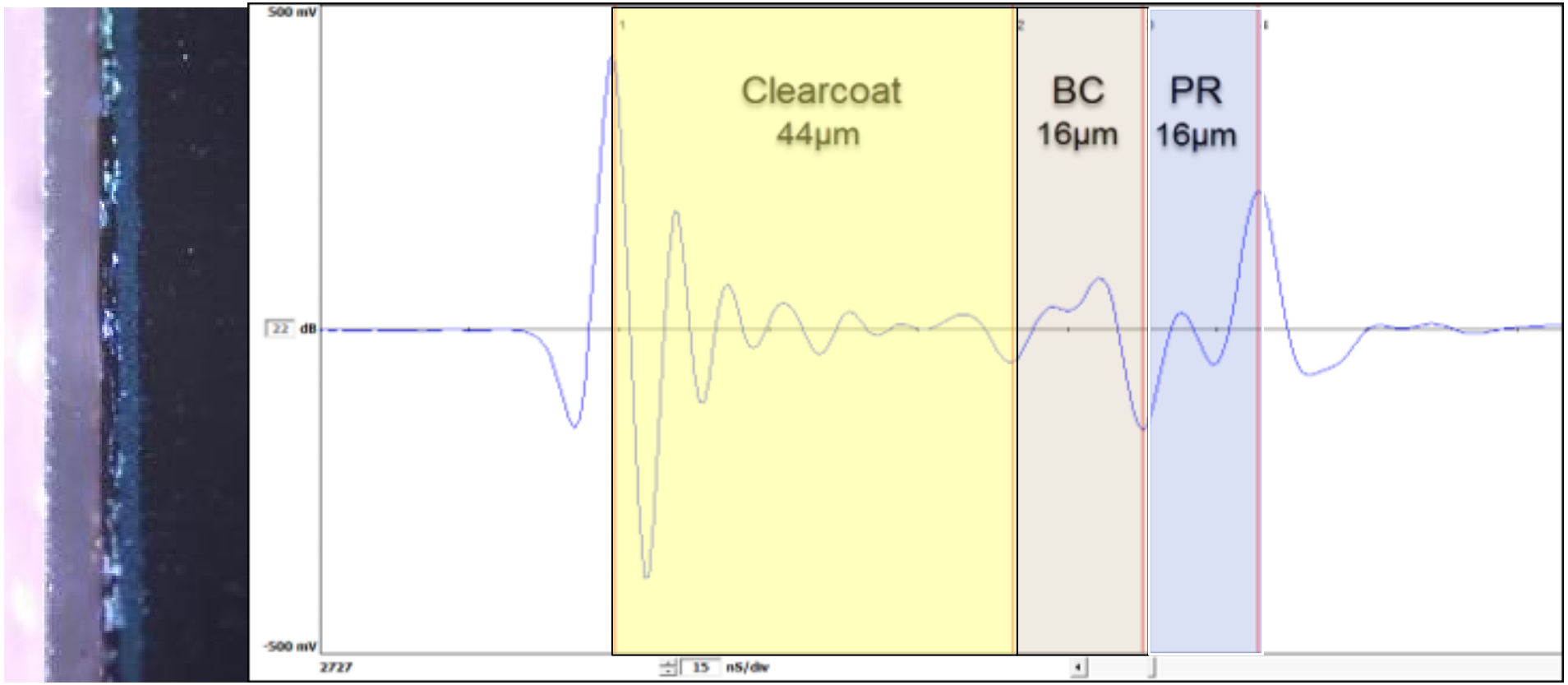
On this sample, the substrate is blasted, and the zinc prime layer varies in thickness.

Despite the blasted substrate, the echoes are clear with clear layer boundaries, resulting in accurate thickness measurements.

