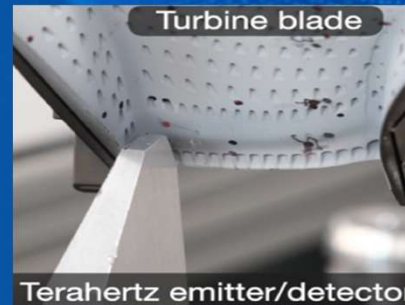
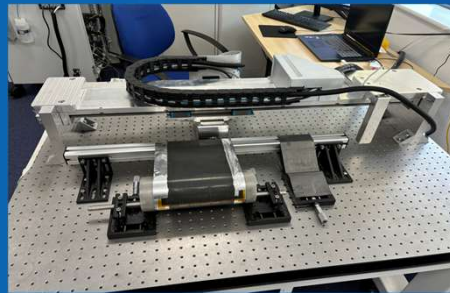


TeraView

Company Introduction



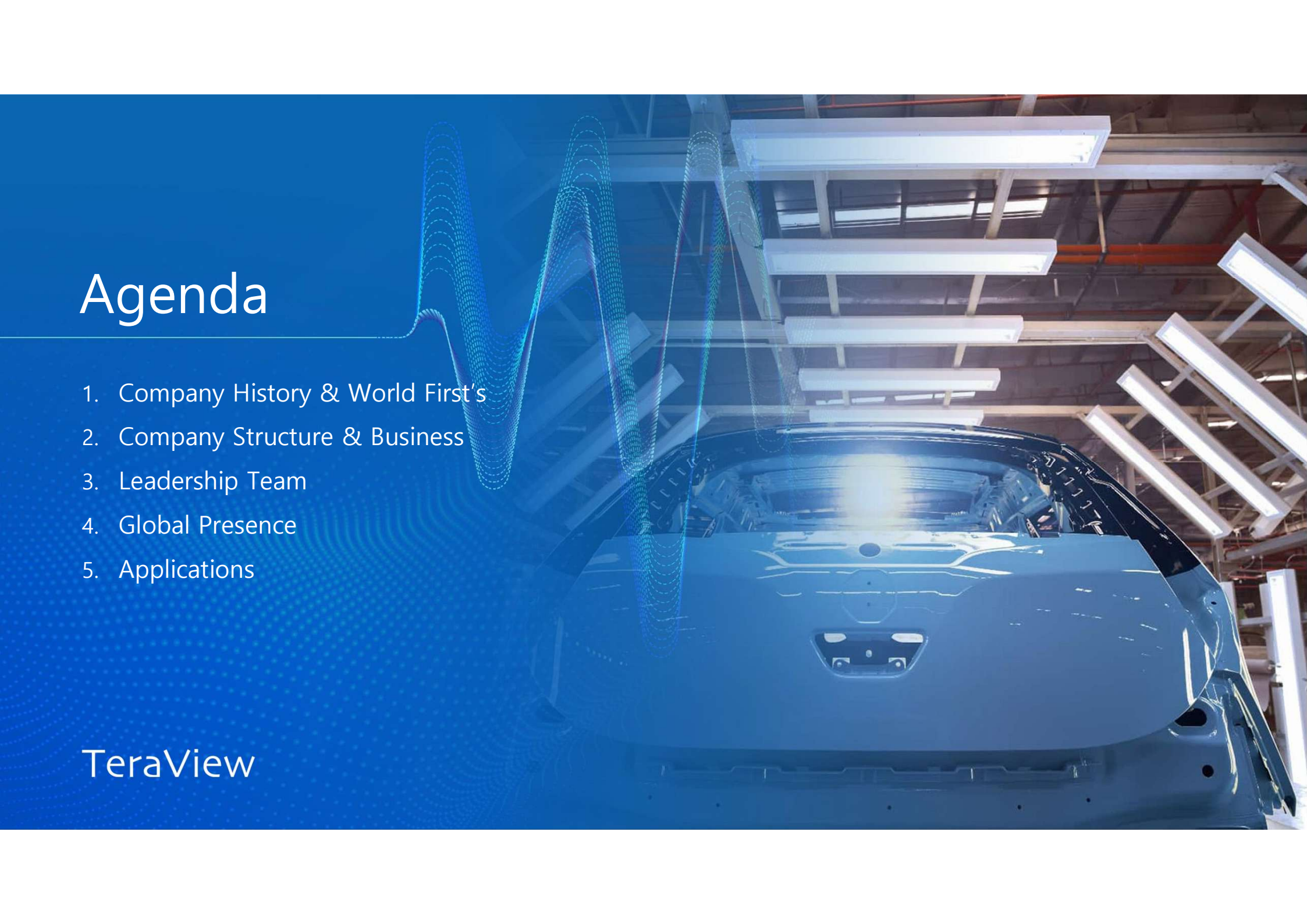
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TeraView

