C10G-E098

SHIMADZU
Excellence in Science

Solutions for
CASE and Weight Reduction Development of Automobiles

Evaluation of CASE and Weight Reduction Technologies

—Evaluation Applications Useful for Achieving CASE Characteristics and Reducing Weight—

With various countries specifying major policies for realizing carbon neutrality, the key to achieving the goals set forth in those policies will be to promote the widespread adoption of next-generation CASE mobility solutions. However, there are a variety of challenges involved in making CASE mobility a reality, such as establishing 5G communication infrastructures, improving LiDAR spatial recognition performance, ensuring the comfort of shared spaces, developing high-output electric motorized systems, and developing high-performance next-generation batteries. Also, in order to extend the travel range of next-generation mobility, weight reduction will be an important factor. To solve such market challenges for achieving CASE mobility and reducing weight, Shimadzu is committed to offering a wide range of evaluation and measuring technologies for supporting such innovations in the automotive industry.

CASE

CASE is an acronym that refers to mobility solutions that are "Connected," "Autonomous," "Shared & Services," and "Electrification." It symbolizes the automotive industry as it charges ahead into the largest industry revolution in a hundred years. This e-book describes evaluation applications and the Shimadzu analytical, testing, and measuring instruments available to solve market challenges.

Reducing Weight

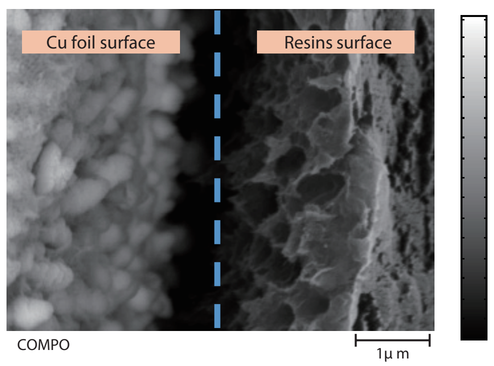
To reduce the environmental impact of automobiles, the industry is developing ways to reduce weight in order to increase fuel and electricity efficiency. Weight reduction is also important as a countermeasure for the increase in the number of ECU units and the weight of batteries as vehicles are electrified. Numerous testing, analysis, observation, and measurement methods are used during the evaluation and development process of various materials, such as high tensile steels that possess excellent strength but also have good press workability, high-strength aluminums, and GFRP or CFRP composites. The following describes evaluation methods used to develop lighter weight materials.

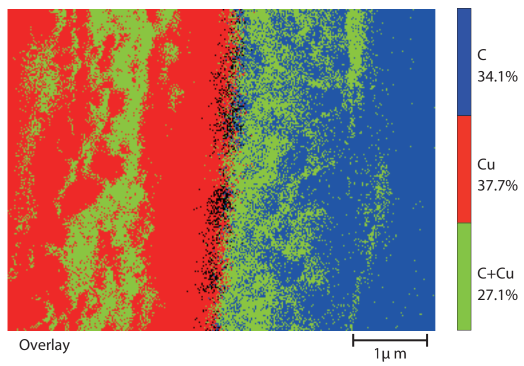
01 Connected | 5G Communication | Hot Topics

Connected vehicles with built-in communication equipment use various sensors to collect a variety of data, such as data about the vehicle status, road status, and surrounding environmental conditions, and then transmit the data via a network for accumulation and analysis. By interactively communicating with other vehicles or public infrastructure, they can help ensure smooth and safe driving. Fifth-generation (5G) mobile communication systems are anticipated for use in connected vehicles due to their high speed and high capacity. For 5G communication to achieve substantially faster transmission speeds than 4G technology, a higher frequency range is required. Therefore, the printed circuit boards and other electronic components in 5G devices must be compatible with high frequencies. The following describes evaluation methods used during development related to connected vehicle communication.

Analysis of Circuit Boards for 5G Communication Device

The high frequency band used for 5G communication can cause signal degradation issues due to dielectric losses. Consequently, fluoropolymer (PTFE) and liquid crystal polymer (LCP) materials have attracted attention as an insulation material in circuit boards. In this example, an electron probe microanalyzer (EPMA) was used to analyze the surface and boundaries between copper and low-dielectric materials in a laminated 5G circuit board.





Analysis of Printed Circuit Boards for 5G Communication Equipment

Application

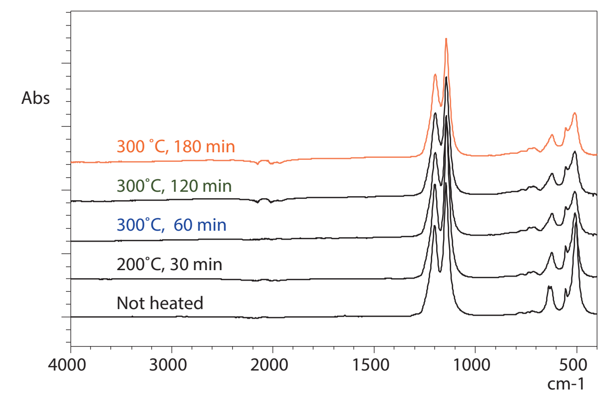
Electron Probe Microanalyzer

EPMA-8050G

Product

Property Evaluation of Fluorocarbon Resin that Supports Popularization of 5G

Given the rise of 5G, there is growing interest in utilizing new materials as an alternative to glass epoxy and glass polyimide in circuit boards. Such alternatives include fluorocarbon resins and LCPs (liquid crystal polymers). In this example, a Fourier transform infrared (FTIR) spectrophotometer and thermogravimetric analyzer (TGA) were used to evaluate the structural and weight changes in fluorocarbon resins when heated.



Property Evaluation of Fluorocarbon Resin Supporting Popularization of 5G by FTIR and TGA

Application

Fourier Transform Infrared Spectrophotometer

IRTracer-100

Product

CE

01 Latest Applications

[Connected]

Evaluation of a Ceramic Filter for Communication Base

Example of Observing Printed Circuit Board in a 5G Smartphone Using a Microfocus X-Ray CT System

Application

Microfocus X-Ray CT System

inspeXio SMX-225CT FPD HR Plus

Product

X-Ray Observation of a Circuit Board Installed in a 5G Smartphone

Example of Observing a Printed Circuit Board in a 5G Smartphone Using a Microfocus X-Ray CT System

Application

Microfocus X-Ray Inspection System

Xslicer SMX-6010

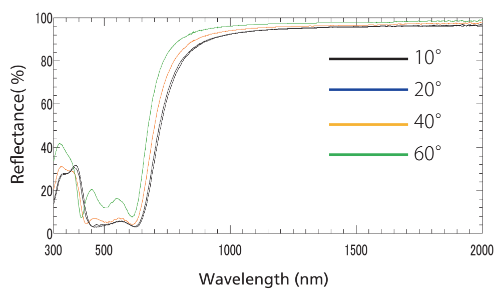
Product

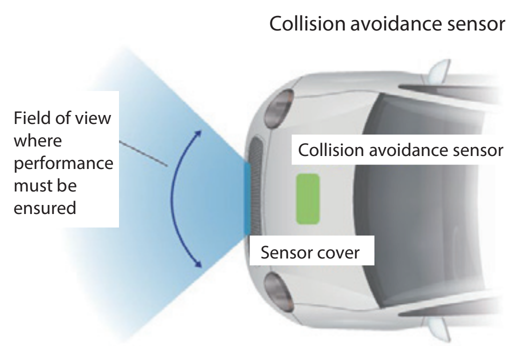
02 Autonomous | LiDAR and Sensory / Quantitation | Hot Topics

In 2020, the Japanese Ministry of Land, Infrastructure, Transport and Tourism defined "autonomous driving" as the state when all driving tasks are performed by an automated driving system. Autonomous driving has also been classified into 5 levels from 1 to 5, with many automobile manufacturers already offering vehicles with autonomous driving technology levels 1 and 2. Now vehicles equipped with level 3 technology are starting to be released. For autonomous driving levels 1 to 3, the human driver remains in primary control of driving tasks, but the system is in control for levels 4 and 5. That has made LiDAR technology extremely important for identifying potential obstructions during driving and a key technology for realizing true autonomous driving. The following describes evaluation methods used during development related to autonomous driving.

LiDAR Evaluation System

LiDAR can be used to determine the distance and angle to distant objects of interest and analyze their material characteristics by shining a laser light against the object and then measuring the amount of scattered or reflected light. During autonomous driving, LiDAR is used instead of humans to detect traffic signals, road width, oncoming vehicles, and pedestrians, for example, and then execute appropriate driving operations. UV-VIS-NIR spectrophotometers can be used to evaluate the optical properties of a wide range of materials related to LiDAR.





LiDAR Evaluation System: Measurement of Transmittance/ Reflectance of Optical Materials

Application

LiDAR Evaluation System: Measurement of Transmittance of Bandpass Filters

Application

UV-VIS-NIR Spectrophotometer

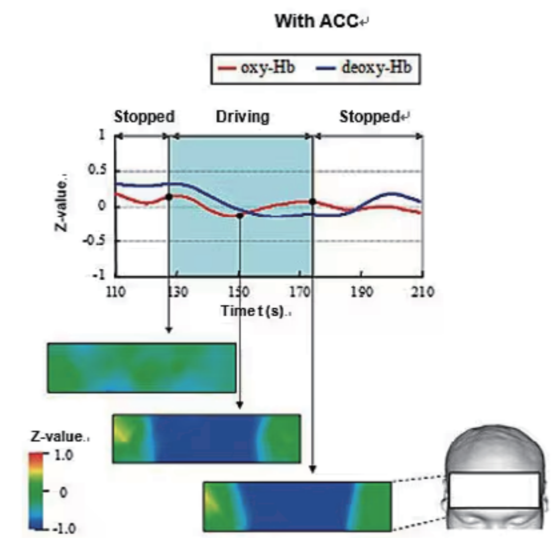
SolidSpec-3700i/3700iDUV

Product

CE

Measuring Brain Function During Driving of an Automobile

Functional near-infrared spectroscopy (fNIRS) brain imaging systems use near-infrared light to visualize the activation status of brain surfaces in real time. Due to their ability to measure brain activation non-invasively and in a natural state, fNIRS systems are being used for research in automotive and other transport equipment fields.