Automotive Steel & Aluminum

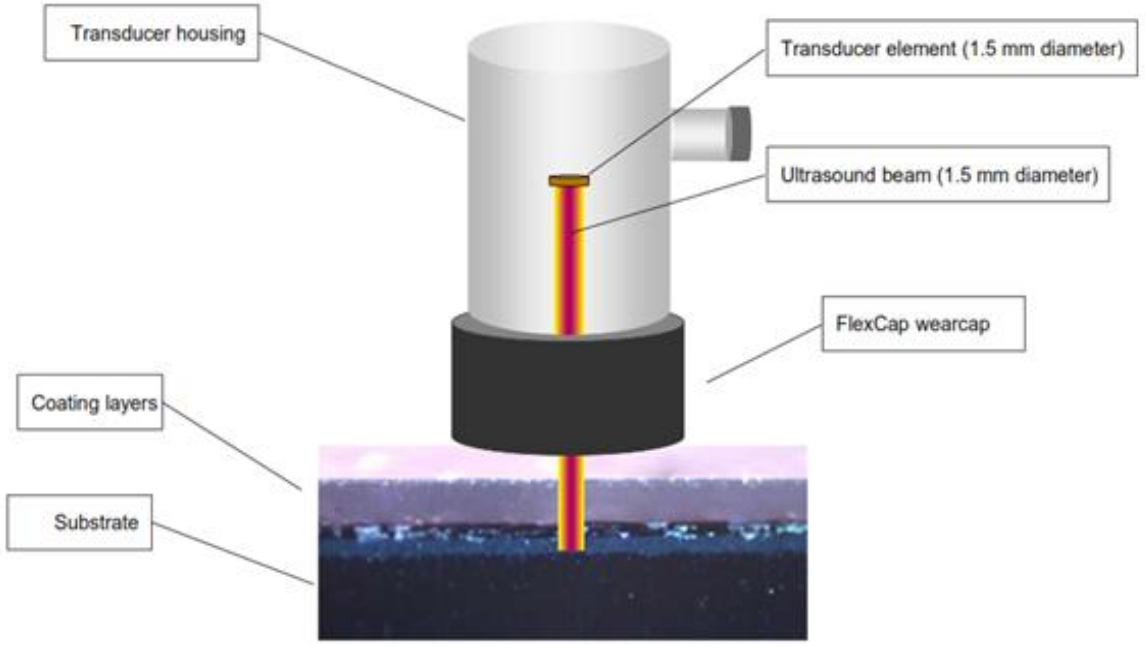


Automotive Plastic Parts



Ultrasonic Transducers

High Frequency UltrasonicTransducers



Transducers are composed of:

- Piezoelectric element that converts electrical energy into sound waves
- Acoustic matching layer(s) - reduce reflections at piezoelectric material
- Damping layer(s) – reduce ringing and broaden frequency bandwidth
- Backing material – absorbs energy from back face, preventing reflections and improving resolution
- Housing and electrical connections – mechanical support and protection, and connects to the pulser/receiver

Transducers
Thicker Coatings and Materials

300 µm – 5 mm

- Plastic bumper substrate thickness.
- Rubberized coatings.

150 µm – 1 mm

- Thick films.
- Rubberized coatings.
- Aerospace coatings.

80 µm – 750 µm

- Wind Turbine primers and filler material.
- Aerospace coatings.

Transducers
Thick Coatings & Materials

36 µm – 600 µm

- Thick or soft coatings.
- Marine coatings.
- May require thicker cap, depending on coating thickness.

30 µm – 550 µm

- Thick or soft coatings.
- Coatings on textured surfaces.

18 µm – 500 µm

- Shipping Containers
- Thick UV coating on carbon fiber.