Agenda

1. Company History & World First's
2. Company Structure & Business
3. Leadership Team
4. Global Presence
5. Applications

TeraView



Company History

TeraView

Early 1990's saw collaboration between Toshiba corporation (Japan) and Cambridge University UK) to create Toshiba's 1st R&D centre outside of Japan focused on terahertz measurements for semiconductor manufacturing

Circa 2000 Toshiba corporation closed all Global R&D centres and withdrew them to Japan

April 2001 Senior Management formed a limited private company "TeraView Limited"

Initial solutions were based around Semi Conductor manufacturing, as per Toshiba expertise

Since 2001 the company has diversified into additional markets such as Pharmaceutical, Automotive & Aerospace, Battery Electrode manufacturing and Industrial Film measurement.

From it's initial headquarters in Cambridge, UK, TeraView has developed regional resources with the opening of an office in Seoul, South Korea providing Sales & support and additionally has dedicated Sales & support in N. America.

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TOSHIBA



TeraView

Company “Firsts”

TeraView

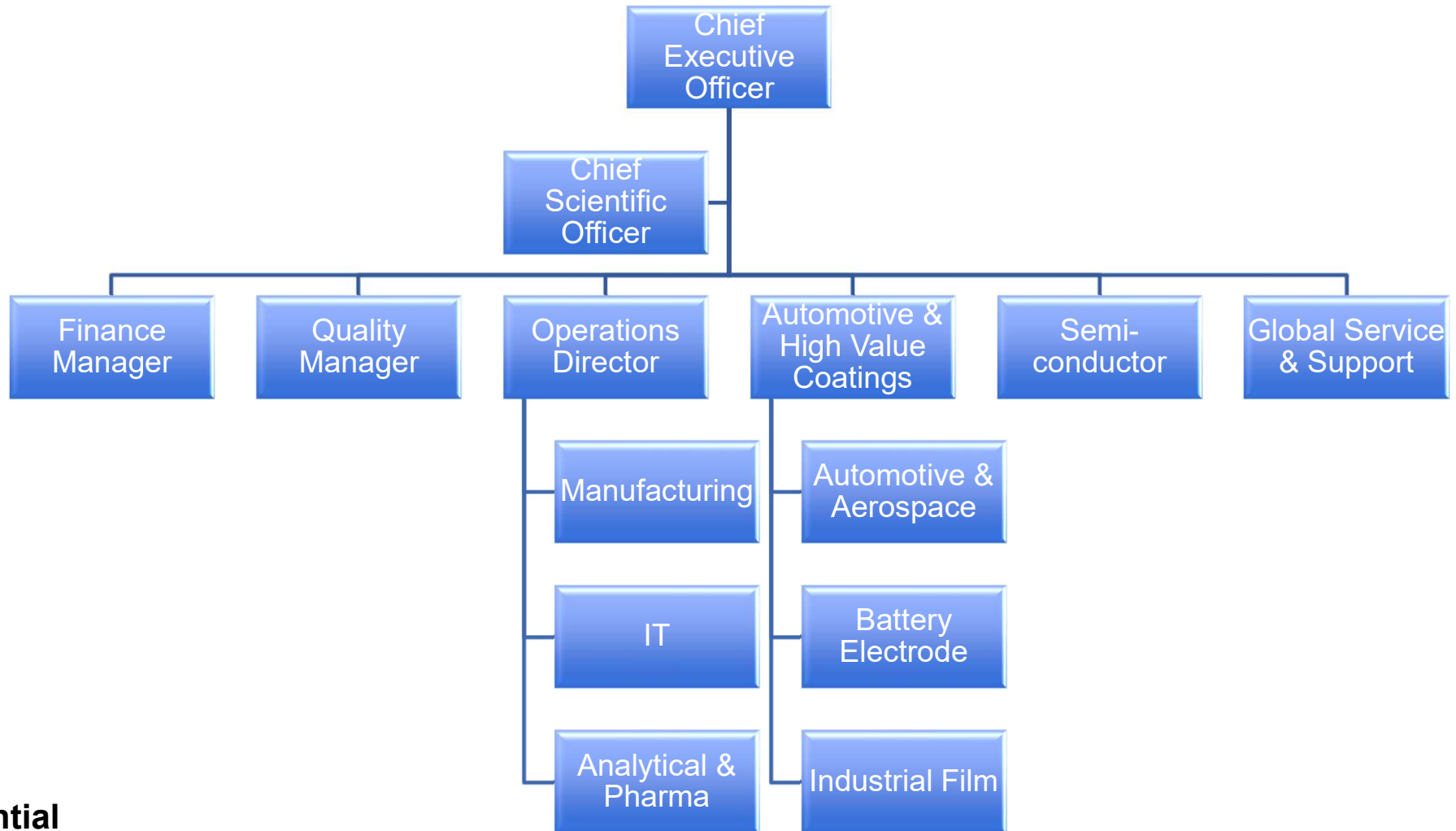
- 1999:** Dental imaging of enamel layers with Terahertz.
- 1998/01:** Medical imaging of breast cancer.
- 2002:** 1st image of polymer layer thickness on pharma tablets.
- 2003/4:** 1st detection of concealed explosives with US govt.
- 2004/5:** 1st product to measure coating thickness on non planar surfaces using robotic system—polymer & metallic layers.
- 2005:** 1st applications work and IP on LCDs.
- 2007:** Production systems for coating thickness on crucibles used in silicon wafer production & Industrial coaters used in pharma coatings.
- 2008:** 1st semiconductor packaging inspection system (Intel).
- 2008:** 1st paint thickness on auto (Ford) & aero (Boeing).
- 2013-2017:** Car paint thickness measurements, trials (Ford).
- 2016:** Automated inspection for semiconductor packaging (Samsung).
- 2017:** Proof of concept work on mobile phone displays (Samsung).
- 2018/19:** Initial deployments in automotive production plants (Toyota).
- 2020/21:** Markets in pharmaceuticals (US FDA), aerospace & 6G (UK Govt).
- 2020/22:** First to market with cathode & anode inspection for lithium-ion batteries.
- 2022/24:** Development of sensor for turbine blade ceramic coating measurement.