Measuring Brain Function During Driving in a Driving Simulator

Movie

Application

Functional Near-Infrared Spectroscopy System for Research

LABNIRS

Product

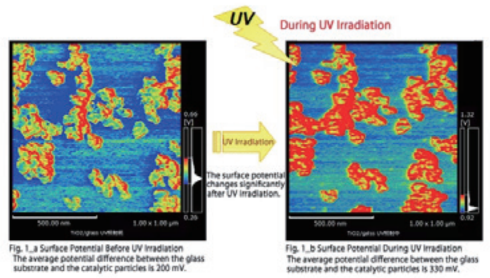
CE

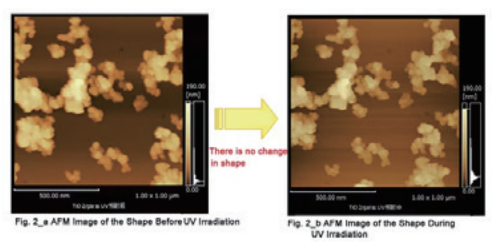
03 Shared & Services | Odors and Contamination | Hot Topics

Services for sharing a single vehicle among multiple people are expected to increase in the coming future. However, sharing will involve issues with odor and contamination. Shining light onto a photocatalyst generates oxidative forces at its surface, which can eliminate organic compounds, microbes, or other hazardous substances. Therefore, it is anticipated that this process will be used for reducing odors and contaminants inside vehicles, as well as for antibacterial or antiviral measures. Because the effectiveness of photocatalysts depends on the properties, dimensions, and shape of materials used, it is useful to analyze the particle size distribution in addition to evaluating electrical properties during reaction processes and optical properties. In addition to ensuring compliance with regulatory VOC requirements for a vehicle's interior and other indoor environmental regulations, odor analysis is used to evaluate comfort levels inside vehicles.

Evaluation of Photocatalyst Surface Potential During Photoirradiation

In this example, the excitation level of a photocatalyst was measured by measuring the electrical potential at the surface during irradiation with light. Using a scanning probe microscope (SPM), the surface potential levels and shapes of platinum supported titanium (TiO2) microparticles, used as a photocatalyst were observed by securing the microparticles to a glass substrate.





Samples were supplied by Kazuhiko Maeda, Associate Professor at The Department of Chemistry Graduate School of Science and Engineering, Tokyo Institute of Technology.

In-Situ Measurements Using a Light Irradiation-Scanning Probe Microscope System

Application

Scanning Probe Microscope/Atomic Force Microscope

SPM-Nanoa

Product

CE

Analysis of VOCs Inside Vehicles

In recent years, measures to reduce the use of organic compounds in automotive interiors have progressed. In Germany, the VDA278 standards were created for the analysis of volatile organic compounds (VOC) and semivolatile organic compounds (SVOC) produced from automotive interior material. In this investigation, an analysis of VOC and SVOC emissions from automotive interior materials was attempted in accordance with VDA278 using the TD-30.

Table 3: List of Quantitative Values of Compounds Produced by Automotive Interior Materials

Name of Compound	VOC			SVOC		
	Rubber	Plastic	Leather	Rubber	Plastic	Leather
C8	0.00	0.00	0.00	0.00	0.00	0.11
Toluene	0.35	0.54	0.53	0.31	0.44	0.24
C9	0.00	0.00	0.00	0.00	0.00	0.13
C11	0.00	0.00	0.00	0.00	0.00	0.31
Benzene, 1,3-dichloro-	0.00	0.00	0.00	0.00	0.00	0.08
2-Propyl-1-pentanol	0.36	0.52	0.73	0.11	0.18	0.78
C12	0.00	0.00	0.17	0.00	0.03	0.06
Nonanal	0.00	0.00	0.43	0.09	0.06	0.87
C13	0.20	0.14	0.26	0.09	0.13	0.13
C15	0.14	0.12	0.36	0.13	0.16	0.14
C16	0.31	0.00	0.60	0.42	0.16	0.86
C18	0.14	0.00	0.73	0.39	0.00	2.02
C19	0.00	0.00	0.30	0.39	0.00	1.37
Dibutyl phthalate	0.00	0.00	2.92	0.00	0.00	17.53
C20	0.00	0.00	0.18	0.14	0.00	1.28
C22	0.00	1.09	0.17	0.00	0.00	0.82
C23	0.00	0.00	0.15	0.00	0.00	0.82
C25	0.00	0.00	0.00	0.00	0.00	1.78
Bis(2-ethylhexyl) phthalate	0.41	1.60	33.67	0.00	0.00	333.28

Analysis of VOC and SVOC Emissions from Automotive Interior Materials in Accordance with VDA278 Using the Thermal Desorption Method

Application

Gas Chromatograph Mass Spectrometer

GCMS-QP2020 NX

Product

CE

03 Latest Applications
[Shared & Services]

Optical Property Evaluation of a Photocatalyst

Band Gap Measurement of Titanium Oxide

Application

UV-Vis-NIR Spectrophotometers
UV-2600i, UV-2700i

Product

CE

Vehicle Interior Aldehyde Analysis

Rapid Analysis of 2,4-DNPH-Derivatized Aldehydes and Ketones Using the Prominence-i with a Shim-pack XR-ODS Column

Application

High Performance Liquid Chromatograph
i-Series

Product

CE

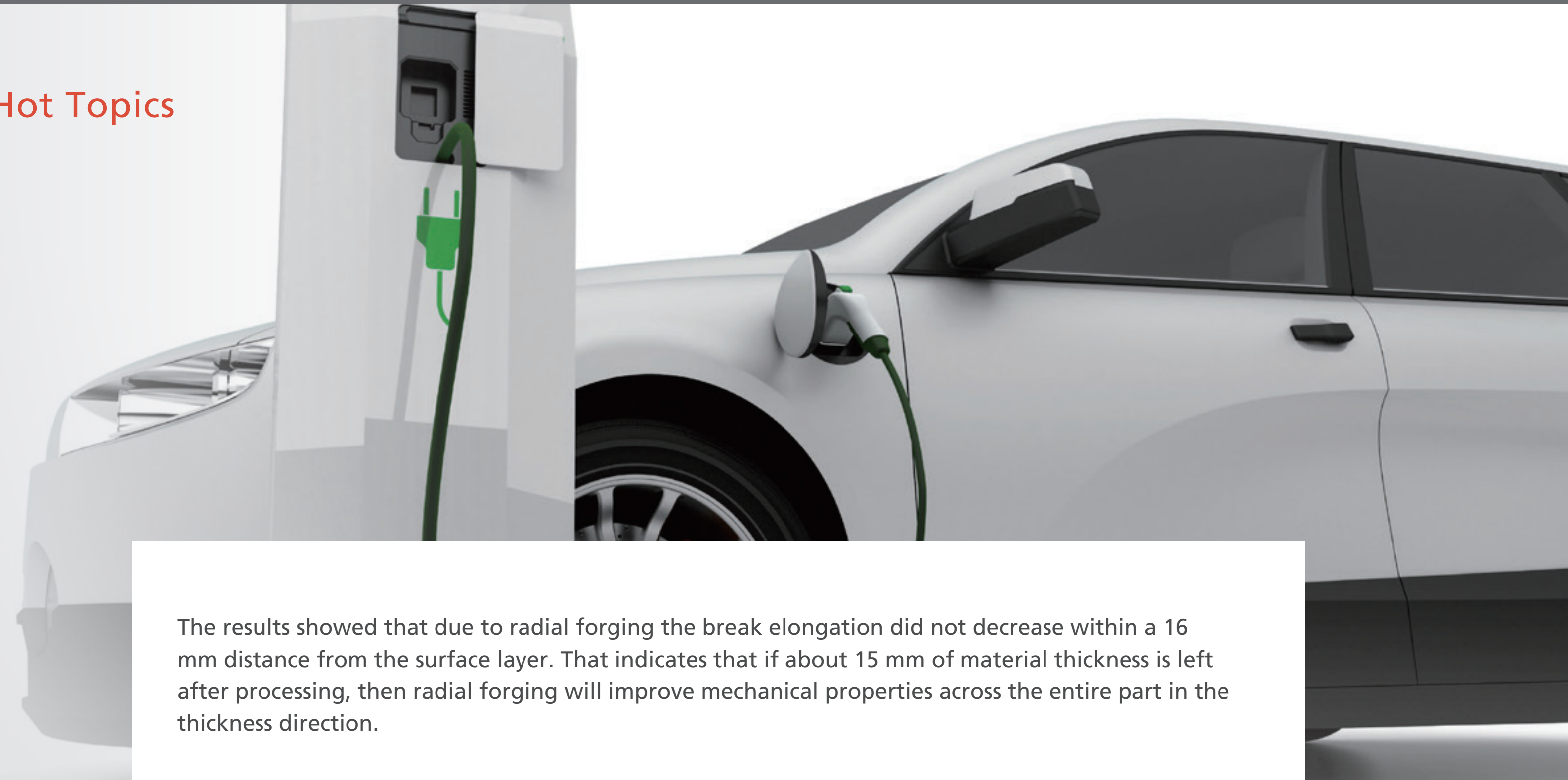
Achieving Both Easy Operation and Long-term Durability

Evaluating Durability of Steering Mechanisms for Automobiles in Three Axes

EHF-JF Series Compact Hydraulic Force
Simulator

Product

04 Electrification | Electric Motorized Systems | Hot Topics

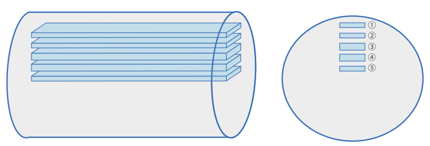


For development of electric motorized systems, it is important to achieve reliability in addition to high output, high energy efficiency, and a smaller size. That involves optimizing the performance of motors, gear reducers, inverters, and other components in corresponding assemblies. For example, increasing output requires increasing durability, whereas downsizing requires improving the mechanical properties of the materials themselves. A multifaceted evaluation can provide a deeper understanding of component properties, such as by evaluating the mechanical properties, observing the shape, and analyzing the composition (for causes of property changes) of components. The following describes evaluation methods used to develop an electric motorized system.

