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# Application News

inspeXio™ SMX™-225CT FPD HR Plus Microfocus X-Ray CT System
AIMsight™ Infrared Microscope

# Nondestructive Analysis of Automotive Parts Used in Advanced Driver-Assistance Systems (ADAS)

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## User Benefits

- The X-ray CT system can be used to verify the internal quality of products, as nondestructive 3-dimensional observation of the internal structure of specimens is possible, enabling the evaluation of voids that occur in adhesives and length measurement of built-in parts.
- Qualitative analysis of organic substances such as resin materials and adhesives of component parts is possible by using an infrared microscope.

## ■ Introduction

ADAS (Advanced Driver-Assistance Systems) are systems which are used to support safe driving, and have functions that improve driving safety by monitoring the surrounding information of an automobile and providing displays and alarms to prevent accidents, allowing drivers to drive safely and comfortably.

In monitoring the surrounding environment of a vehicle, ADAS uses wide field cameras, millimeter-wave radar, ultrasonic sensor, and other instruments, but because these devices consume a large amount of electric power and also generate considerable heat, a mechanism for efficient heat dissipation and cooling is necessary. Furthermore, since these monitoring sensors are arranged outside the vehicle body, airtightness is important in sensor cases. While resin parts are used in some sensor cases from the viewpoint of weight reduction, heat resistance and low warpage are required so that the cases will not be deformed by the heat generated by the electronic parts they contain. Therefore, it is necessary to evaluate the properties of the resin material itself and its additives.

In this article, a millimeter-wave radar device used in an ADAS was evaluated using a microfocus X-ray CT system (Fig. 1) and an infrared microscope system (Fig. 2). The X-ray CT system was used in nondestructive observation of the internal structure and investigation of voids in the adhesive and the installation angle of the wide-field camera, and a qualitative analysis of the resin material used in the case was carried out with the infrared microscope.

Fig. 1 Appearance of inspeXio™ SMX™-225CT FPD HR Plus Microfocus X-Ray CT System

Fig. 2 Appearance of IRTracer™-100 and AIMsight™ Infrared Microscope System

## ■ Observation and Measurement of Millimeter-Wave Radar

With X-ray CT systems, it is possible to collect transmission X-ray information from the full circumference (360°) of a sample and construct 3-dimensional data by computer calculations. Nondestructive observation of the internal structure is possible because areas appear brighter as X-ray absorption increases and darker as absorption decreases. Quantitative analysis, such as measurement of distance or volume, is also possible by using numerical information such as color and pixels, and is used in quality control, failure analysis, and benchmarking against products of other companies.

Fig. 3 shows a cross-sectional image of the antenna part of the millimeter-wave radar with resolution of approximately 0.050 mm. Length measurement, for example, measurement of the distance between the antennas, is possible using this image.

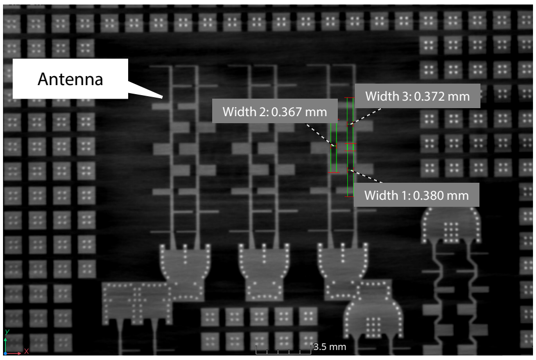


Fig. 3 Cross-Sectional Image of Antenna Part

Fig. 4 shows a 3-dimensional display image of the adhesive part sealing the case to the internal circuit board of the millimeter-wave radar. Here, the void volume of the adhesive is analyzed, and the volume is displayed in color. Since the void volume of adhesives can be analyzed in this manner, the X-ray CT system can be utilized in evaluations of sealing materials before and after endurance tests, such as test of thermal shock resistance.

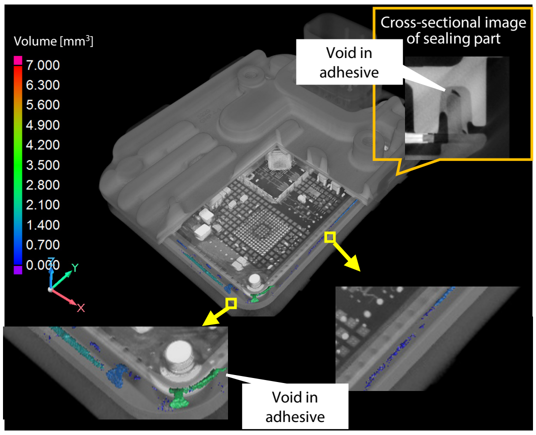


Fig. 4 3-Dimensional Display Image in Evaluation of Void Volume in Adhesive

Next, a qualitative analysis of the resin material was conducted using the infrared microscope system. The resin part used in the millimeter-wave radar was sampled, and the measurement was carried out after crushing the sample with a diamond cell. Table 1 shows the measurement conditions, and Fig. 5 shows an overlay of the obtained infrared spectrum and the search result.