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Company Organisation

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Leadership Team

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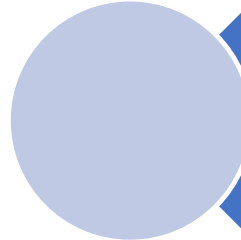
Chief Executive Officer
Dr Don Arnone
FREng



Quality & Service Manager
Rebecca Goodall



Chief Scientific Officer
Professor Sir Mike Pepper
FRS FREng HonFInstP



Vice President Semiconductor
Business
Martin Igarashi



Operations Director
Jacob Samuel



Vice President
Automotive & High Value
Coatings
Andy Bell

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Business Units

TeraView

Semiconductor Advanced Packaging Inspection

TeraView's solution enables rapid high accuracy fault isolation in advanced semiconductor packages

Solution:
EOTPR

Automotive & Aerospace

TeraView's solution measures individual layer thicknesses on multi-layer vehicle coatings.

TeraView also has a solution to measure the thickness of Thermal Barrier Coating on jet engine blades.

Solution:
TeraCota2000

Battery Manufacturing

TeraView's solution enables real-time production measurement of thickness, density, loading & conductivity for both anodes & cathodes. This enables fast & accurate control of electrode quality.

Solution:
TeraCota3500

Industrial Thin Films

TeraView's solution enables measurement of single & multi-layer thicknesses of Industrial thin films.

Solution:
TeraCota3000

Analytical & Pharma

TeraView's solution measures critical quality attributes in pharmaceutical and medical products such as crystalline structure, thickness and chemical composition.