Evaluation of Radial Forging of Metal Materials Used to Make Motor Shafts for Electric Motorized Systems

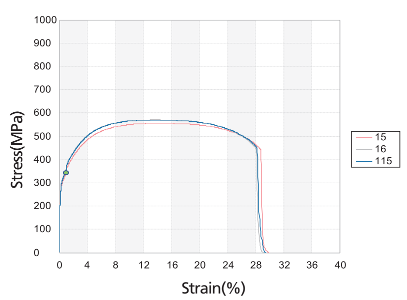
Due to concerns that increasing electric vehicle weight will decrease the distance these vehicles can travel, manufacturers are studying ways to reduce the weight of forged parts that must be both strong and durable. One type of component that is typically forged is the motor shaft used in EV motorized systems. Therefore, a new radial forging method has attracted attention as a way to reduce weight by forging shafts with a hollow core. In Europe, the technology is being introduced mainly for luxury vehicles. Forging is a metal processing method that applies impact forces from the metal surface layer to the interior in order to form the metal and simultaneously change the metal composition to improve its mechanical properties. How far forging effects extend from the surface into the interior of the metal can vary depending on the process parameters. Consequently, production forging technical capabilities can be increased by determining how different processing parameters can affect material properties.

Note: The indicated data was obtained jointly by Shimadzu Corporation and Tsuzuki Manufacturing Co., Ltd.

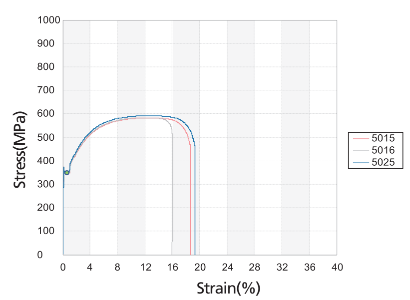


Sampling Point	Distance from Surface Layer
①	4 mm
②	10 mm
③	16 mm
④	22 mm
⑤	28 mm

Illustration of Sample Removal Points



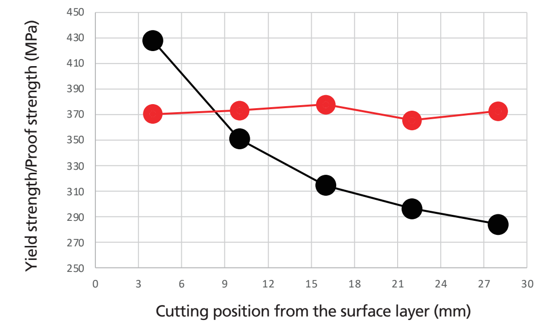
Stress-Strain Curve of Sample A-(5)

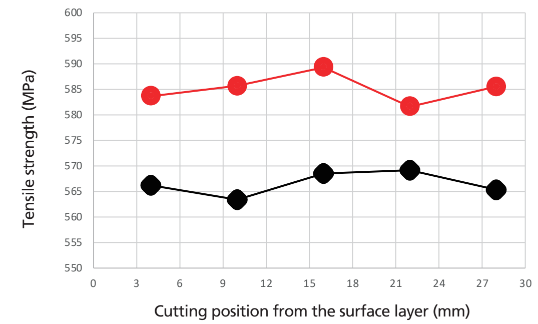


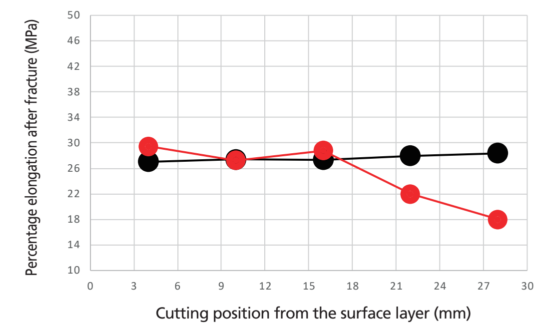
Stress-Strain Curve of Sample B-(5)

Sample A: Without radial forging
Sample B: With radial forging

The results showed that due to radial forging the break elongation did not decrease within a 16 mm distance from the surface layer. That indicates that if about 15 mm of material thickness is left after processing, then radial forging will improve mechanical properties across the entire part in the thickness direction.







AUTOGRAPH Precision Universal Tester

AGX-V2

Product

04 Latest Applications

[Electrification/Electric Motorized Systems]

Evaluation of Electric Motorized Systems

Various Evaluations Used During Development of Electric Motorized Systems

Industries

Evaluation of Neodymium (Nd) Magnet Composition Distribution

Analysis of Neodymium Sintered Magnets Produced by the Grain Boundary Diffusion Process

Application

Electron Probe Microanalyzer

EPMA-8050G

Product

Evaluation of Lubricating Oil Degradation

Lubricant Analysis

Application

Laser Diffraction Particle Size Analyzer

SALD-2300

Product

Observation of Lubricant Oil Film Formation Status

Analysis of Phosphate Ester Adsorption Film Formed on the Surface of Iron Oxide in a Lubricant by SPM-8100FM

Application

High-Resolution Scanning Probe Microscope

SPM-8100FM

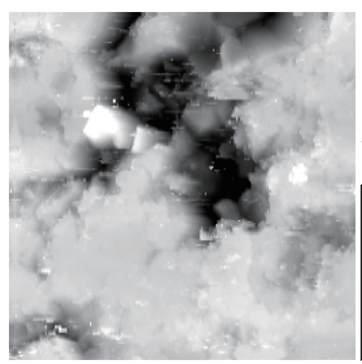
Product

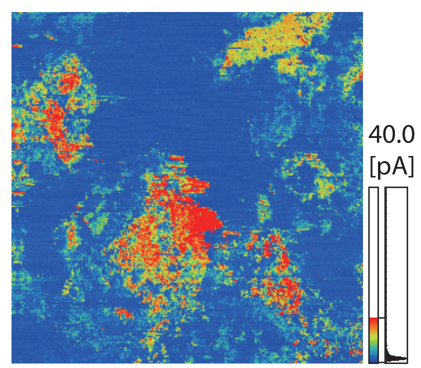
04 Electrification | Battery / Lithium-Ion Batteries | Hot Topics

Additional lithium-ion battery development will be required to achieve widespread use of electric vehicles. Shimadzu offers a variety of evaluation and analysis technologies cultivated over its long history for supporting operations related to satisfying market needs for higher battery capacity, longer service life, higher safety, lower cost, and so on. The following describes evaluation methods used to develop a lithium-ion battery.

SPM (AFM) Measurement of All-Solid-State Battery Cathode and Anode Materials

SPM (AFM) systems can be used to observe and measure cathode and anode materials used in all-solid-state batteries. They can also be used to visualize the shapes and distributions of electrical current in micro areas.





SPM (AFM) Measurements of Cathode and Anode Materials from All-Solid-State Lithium-Ion Batteries without Exposure to Air

Application

Scanning Probe Microscope/Atomic Force Microscope

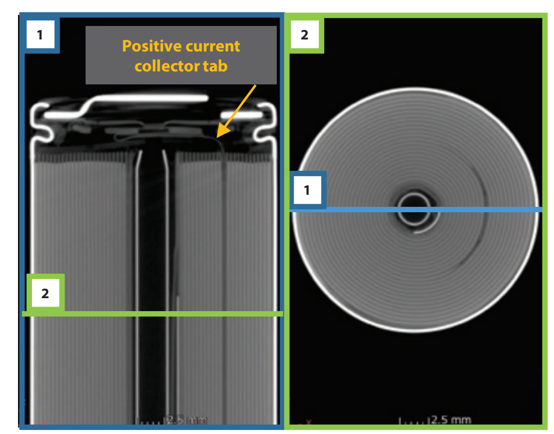
SPM-Nanoa

Product

CE

Analysis of Cylindrical Lithium-Ion Batteries by X-Ray CT

X-ray CT systems can be used to non-destructively observe structures inside lithium-ion batteries. They can also measure the distance between electrodes or observe the joint status on current collector boards.



