November 2024

Simplifying Aerospace Testing with XARION

Industrialization of Dry, Automated Ultrasonic Testing for the Aerospace Sector with XARION's Laser Excited Acoustics

MICHAEL KELLER
Application Engineer at
XARION Laser Acoustics GmbH

The aerospace industry has long been a source of numerous innovations. Although materials and production methods have significantly advanced over recent decades, many commonly used non-destructive testing (NDT) methods have remained largely the same. For ultrasonic testing, this typically involves manual procedures or the use of large amounts of coupling fluids, which can be inconvenient and costly. XARION is transforming this field with its dry, automated Laser Excited Acoustics (LEA) technology, which delivers real business advantages by enabling high inspection speeds and eliminating the need for liquid couplants and associated costs (see Figure 1).

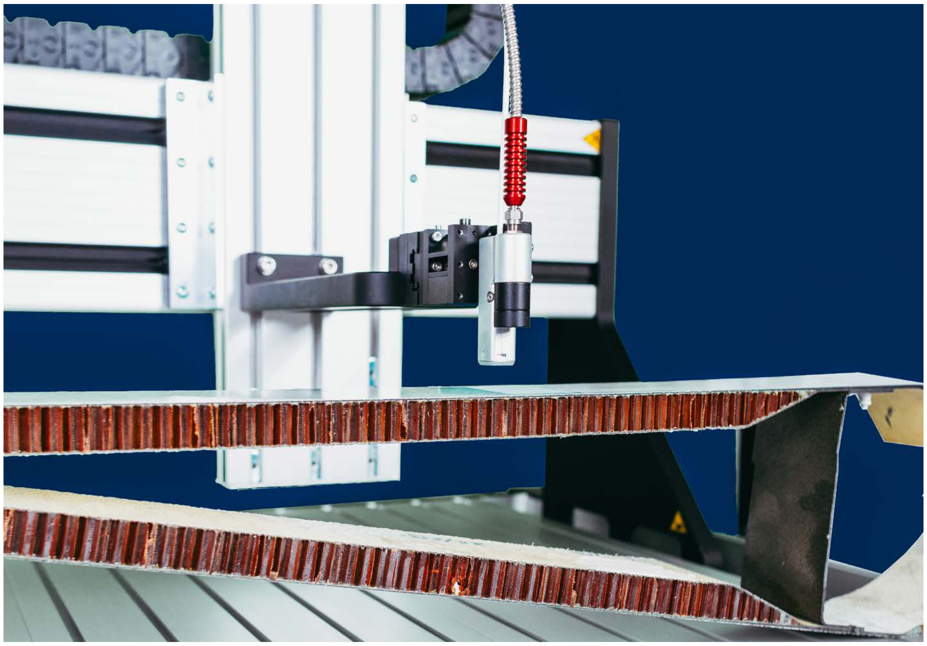

Figure 1: XARION's single-sided inspection probe scanning a composite sandwich structure. The contact-free technology allows high scanning speeds, and removes the need for coupling liquids, enabling cost savings and greater reproducibility through the automation of formerly manual processes.

NDT in the Aerospace Industry: the Status Quo

When it comes to airplanes and spaceships, not only the requirements for material properties are exceptionally high but also the standards for quality control. Even the smallest material weaknesses can have catastrophic consequences. Issues such as delaminations, disbonds, voids, or faulty connections can lead to complete component failure. Therefore, highly reliable testing methods are essential.

Most forms of ultrasonic testing, which remains the most used NDT method for composite materials, rely on liquid-coupled ultrasonic transducers. For large area inspections, components are often immersed in a water bath or require squirter systems to establish coupling between the transducer and the material. However, liquid coupling can be problematic for porous or perforated materials, or materials where moisture is undesirable. The necessary additional effort comes in two forms: preparatory work (e.g., covering openings in honeycomb-sandwich structures) and post-inspection drying to eliminate water or gel remains. Furthermore, the use, treatment, and reuse of water in production facilities add challenges and expenses.

XARION's Revolutionary Sensor Technology: the Optical Microphone

To avoid these problems, XARION Laser Acoustics GmbH, based in Vienna, Austria, has developed an innovative, contact-free ultrasound testing method called Laser Excited Acoustics (LEA). This unique approach combines ultrasound generation with laser pulses and a membrane-free Optical Microphone for ultrasound detection.

The Optical Microphone (see Figure 2) is central to XARION's technology. The microphone head consists of two mirrors forming a small cavity, only a few millimeters in size. This cavity is coupled to a laser via an optical fiber. As sound passes through, it modulates the refractive index of the air within the cavity, changing the amount of reflected laser light. This technology enables an exceptionally wide bandwidth of up to 4 MHz in air, surpassing the bandwidth of piezo transducers. At the same time it provides angular alignment tolerance that outperforms conventional laser ultrasound techniques, especially when measuring rough surfaces or on complex surface geometries. Dr. Balthasar Fischer, inventor of the Optical Microphone and founder and CEO of XARION, explains: "The laser-based approach enables precise defect detection in complex structures, offering greater sensitivity and resolution than other non-contact NDT methods."

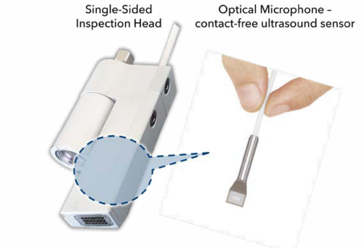

Figure 2: Left: XARION's single-sided inspection probe measures below 70 mm x 35 mm x 20 mm. Right: XARION's proprietary ultrasound detector, the Optical Microphone. It allows for contact-free, broadband ultrasound detection.