Solution:
**TeraSolve
TeraPulse Lx**

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Global Presence

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Global Head Quarters –

Cambridge, UK

- Management
- R&D
- Manufacturing
- Global Support

Regional Office – Seoul, S. Korea

- Sales
- Service

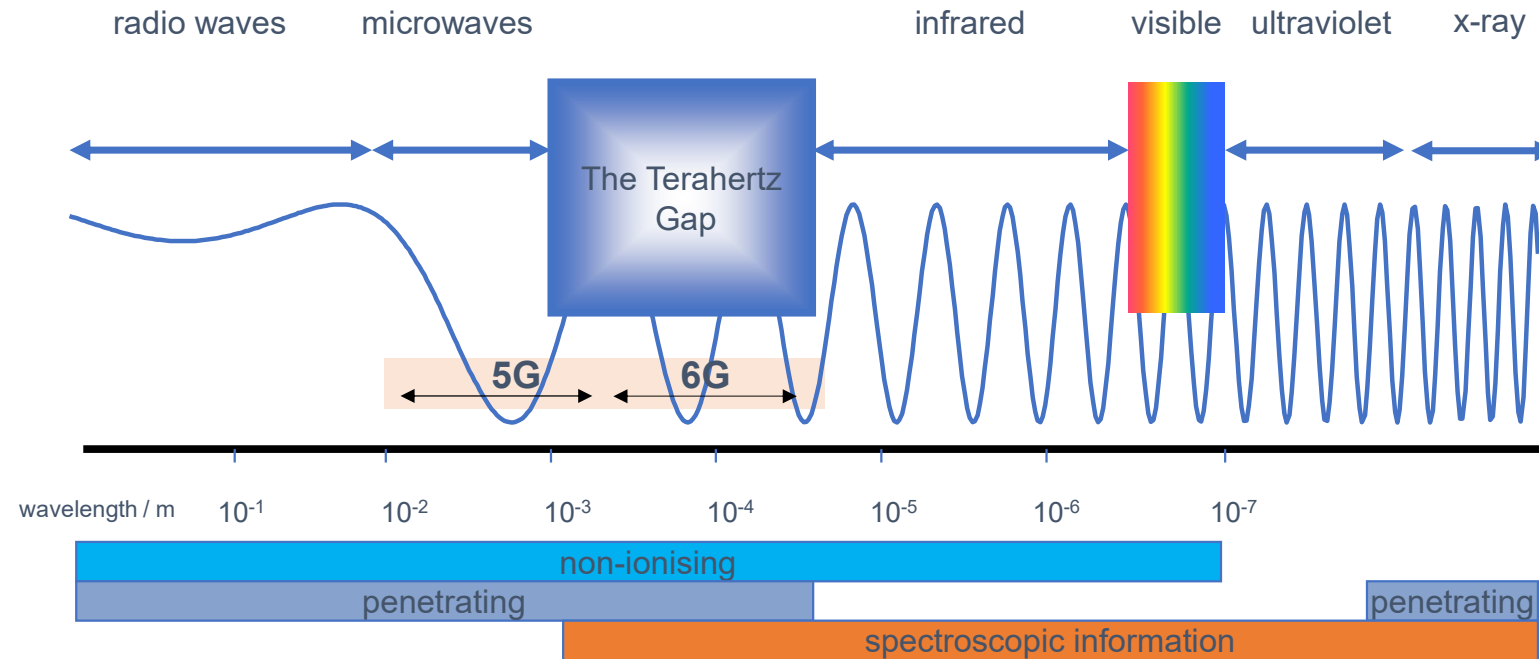
N. America – Legal entity

- Sales
- Service

Over 250 installations across 30 countries globally

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Terahertz - Technology

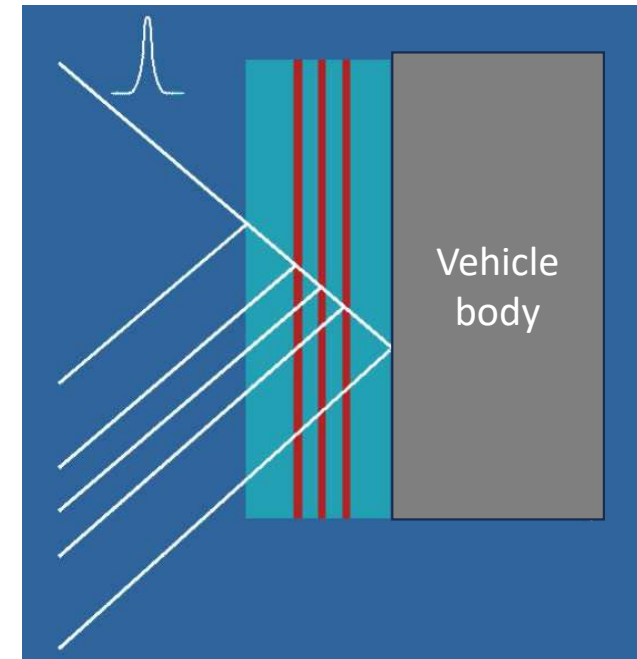


- Terahertz region between microwaves & infrared
- Until recently inaccessible due to lack of sources and detectors, only enabled with advent of high speed lasers.
- Many materials semi transparent in Terahertz – Car paint coatings
- **Safe** – non ionizing, low power

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Terahertz – how it works

- Paint layers are semi transparent to THz
- Terahertz pulses are reflected from different interfaces between paint layers
- Time of flight to the detector is measured accurately, allowing the thickness of the layers to be determined from the differences in arrival times of the pulses