Analysis of the Cylindrical Lithium-Ion Battery by X-Ray CT and Introduction to the Attached Charge/Discharge Device

Application

Microfocus X-Ray CT System

inspeXio SMX-225CT FPD HR Plus

Product

CE

04 Latest Applications

[Electrification / Battery]

Compression Test of Positive Electrode Active Materials

Compression Tests for Anode Material for Lithium-Ion Batteries

Application

Micro Compression Tester

MCT Series

CE

Product

Thermal Property Evaluation of Various Battery Materials

Investigation of Thermal Properties of Lithium-Ion Battery Components

Application

Differential Scanning Calorimeter

DSC-60 Plus Series

Product

Observation and Elemental Analysis of Micro Areas on Electrodes

Analysis of the Positive Electrode of a Lithium-Ion Battery

Application

Electron Probe Microanalyzer

EPMA-8050G

Product

Evaluation of Electrolyte Solution in an Inert Atmosphere

Compression Tests for Anode Material for Lithium-Ion Batteries

Application

Fourier Transform Infrared Spectrophotometer

IRSpirit

CE

Product

Evaluation of Internal Gases Generated Due to Charging-Discharging

Confirming Changes in Evolved Gas Composition Due to Degradation

Analysis System for Gases in Rechargeable Lithium-Ion Batteries

CE

Product

Particle Size Distribution Measurement and Shape Confirmation of Active Particles

Detection of Coarse Particles Contained in Positive Electrode Material

Application

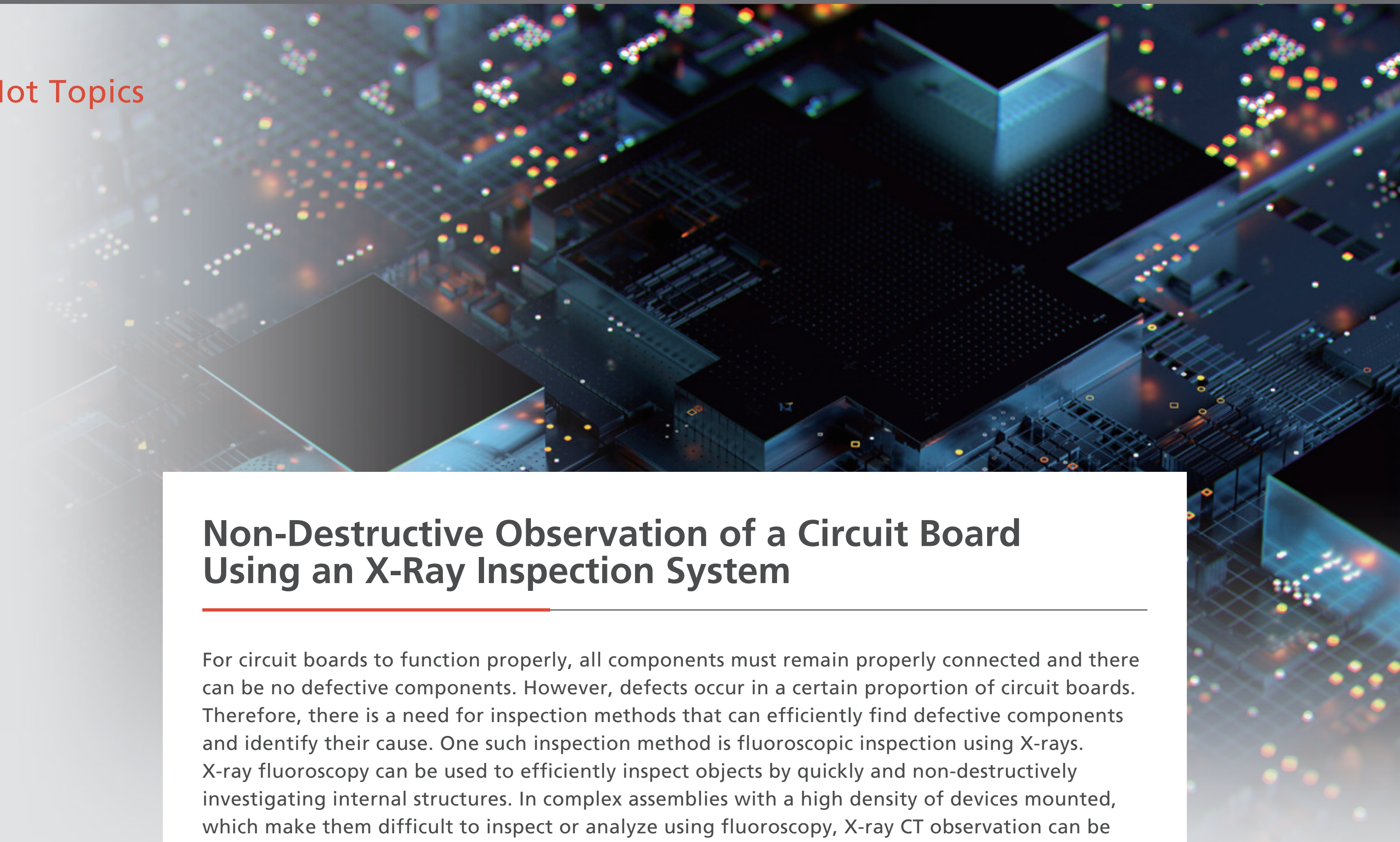
Dynamic Particle Image Analysis System

iSpect DIA-10

CE

Product

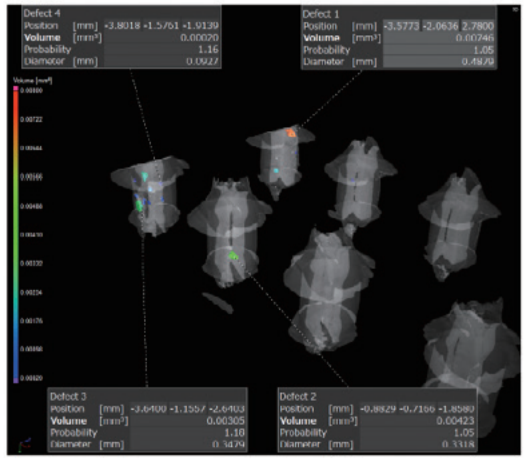
04 Electrification | Inverter / Circuit Boards | Hot Topics



Inverters are essential for the electrification of automobiles. They convert the direct current (DC) output from the battery into alternating current (AC) using a power transistor with a high voltage and current capacity. They are also used to control the rotation speed or torque of motors by adjusting the frequency or power level. Inverter development includes reducing part counts by installing them directly on transmissions and motors or by increasing the device density. In the development process, it is important to implement measures for dissipating heat and protecting against impact and vibration. There is also demand for non-destructive observation inside ECUs, fatigue/durability testing of joints, and so on. The following describes evaluations performed for each major component in inverters during development.

X-Ray CT Observation of an ECU

Automobiles contain a wide variety of electronic devices used to control performance and safety. Such vehicle control actions are performed by electronic control units (ECUs). However, vehicles are constantly vibrating during operation and subjected to temperature variations due to heat from the air temperature, engine, or road. Therefore, they must function properly even under harsh conditions. To ensure reliability, most ECUs and other electronic devices are sealed in a case. Under such circumstances, the electronic device cannot be inspected directly from outside the case, requiring X-rays to inspect them non-destructively. In this example, an X-ray CT system is used to observe an ECU.



Observation of an Automotive Computer Using the inspeXio SMX-225CT FPD HR X-Ray CT System

Application

Microfocus X-Ray CT System

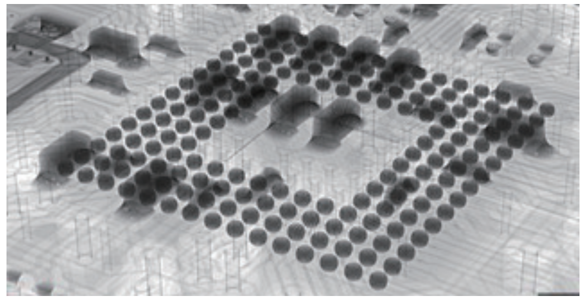
inspeXio SMX-225CT FPD HR Plus

Product

CE

Non-Destructive Observation of a Circuit Board Using an X-Ray Inspection System

For circuit boards to function properly, all components must remain properly connected and there can be no defective components. However, defects occur in a certain proportion of circuit boards. Therefore, there is a need for inspection methods that can efficiently find defective components and identify their cause. One such inspection method is fluoroscopic inspection using X-rays. X-ray fluoroscopy can be used to efficiently inspect objects by quickly and non-destructively investigating internal structures. In complex assemblies with a high density of devices mounted, which make them difficult to inspect or analyze using fluoroscopy, X-ray CT observation can be used to determine the cause of failures.



Realizes High Definition, High Resolution, and High Throughput! Rich Features of the Latest X-ray Inspection System

Application

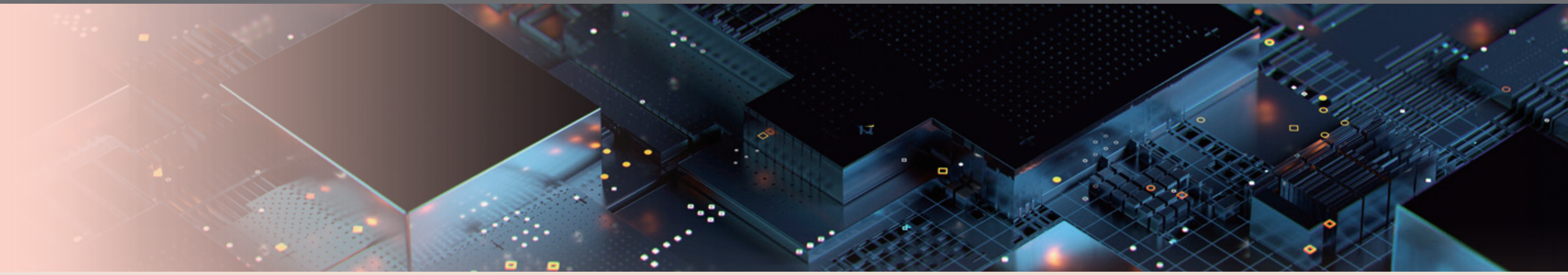
Microfocus X-Ray Inspection System

Xslicer SMX-6010

Product

04 Latest Applications

[Electrification / Inverter]



Example of Using X-Ray CT to Analyze Solder

Application

Example of Power Inductor Observation Using X-Ray CT

Application

Microfocus X-Ray CT System

inspeXio SMX-225CT FPD HR Plus

Product

CE

Strength Evaluation of Electronic Components (Circuit Boards and Soldered Joints)

Strength Evaluation of Electronic Components (Circuit Boards and Soldered Joints)