Table 1 Measurement Conditions

| | |
|---|---|
| Instruments | : IRTracer-100, AIMsight |
| Resolution | : 8 $cm^{-1}$ |
| Accumulation | : 45 times |
| Apodization function | : SqrTriangle |
| Aperture size | : 10 µm × 30 µm |
| Step width | : 2 µm |
| Mapping range | : 30 µm × 120 - 154 µm |
| Detector | : T2SL |

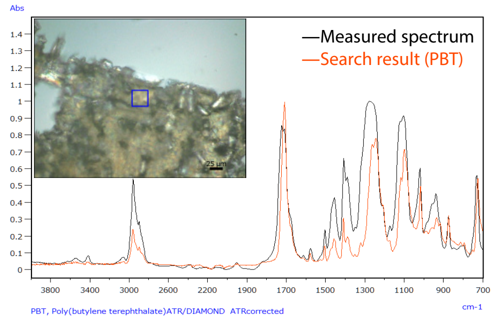


Fig. 5 Measured Spectrum of Millimeter-Wave Radar Resin Part and Search Result

From the comparison with the database, the spectrum of the resin part showed good agreement with the spectrum of polybutylene terephthalate (PBT). PBT is a thermoplastic resin and is one type of polyester. As benefits, it exhibits minimal contraction during molding, boasts mechanical strength, and offers high heat resistance. PBT is used in cases for millimeter-wave radars because it transmits the 77 GHz and 24 GHz radio waves used in this type of radar. Since transparent fibers could be seen in part of the specimen, this part was also measured. Fig. 6 shows the overlay of the obtained infrared spectrum and the search result.

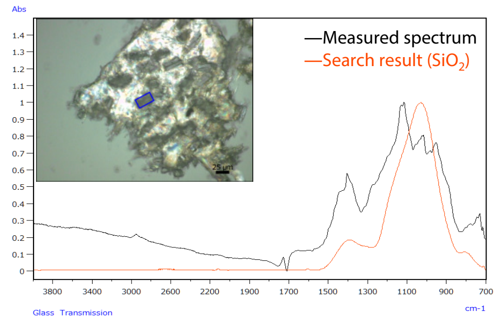


Fig. 6 Measured Spectrum of Glass Fibers in Millimeter-Wave Radar Resin and Search Result

The comparison with the database showed that these transparent fibers were consistent with the spectrum of glass. It is known the glass fibers are added to PBT to improve the stiffness of the resin. As shown in this experiment, the infrared microscope system enables the evaluation of both resin material type and additives.

<Acknowledgement>
We would like to thank to Dr. Tadayoshi Takahara, CEO of Office Tech-T Corporation, for his generous cooperation in the preparation of this paper, including informative discussions on the current status, issues, and needs of onboard automotive devices.

## ■ Observation and Measurement of Automotive Camera

Cross-sectional images and 3-dimensional display images of the onboard automotive camera were also acquired using the X-ray CT system. Fig. 7 shows the observation results. Since the adhesive in the region shown by the orange broken line in Fig. 7 (a) is used to fix the camera, together with the screws (Fig. 7 (b)), these results confirmed that the automotive camera is firmly fixed. In Fig. 7 (c) and (d), the installation angle of the automotive camera observed in Fig. 7 (a) was measured. The axis of the camera lens has an installation angle of 18° with respect to the bottom of the case and is fixed at an angle of 90° to the reference axis of the case side surface. Thus, X-ray CT can confirm the internal quality specified at the time of product development and manufacture without damaging the case.

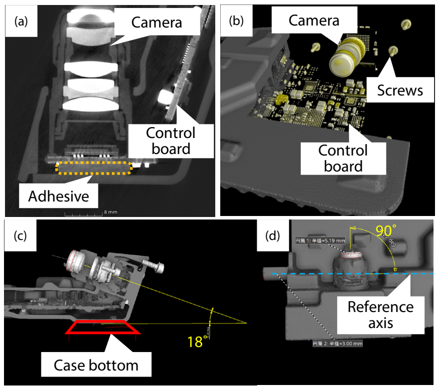


Fig. 7 Cross-Sectional Images and 3-Dimensional Display Images of Automotive Camera

Next, the resin part of the automotive camera was measured by using the infrared microscope system. The case was set as-is on the stage of the microscope and measured by the ATR (Attenuated Total Reflectance) method. According to a search of the obtained infrared spectrum, the resin part showed good agreement with epoxy resin (Fig. 8), which is a thermosetting resin with high mechanical strength and high heat resistance and water resistance.

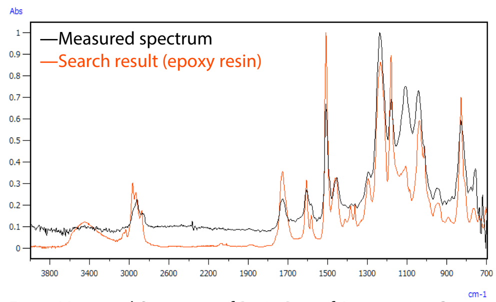


Fig. 8 Measured Spectrum of Resin Part of Automotive Camera and Search Result

## ■ Conclusion

The internal structures of a millimeter-wave radar and onboard automotive camera were observed with an X-ray CT system. It was possible to observe the shape and measure the dimensions of the radar, confirm the existence of voids in sealing parts, and check the installation angle of the camera lens. Using an infrared microscope system, qualitative analyses of the resin parts of the millimeter-wave radar and automotive camera were carried out, and it was found that different types of resins were used. These kinds of information can be utilized in design studies and evaluations of durability in the development stage, confirmation of internal quality during manufacture, or benchmarking against the products of other companies.



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