- The basic requirement for thickness measurement is a refractive index difference between adjacent coatings
- The method is applicable to multiple coatings



peak separation
coating thickness, $d_i \sim \frac{\Delta t_i}{n_i}$
refractive index

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Terahertz – how it works on automotive paints

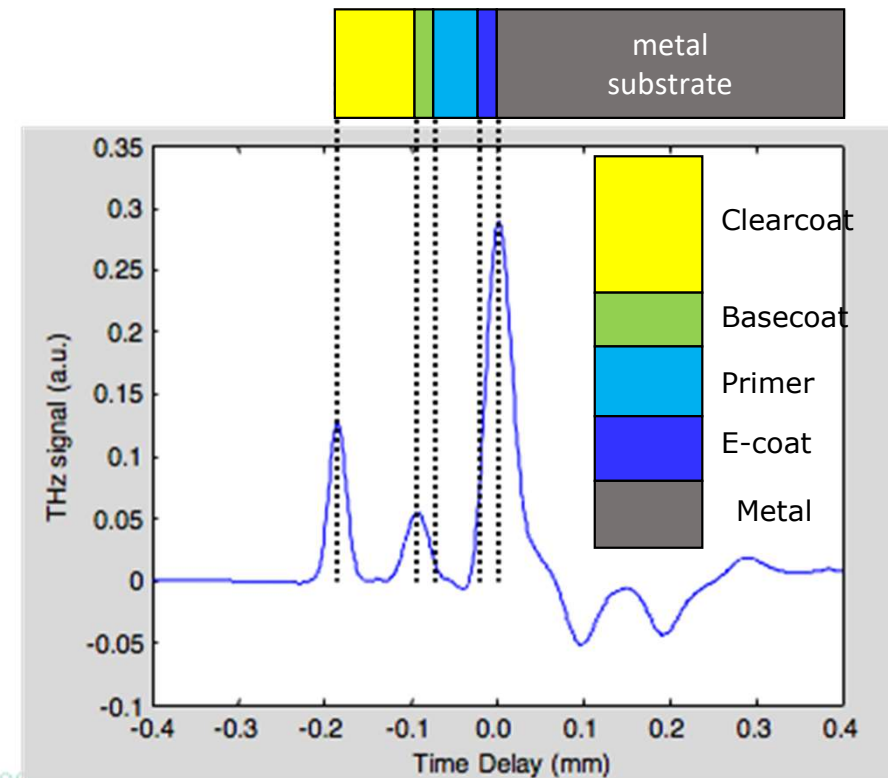
Analysis is challenging on car paint: cannot easily resolve reflections from different layers due to overlap

- Number of coatings: typically 3-5 or more
- Wavelength of THz > layer thickness
- Large variety in pigments (aluminium, mica flakes)
- **Relatively thin coatings** (down to 2µm)

TeraView has developed a patented technique to resolve layers and calculate thicknesses

- Developed & refined over several years with customers
- Patented calibration technique for accuracy & sensitivity

peak separation
coating thickness, $d_i \sim \frac{\Delta t_i}{n_i}$
refractive index



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Customer View – Ford View of Advantages of TeraCota