AUTOGRAPH Precision Universal Tester

AGX-V2

Product

CE

Analysis of Lead-Free Solder Joint Interface

Application

Analysis of Micro Ag Particles of Lead-Free Solder

Application

Electron Probe Microanalyzer

EPMA-8050G

Product

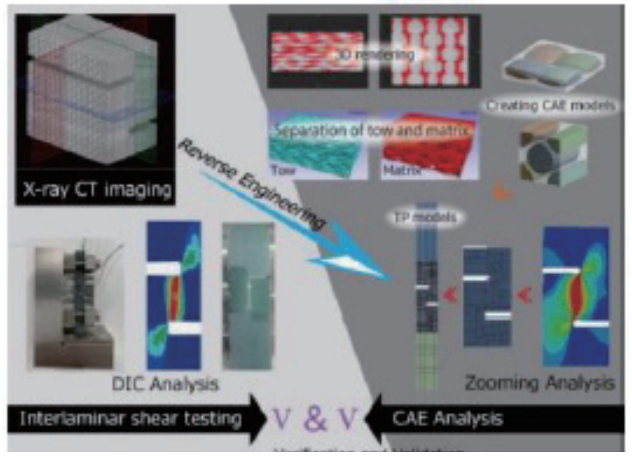
01 Composite Materials
Validation and Verification (V&V) of CAE and Measured Values

Hot Topics

The complex internal structures in composite materials need to be taken into consideration when designing products. That means multiscale simulations must be performed for products designed using composite materials. Multiscale simulation uses software to model the internal composite material structures so they can be analyzed based on the mechanical properties of the fibers and polymers in the composite material. To ensure the analysis is accurate, internal structural data, material property data, and test data for verifying and validating (V&V) the multiscale simulation model are required. The following describes evaluation methods useful for multiscale simulations of composite materials.

V&V of GFRP Out-of-Plane Shear Test

The accuracy of composite material shear properties was improved with multiscale simulation by using X-ray CT to model internal structural data and an AGX-V2 tester to obtain accurate material data and loaded strain distribution data.



Evaluation Example | Application
Validation of the Applicability of the Modified Notch Compression Interlaminar Shear Test Method for GFRP Plain Woven Materials Using Homogenization

Application

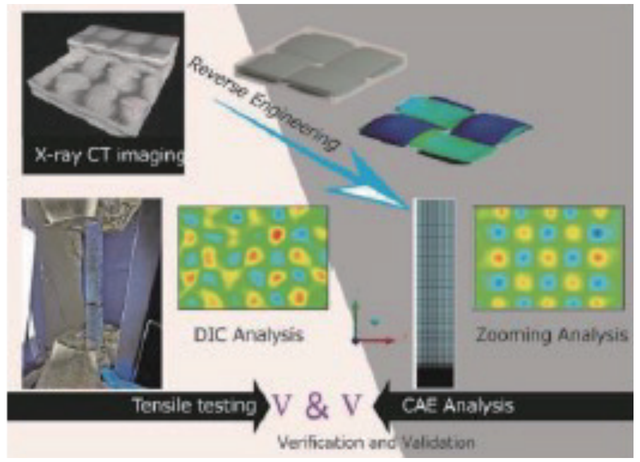
Microfocus X-Ray CT System
inspeXio SMX-225CT FPD HR Plus

Product

CE

V&V of CFRTP Uniaxial Tensile Test

The accuracy of composite material tensile properties was improved with multiscale simulation by using X-ray CT to model internal structural data and an AGX-V2 tester to obtain accurate material data and loaded strain distribution data.



Material Characterization Examples and Technology for Achieving Accurate CAE (Computer Aided Engineering) Analysis

Verification and Validation (V&V) of Uniaxial Tensile Test Simulation Results of Composite Materials

Movie

Application

Other Applications
Validation of the Applicability of the Modified Notch Compression Interlaminar Shear Test Method for GFRP Plain Woven Materials Using Homogenization

Application

ASTM D6641 Combined Loading Compression (CLC) Testing of CFRP

Movie

AUTOGRAPH Precision Universal Tester
AGX-V2

Product

CE

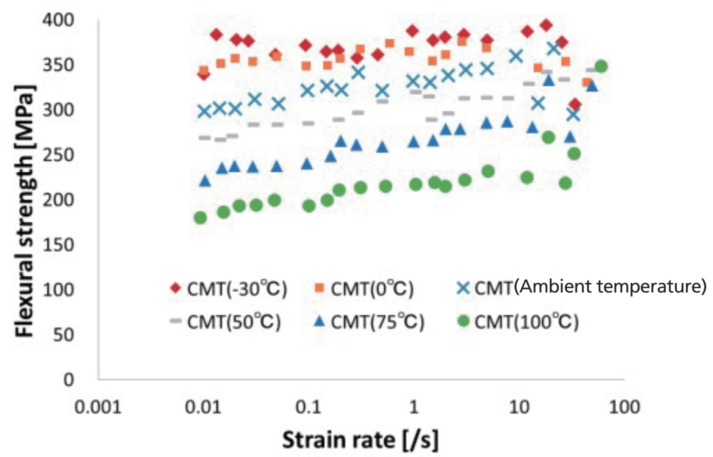
01 Composite Materials
Impact Analysis

Hot Topics

Due to the viscoelasticity of polymers used in composite materials, mechanical properties can vary depending on strain rates. Therefore, that strain rate dependence must be understood in order to increase the accuracy of designs potentially subject to impacts. Furthermore, composite materials have different properties in tensile and compression directions. Given that products made with composite materials can exhibit unique properties during impact analysis, the following describes methods useful for evaluating how the strain rate depends on how various tensile, compressive, bending, or other loads are applied.

High-Speed Bending Test of Composite Materials in a Temperature-Controlled Environment

The results show that bending strength increases when increasing the testing speed. In addition, the change in bending strength in response to the testing speed was also evaluated as the temperature was varied. Evaluating such temperature dependence and strain rate dependence can help increase the accuracy of impact analysis.



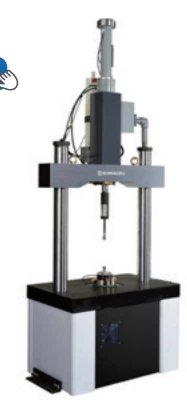
Measurement Example | Webinar
New Design Factors for Composite Materials and Cutting-Edge Test Evaluation Technologies
— Significance and Methods for Impact Testing Composite Materials —

Movie

High-Speed Impact Testing Machines
HITS-X Series

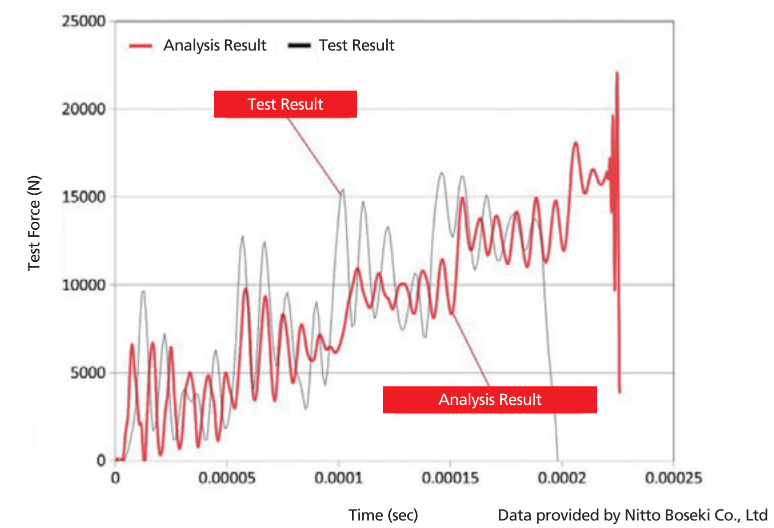
Product

CE



High-Speed Compression Testing of Composite Materials

During automobile crashes, since parts are sometimes subjected to compressive loads, the strain rate dependence in the compression direction needs to be determined. Due to a high risk of instrument damage from upper and lower jigs colliding after high-speed compression testing, special jigs are used that stop the instrument systems to prevent damage.



Technology Example
Analysis of the Failure Behavior of Fiber Reinforced Plastics using High-Speed Compression Testing

Application

01 Latest Applications

Observation of Composite Material Impact Testing Failure

Material Testing by Strain Distribution Visualization - DIC Analysis -

Application

Evaluation of Strain Distribution during Sheer Impact Testing

3D-DIC Analysis in an Interlaminar Shear Impact Test of Composite Materials

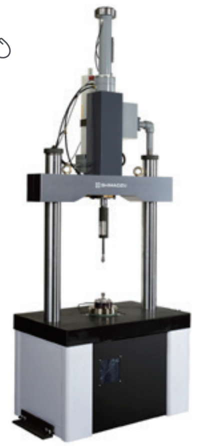
Application

High-Speed Impact Testing Machines

HITS-X Series

Product

CE



Compression After Impact Testing of Composite Material

Compression After Impact Testing of Composite Material

Application

AUTOGRAPH Precision Universal Tester

AGX-V2

Product

CE

Evaluation of High-Speed Strain Distribution during Impact Testing

3D-DIC Analysis of CFRP Subjected to Collision with a High Speed Flying Object

Application

High-Speed Video Camera

Hyper Vision HPV-X2

Product

CE

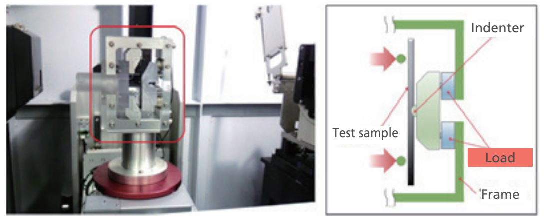
01 Composite Materials
Failure Analysis

Hot Topics

Composite materials can exhibit complex failure behavior. Understanding the processes involved in actual failure behavior enables the construction of simulation models based on the starting point and progression of failures that better reflect actual circumstances. The following describes an evaluation method useful for analyzing the failure behavior of composite materials.