Transducers
High Resolution for Thin Layers

10 µm – 400 µm

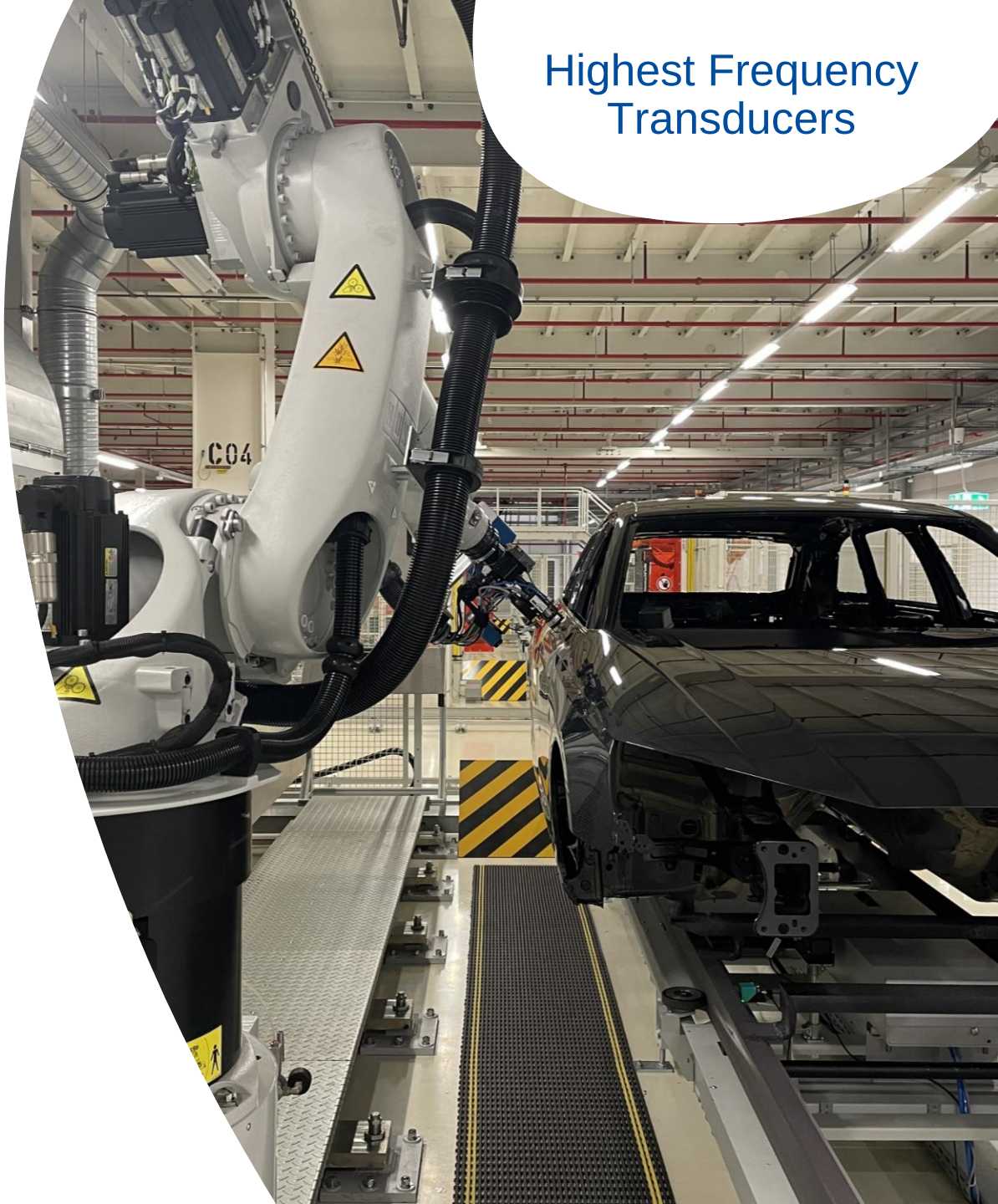
- Automotive painted steel & plastic parts.
- SMB version- smaller for tight or curved surfaces

6 µm – 200 µm

- Low contrasting layer boundaries.
- Thin mica or prime layers.

5 µm – 175 µm

- Low contrasting layer boundaries.
- Thin mica or prime layers.
- Requires special measurement cable (94087).



Highest Frequency Transducers

Summary

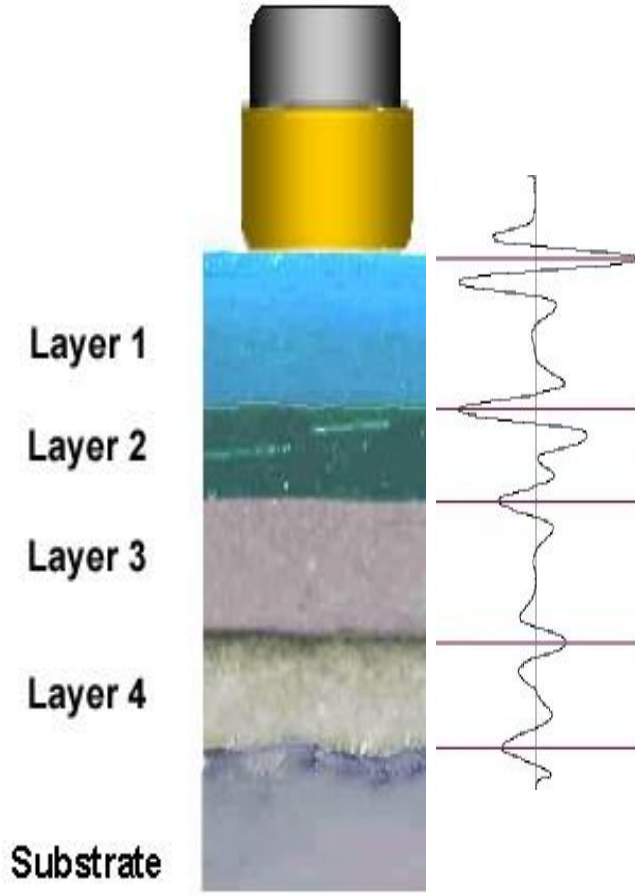
Coating Thickness Technology:
Offering precision control of exacting coating applications

Acoustic Microscope

Non-Destructive

Multi-layer coatings

Virtually any substrate



Thank you for your attention.

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