Key Terahertz Advantages



- Non-contact and no water required – not possible with ultrasound
- Good resolution
- Very fast sample rate relative to ultrasound
- Capability to measure windshield flange – not possible with ultrasound
- Ability to collect all film-build control plan data points
- Capability to “scan” a vehicle with all paint layers at once – not possible with ultrasound
- First in industry technology development



2

Internal slide presented by Ford Paints and Vehicle Operations Group to Ford management

Reference customer at Ford:

Mark Nichols, Ph.D.
Senior Technical Leader:
Materials, Coatings, and
Analysis
Ford Research and Advanced
Engineering
mnichols@ford.com
c: 734-678-7159

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Deployment

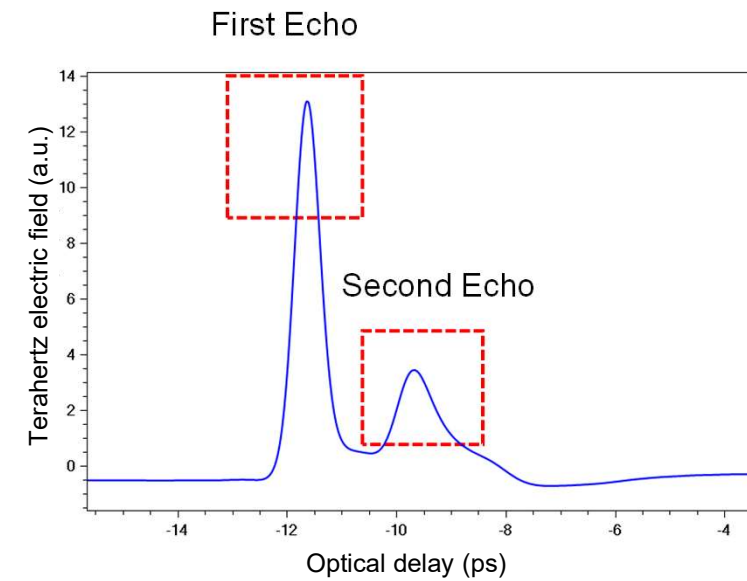
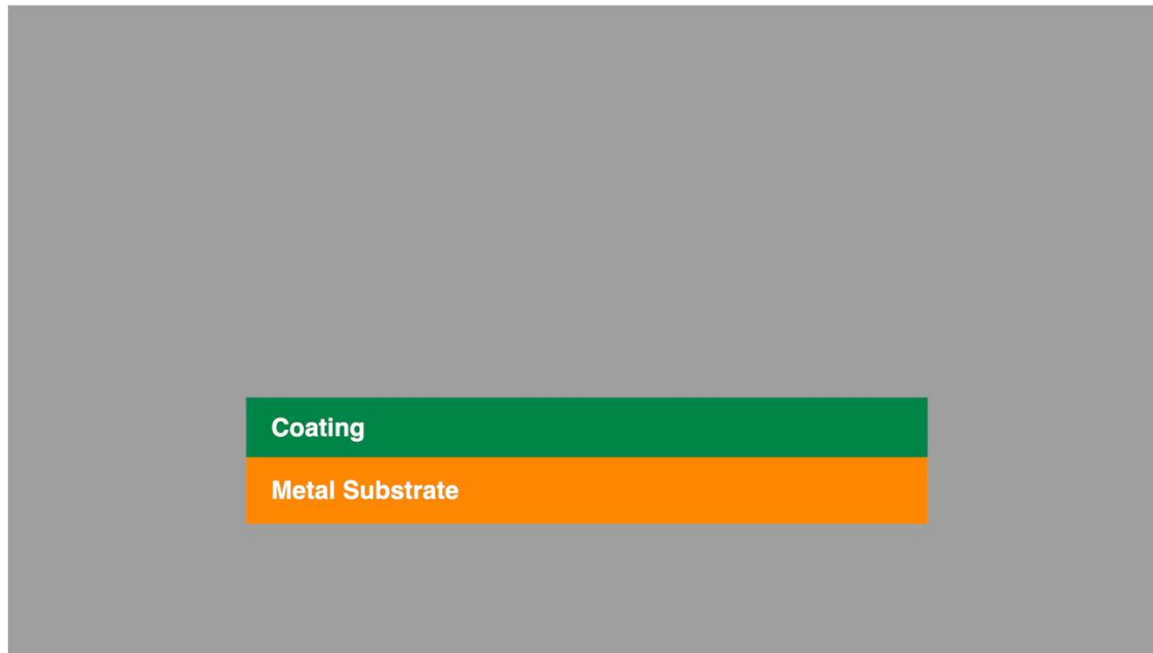
- The Volkswagen Group, together with TeraView, have recently completed installation of a Terahertz system at their production plant in Bratislava, Slovakia
- In this project, TeraView's TeraCota product was the first terahertz system to measure coating thicknesses in Volkswagen's 2010V painting process
- System acceptance was achieved by demonstrating the ability of the TeraView system to measure multiple points on different types of car bodies to an accuracy of 1µm. This accuracy was demonstrated over several repeat measurements on each car body.
- Due to this and other terahertz projects, Volkswagen plans to continue to use terahertz technology to determine layer thickness in the future