In-Situ Observation of Fracture Onset and Progression during Composite Material Failure

Using an X-ray CT system equipped with a small testing machine allows observation of internal structures in composite materials with loads applied. This test can be used to confirm the onset of cracking or the progression of microcracking that was not previously observable.



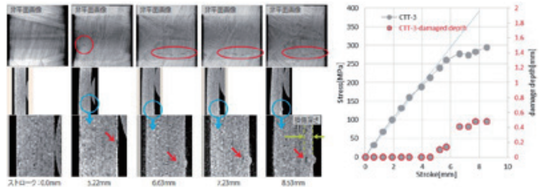
Three-Point Bending System

AUTOGRAPH Precision Universal Tester

AGX-V2

Product

CE



Microfocus X-Ray CT System

inspeXio SMX-225CT FPD HR Plus

Product

CE

Measurement Example | Webinar

New Design Factors for Composite Materials and Cutting-Edge Test Evaluation Technologies — Non-Destructive Internal Observation and Testing System for Composite Materials Using a Bending Testing Machine for 3D X-Ray CT Systems —

Movie

Technology Example

Identification of Composite Material Failure Mechanisms — Observation of the CFRTP Failure Process —

Application

Latest Applications

Observing the Fracture of Unidirectional CFRP in Static Tensile Testing

Application

Observing the Failure of Open-Hole CFRP Specimens in Tensile Tests

Application

MMB Test of CFRP in Conformance with ASTM D6671

Application

Open-Hole Compression Test of Composite Material
ASTM D6484 Open-Hole Compression (OHC) Testing of CFRP

Movie

Application

ASTM D7078 V-Notched Rail Shear Testing of CFRP

Movie

AUTOGRAPH Precision Universal Tester

AGX-V2

Product

CE

02 Sheet Metal Forming

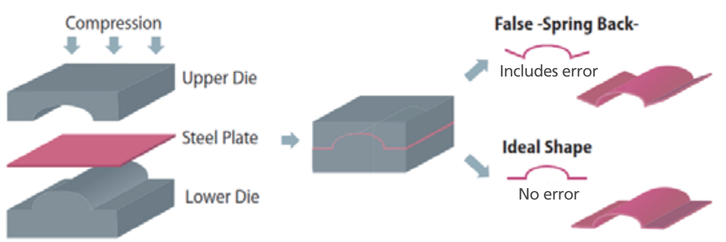
Springback Analysis

Hot Topics

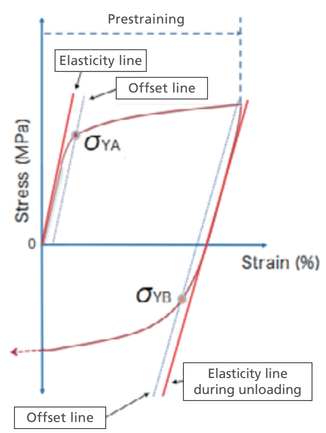
Simulation to predict springback, cracks, wrinkling, or other characteristics during sheet metal forming requires using accurate material models. Springback, forming limits, and other characteristics are said to be affected by material anisotropy and the Bauschinger effect. The following describes a method useful for evaluating sheet metal forming, in addition to typical tensile testing.

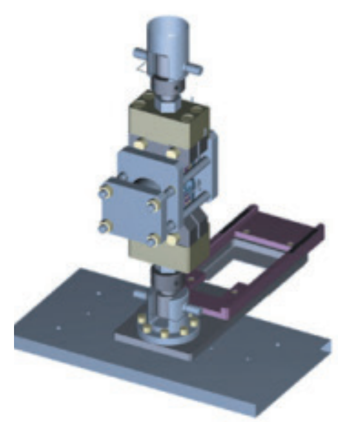
Measuring the Bauschinger Effect to Improve Simulation Accuracy of Press Forming High Tensile Steel Sheet

Data from measuring the Bauschinger effect was used to improve the accuracy of simulating press forming of automotive parts with complex shapes. The following describes an example of dramatically improving the surface matching accuracy of actual press-formed parts.

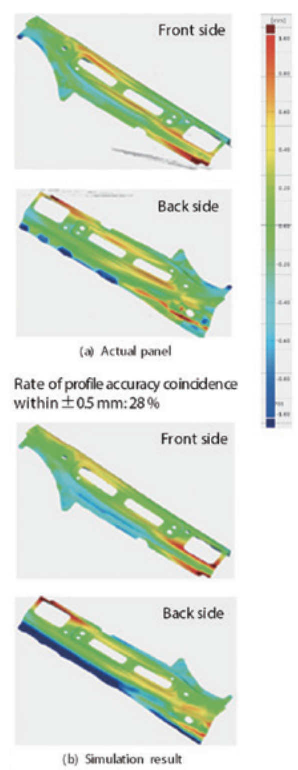


Sheet Steel Press Forming and Springback





Bauschinger Effect Measurement Jig



Measurement Example | Webinar

Example of Material Evaluation for Increasing the Accuracy of Sheet Metal Forming Simulation

Movie

Improvement of the Profile Accuracy Coincidence Rate in Press-Forming Simulation of High Tensile Strength Steel Considering the Bauschinger Effect

Application

Latest Applications

Testing for Press Forming Simulation

Example of Sheet Metal Evaluation for Press Working

Application

AUTOGRAPH Precision Universal Tester

AGX-V2

Product

High-Speed Tensile Test of High-Strength Steel

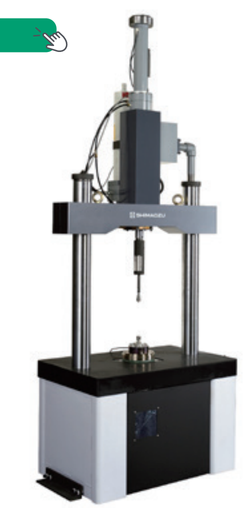
Example of High-Speed Tensile Test of High-Strength Steel

Application

High-Speed Impact Testing Machines

HITS-X Series

Product



03 Multiple Materials (Joining Dissimilar Materials)

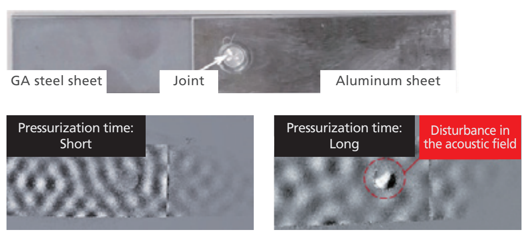
Joining Dissimilar High-Tensile Steel Sheet and Aluminum Alloy Sheet Materials

Hot Topics

Rather than conventional joints between identical materials, multi-material joints are used as a technique for reducing weight and increasing strength by combining multiple materials optimized for their respective locations. One important challenge for multi-material joints is determining how to adhesively or otherwise join dissimilar materials together. Joints between dissimilar materials cannot maintain the same joint strength as conventional joints between similar materials, so new joining technologies need to be developed. The adhesive and joint strength are affected by differences in the linear coefficient of expansion of the respective materials, the properties of boundary surfaces between each adhered material, the microstructure of adhesion surfaces, the properties of the adhesive, and other factors, so a variety of evaluation methods are used. The following describes evaluation methods useful for joints between multiple dissimilar materials.

Multifaceted Evaluation of Joints between Dissimilar High-Tensile Steel Sheet and Aluminum Alloy Sheet Materials

Using the MIV-500 Detector to Non-Destructively Visualize the Distribution of Defects



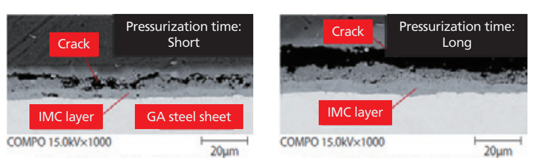
MAIVIS Ultrasonic Optical Flaw Detector

MIV-X

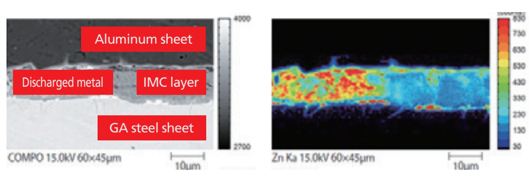
Product

CE

Using the EPMA to Visualize Defect Micro Areas



EPMA Image of Zn Distribution in Joint

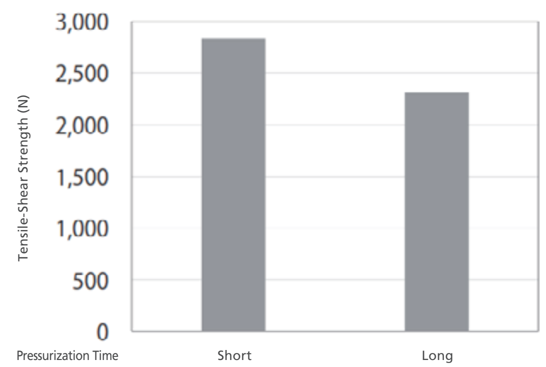


Electron Probe Microanalyzer

EPMA-8050G

Product

Using the AGX-V2 Tester to Evaluate Shear Strength



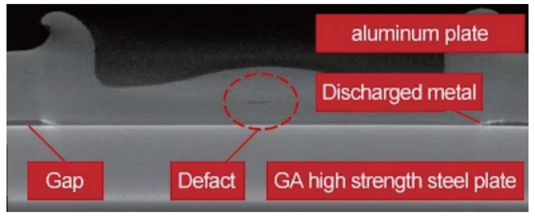
AUTOGRAPH Precision Universal Tester

AGX-V2

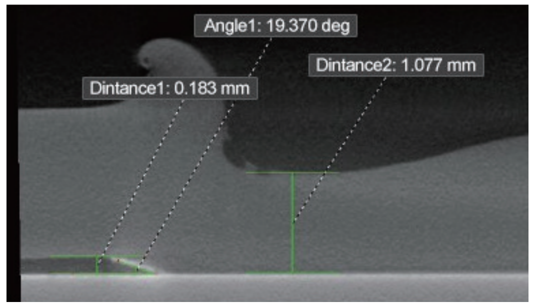
Product

CE

Using the SMX-225CT System to Non-Destructively Observe Shapes



Cross-section image



Measurement of plate thickness and gap near the joint

Microfocus X-Ray CT System

inspeXio SMX-225CT FPD HR Plus

Product

CE

Technology Example

Multi-faceted Evaluation of Friction Stir Welding of Dissimilar Metals

Industries

The accuracy of composite material shear properties was improved with multiscale simulation using X-ray CT to model internal structural data and the AGX-V2 tester to obtain accurate material data and loaded strain distribution data.

03 Latest Applications

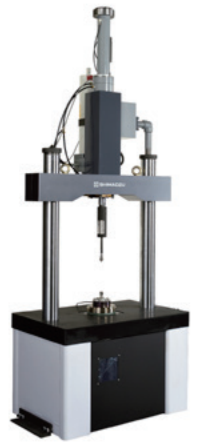
High-Speed Tensile Testing of an Adhesive Joint

High-Speed Impact Testing Machines

HITS-X Series

Product

CE



Analysis of the Reaction Process of a Quick-Curing Adhesive

High-Speed Monitoring of the Curing Reaction in UV-Irradiated Resin by Rapid Scan

Application

Fourier Transform Infrared Spectrophotometer

IRTracer-100

Product

CE

Analysis of the Reaction Process of a Slow-Curing Adhesive

Time-Course Analysis of Polyvinyl Chloride Adhesive by FTIR

Application

Fourier Transform Infrared Spectrophotometer

IRXross

Product

CE

04 Shape Optimization (3D Printer)

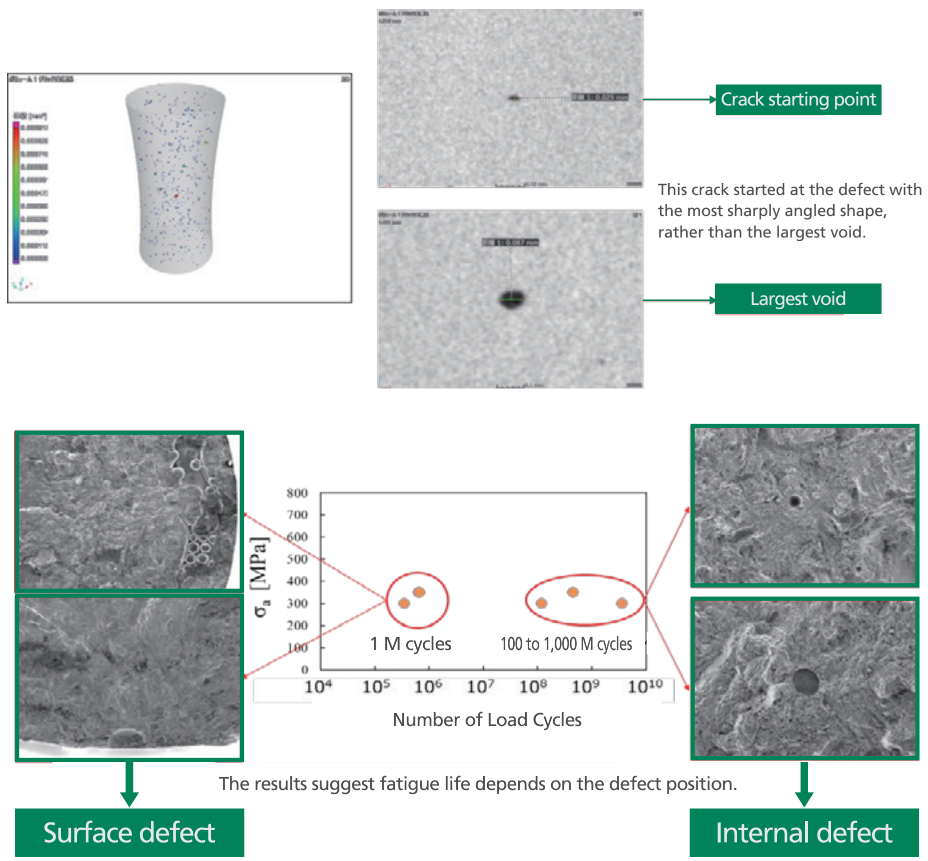
Three-Dimensional Forming with Metal Materials

Hot Topics

Due to improvements in simulation technologies, advancements are being made in shape optimization (topology) technologies for changing part shapes in efforts to reduce the weight of parts while maintaining their strength. Optimized shapes determined by analysis may be too complicated and difficult to manufacture using conventional methods. Three-dimensional forming (3D printer) methods are anticipated for use in such cases. Unlike conventional manufacturing methods, 3D printing can require multifaceted evaluations due to unique internal structures. The following describes an evaluation method useful for 3D printing.

Fatigue Life Effects of Defects in Additive Manufacturing Using Titanium Alloys

Due to the likelihood of defects in 3D printed objects that can affect product life, it is important to evaluate their fatigue characteristics. Identifying the causes that affect fatigue life can result in product life improvements. In this example, an X-ray CT system was used to non-destructively observe the distribution and shapes of internal defects. Fatigue life was evaluated using ultrasonic fatigue testing to quickly conduct fatigue testing at gigahertz loading cycle speeds. EPMA can be used to confirm whether the location of defects affects fatigue life by analyzing the starting point of failures.



Microfocus X-Ray CT System

inspeXio SMX-225CT FPD HR Plus

Product

CE

Ultrasonic Fatigue Testing System

USF-2000A

Product

CE

Electron Probe Microanalyzer

EPMA-8050G

Product

04 Latest Applications

Thermal Property Evaluation of 3D-Printed Plastic Materials

Thermal Properties of Composite Filaments for a 3D Printer

Application

Differential Scanning Calorimeter

DSC-60 Plus Series

Product

Thermal Property Evaluation of 3D-Printed Plastic Materials

Quality Evaluation of Powder for a Metal 3D Printer: Shape Analysis by Dynamic Image Analysis Method

Application

Dynamic Particle Image Analysis System

iSpect DIA-10

Product

CE

05 Plastic Molding

Latest Applications
Multifaceted Evaluation of Changes in Properties Due to Differences in Forming Parameters — Part 1

The properties of molded plastics can vary depending on molding parameters. Therefore, the relationship between molding parameters and material properties needs to be understood. For example, if a plastic part does not satisfy specified strength requirements, the molding parameters need to be reconsidered.
In such cases, a multifaceted evaluation of strength, internal structures, composition, and other factors can help improve molding parameters. Due to the wide variety of molding parameters available, an example of evaluating material properties in response to varying several parameters is described.

Differences in PC/ABS Blending Ratios

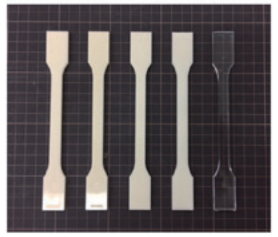


Fig. 1 Sample Appearance
Ratios, starting from the left
PC:ABS = 0:100, PC:ABS = 25:75,
PC:ABS = 50:50,
PC:ABS = 75:25, PC:ABS = 100:0

Table 1 Heating Conditions before Molding

PC:ABS	Mixing in a Mixer	Mixing in a Molding Machine
0:100	None	220 °C for about 250 sec
25:75	260 °C for about 120 sec	260 °C for about 250 sec
50:50	260 °C for about 120 sec	260 °C for about 250 sec
75:25	260 °C for about 120 sec	260 °C for about 250 sec
100:00	None	290 °C for about 250 sec

Properties to material injection ratios are compared.

Tensile strength and PC glass transition (Tg) values can be used to confirm the composition ratio after molding

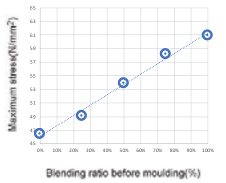


Fig.5 Blending ratio - Maximum force graph

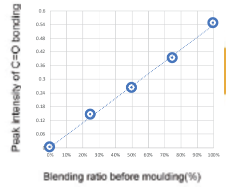


Fig.12 Blending ratio - the peak strength of the C=O bond graph

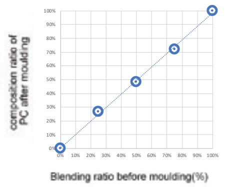


Fig.13 Blending ratio before moulding - composition ratio after moulding graph

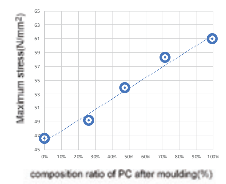


Fig.14 Composition ratio after moulding - Maximum force graph

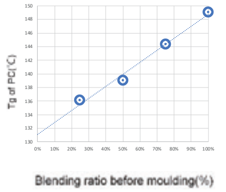


Fig.8 Blending ratio - Tg of PC graph

Confirms that the molded part composition matches the material injection ratio

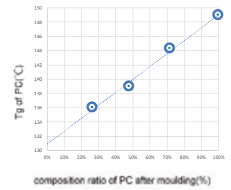
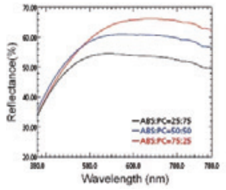


Fig.15 Composition ratio after moulding - Tg of PC graph

Confirms that the yellow color varies depending on the material injection ratio



Acquired data suggests the formation of sea-island structures

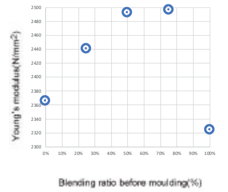


Fig.6 Blending ratio - Young's modulus graph

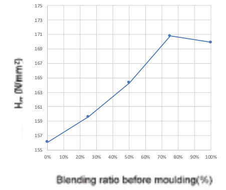


Fig.10 Blending ratio - Hr graph

Technology Example
Multifaceted Evaluation of Plastics - Difference Due to PC/ABS Blending Ratio

PC/ABS samples were molded using various mixtures of PC and ABS polymers to evaluate the relationship between the blending ratio and various material properties and to evaluate how closely the composition ratio after molding matches the blending ratio.