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Battery Electrodes - Principle of Measurement

- Time domain technique: Fast and accurate



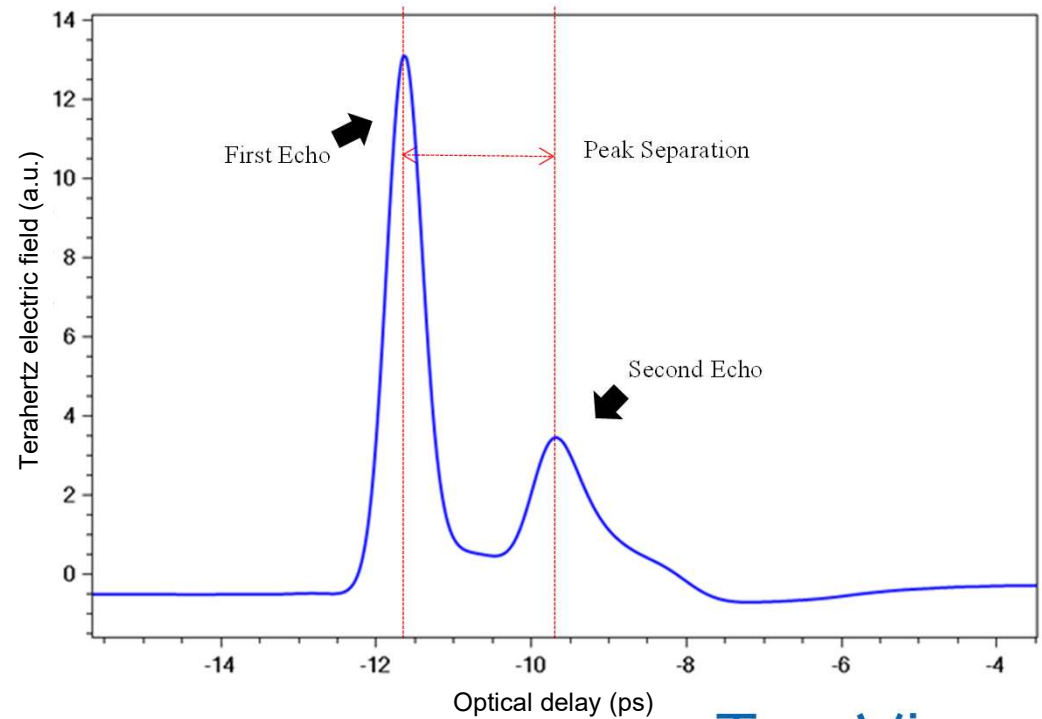
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Battery Electrodes - Principle of Analysis

Simultaneous measurement of coating characteristic

$$n = n_0 + ik$$

- Monitor coating **Loading** (Peak Separation)
- Monitor coating **Density** (First Echo)
- Monitor coating **Thickness**
- Monitor coating **Conductivity** (Second Echo)
- Monitor coating **Porosity** (tbc)



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Bosch Case Study - Quality Control & Cost Reduction for Windshield Wiper Coatings



To accommodate the rapidly growing need for accurate measurement of graphite coating on windshield wipers Bosch installed the system at the Tieggen, Belgium site. The system measures the curvature of the rubber substrate and adapts for this in the final calculation of the coating thickness. The entire process is carried out on moving material at production speeds of up to 40m/min.

The TeraCota2000 system at Bosch has been developed from the systems in use at both VW & Ford Motor Company as well as several other automotive OEMs for several years to enable measurement of multi-layer coatings.



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