Application

AUTOGRAPH Precision Universal Tester
AGX-V2
Product

Dynamic Ultra Micro Hardness Tester
DUH Series
Product

UV-Vis-NIR Spectrophotometer
UV-2600i
Product

Differential Scanning Calorimeter
DSC-60 Plus Series
Product

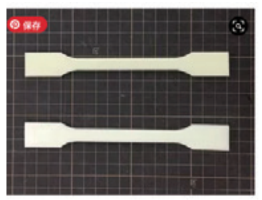
Fourier Transform Infrared Spectrophotometer
IRTracer-100
Product

05 Plastic Molding

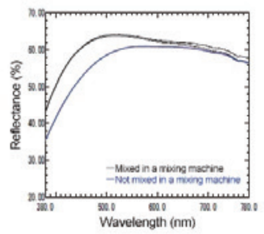
Latest Applications
Multifaceted Evaluation of Changes in Properties Due to Differences in Forming Parameters — Part 2

Differences in PC/ABS Mixing Parameters

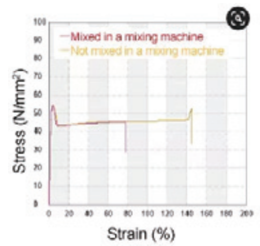
For blended polymers such as PC/ABS blends, the mixture parameters can reduce material property levels, so property differences due to mixing parameters need to be confirmed. Actual confirmation indicated differences in yellowness and break elongation. In addition, all samples were formed adequately. Therefore, variations in butadiene were presumably due to differences in heating time before molding.



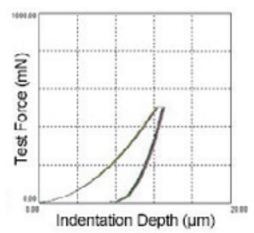
View of Samples
The top sample was mixed in a mixing machine whereas the bottom sample was not



Reflectance Measurement



Tensile Test

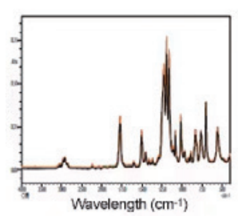


Hardness Test

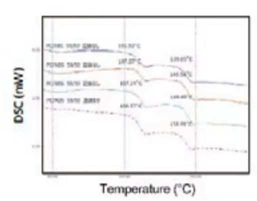
Differences in Various Properties with/without a Mixer

	Yellowness	Tensile Strength (N / mm²)	Modulus of Elasticity (N / mm²)	Break Elongation (%)	HIT (N / mm²)
Mixer + Injection Molding	12.99	53.90	2492.45	71.75	164.3
Injection Molded Only	3.44	54.23	2459.13	120.92	168.8

Confirming the Mixing Status of "Injection Molded Only" Samples



Absorption Spectrum



Thermal Analysis

Technology Example

Multifaceted Evaluation of Plastics to Determine Any Differences Cause by the PC/ABS Mixing Process

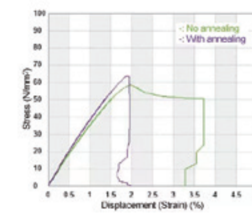
Industries

Differences in PLA Heat Treatment Parameters

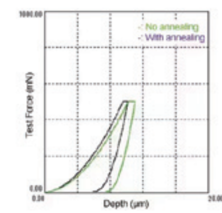
Heat treating PLA plastic improves material properties. When the changes in mechanical properties, based on whether PLA was heat treated, were confirmed, it was speculated that progressive crystallization from heat treatment was a factor.

Differences in Various Mechanical Properties of Samples A and B

	Annealing Parameters	Tensile Strength (MPa)	Modulus of Elasticity (MPa)	Break Elongation (%)	HIT (MPa)
Sample A	None	58.7	3660.9	3.6	221.5
Sample B	100 °C for 30 min	62.5	4020.8	1.9	277.6



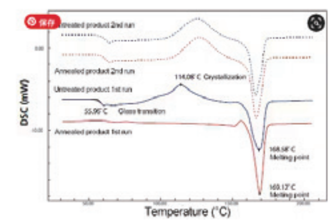
Tensile Test



Hardness Test

Differences in Thermal Properties of Samples A and B

	T g (°C)	Crystallization (°C)	Melting (°C)
Sample A	56.0	114.1	168.6
Sample B	–	–	169.1



Thermal Analysis

The results showed that the mechanical properties changed due to crystallization.

Technology Example

Multifaceted Evaluation of Plastics – Determining the Effects of Annealing on the Mechanical Properties of PLA Plastics and Investigating the Causes of the Changes

Industries

Products

Products Used for Evaluation of Automotive Technology

New release

Xslicer SMX-1010/1020 Microfocus X-Ray Inspection System

This vertical emission X-ray system is equipped with a 90 kV microfocus X-ray generator and high-resolution flat panel detector. It offers significantly higher image quality and improved operation, which has attracted positive market feedback.

Click here for product details.

AUTOGRAPH AGX-V2 Series Precision Universal Tester

This motor-actuated universal testing machine provides high performance, easy operation, and comprehensive safety measures.

Click here for product details.

SPM-Nanoa Scanning Probe Microscope

It includes an advanced high-sensitivity detection system and automatic viewing functionality. That means you can quickly and easily see what you want to observe in more detail. It provides powerful assistance for everything from observing shapes in micro areas to measuring their physical properties.

Click here for product details.

NJ-SERVO Electric Motor-Driven Actuator

This 10 kN ±100 mm electric motor-driven actuator can reduce electric power consumption by about 75 %. Because it is actuated by electric motors, there is no need for a hydraulic unit or cooling water.

Click here for product details.

XSeeker 8000 Tabletop X-Ray CT System

The XSeeker 8000 is a tabletop X-ray CT system equipped with a high-output X-ray generator and a high-resolution flat panel detector.

Click here for product details.

EDX-7200 Energy Dispersive X-Ray Fluorescence Spectrometer

Because it can non-destructively analyze the elements in solids, powders, and liquids, this system is used for a wide variety of applications, such as acceptance inspections for hazardous elements, contaminant analysis, and component analysis.

Click here for product details.

Py-Screener Ver. 2 Phthalate Ester Screening System

This system is used to screen for phthalate esters in plastics.

Click here for product details.

MIV-X Ultrasonic Optical Flaw Detector

This detector can be used to easily inspect items for defects non-destructively, such as flaws in weld or adhesive joints between dissimilar materials, or peeling/delamination in paint or thermally sprayed coatings.

Click here for product details.

Event Information

Shimadzu Automotive Technology Seminar

Supporting Weight Reduction Techniques

Learning about the Future of Weight Reduction!
Trends in Technology and Materials at the Forefront of Weight Reduction

SHIMADZU AUTOMOTIVE ONLINE EXHIBTION

Online Exhibition

Reliable task assessment is necessary for the development of electric cars and batteries, weight reduction, and Model Based Development (MBD) applications, with the aim of achieving carbon neutrality.
To support innovation in the automotive industry, Shimadzu Corporation offers a variety of testing and analytical solutions for task assessment procedures, such as evaluation of mechanical characteristics, structural observations, and characterization of chemicals and metals.

Webinars for Lithium-Ion Battery Evaluation

Online Exhibition

These webinars introduce the challenges and solutions required for the evaluation of lithium-ion and all-solid-state batteries and their materials. Addressing various issues such as degradation analysis, safety, and defect evaluation while aiming for performance improvements such as high output, high capacity, and long life requires appropriate evaluation technology. We sincerely hope that Shimadzu technology can contribute to your business and, ultimately, to the battery industry.

New Solutions for Joining and Welding Dissimilar Materials

Online Exhibition

Dissimilar material joining and welding is a technique that combines materials with different functions and characteristics to create components and products with higher, multiple, and hybrid functions. This online exhibition introduces our solutions for quality evaluation and inspection methods of dissimilar material (multi material) and welded bonding, as well as technology for laser processing solutions.

Automotive Solutions WEB Page

Web

Technologies involved in automobiles are undergoing technical revolutions on a daily basis in an effort to improve safety and comfort, reduce environmental impacts, and so on. This web page describes various Shimadzu instruments developed based on many years of experience evaluating all sorts of automotive parts and materials.

Analysis of Carbon Neutrality Technologies

Web

We contribute to technological development and quality control in fields such as hydrogen fuels, biofuels, wind power generation, and other renewable energies, as well as automobiles and storage batteries, which are all indispensable for achieving carbon neutrality. In addition, we are actively adopting renewable energy in our business activities, aiming to reduce CO_2 emissions.

Electronics Solutions WEB Page

Online Exhibition

Electronic devices and semiconductor technologies support a variety of industries and help us live comfortable lives. Analytical techniques play critical roles in these industries.
Shimadzu provides a complete solution for failure/defect analysis and quality control for electronic components, mobile devices, semiconductors, lithium-ion batteries, fuel cells, and photovoltaic cells.
In addition, we offer solutions from screening to accurate quantification of substances in order to comply with regulations and directives such as RoHS, ELV, and REACH.
Learn more about our solutions and how you can enhance your laboratory performance by visiting our website.

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