Laser Excited Acoustics: a Game-Changer in Automated Ultrasonic Testing

The LEA working principle is as follows: a pulsed laser generates a broadband ultrasound signal on the surface of the specimen under test. This is a thermoelastic effect, i.e. the material is locally heated by a few degrees, leading to sudden expansion which initiates a pressure wave going through the material. The laser intensities are well below the ablation threshold, so the surface remains fully intact. Defects such as delaminations or pores reflect ultrasonic waves, and when these waves reach a surface, part of the ultrasound signal is radiated to the surroundings and can be detected with the Optical Microphone. Both, ultrasound generation as well as detection are hence realized in a contact-free and dry manner. Analyzing the measured signal for total signal strength, arrival time or spectral distribution reveals internal material characteristics, making hidden defects visible (see Figure 3).

“Our slogan, ‘Hear with light – see with sound,’ perfectly sums up our patented testing method,” explains Balthasar Fischer. “This allows us to measure without contact media like gel, which often hinders the automation of conventional ultrasound techniques. Our process is easily automatable and suitable for large industrial robots. We can detect even the smallest cracks, holes, or voids beneath the surface with an inspection machine integrated in the production line,” he continues.

LEA works in through-transmission operation with the excitation laser and the Optical Microphone on opposite sides of the specimen, or in a single-sided configuration with the detector being on the same side as the excitation laser. While single-sided measurements until now used a “pitch-catch” scheme, the most recent extension of the technology allows for “pulse-echo” measurements that can also quantify the depth of a defect (see Figure 4).

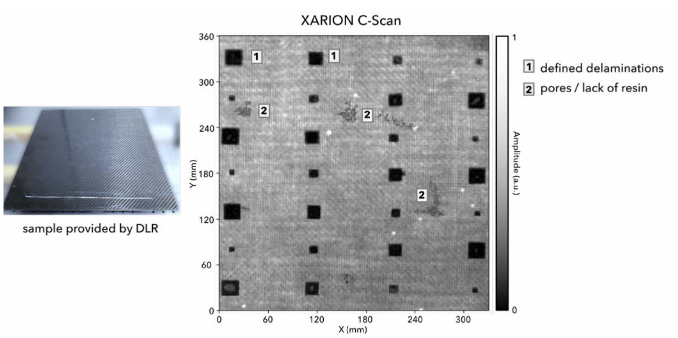

Figure 3: C-Scan of a CFRP reference plate. Besides the square reference defects of varying sizes, also areas with pores due to lack of resin can be identified. For this measurement, LEA has been applied in a through-transmission configuration.

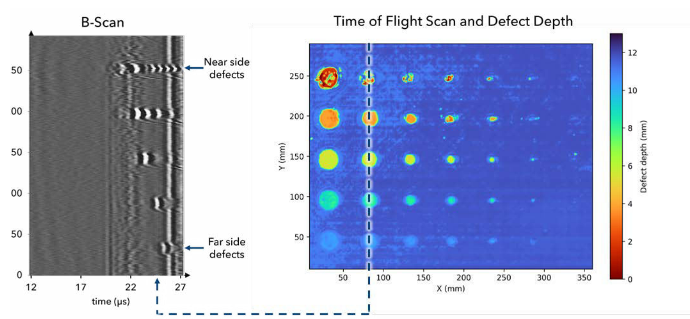

Figure 4: XARION’s new pulse-echo technique, demonstrated on a CFRP reference standard. Left: B-Scan clearly showing the defect echoes with varying arrival times depending on defect depth. Right: Time-of-flight scan where defect depths are color-coded, providing additional useful information when inspecting the scan data.

Laser Excited Acoustics: Real Business Advantage through Versatility and Speed

Beyond being contact-free, LEA provides high-resolution images and functions on rough surfaces and complex geometries. That sets it apart from other technologies like air-coupled ultrasound with piezo transducers or conventional laser ultrasound. XARION’s compact inspection probes (around 70 mm x 35 mm x 20 mm) are connected by just two optical fibers, making them suitable for tight spaces where other NDT technologies are ineffective.

XARION offers the LEAsys, a stand-alone ultrasound inspection tool (see Figure 5), alongside customized solutions. LEAsys combines XARION’s technology with a high-resolution x-y scanner and real-time data analysis, ideal for NDT of composites, metals, and adhesive joints. Operating in single-sided and through-transmission configurations, LEAsys is perfect for R&D and small-to-medium scale production facilities.

“The ability to first test our technology with a LEAsys scanner in a pilot setup is seen as a decisive advantage by our customers. Often, it’s essential to thoroughly test something before being ready to make changes in existing production lines,” says Dr. Josef Pörnbacher, Head of Applications at XARION Laser Acoustics.

As an additional benefit, XARION’s LEA solutions are also offered in an eye-safe configuration. That means that no laser cabinet is required, but a simple fence, light curtain, etc. guaranteeing a sufficient safety distance. This allows for an easy integration on the production floor.

Figure 5: A LEAsys is designed for use in R&D departments small-to-medium scale production facilities. This versatile and user-friendly stand-alone ultrasound inspection tool can handle a wide range of testing tasks.

Automated LEA: a Versatile Solution for Composite Material NDT

Being very compact and working without contact, LEA offers perfect conditions for fully automated, robot-based ultrasonic testing solutions. XARION's LEAdesk solution integrates seamlessly with cobots or industrial robots from any manufacturer (see Figure 6). The new LEAstudio software (see Figure 7) has been programmed with a three-dimensional world in mind. This way, defects can be easily located even on parts with complicated shapes. 3D C-scan representations provide immediate localization of defect positions on the tested parts.

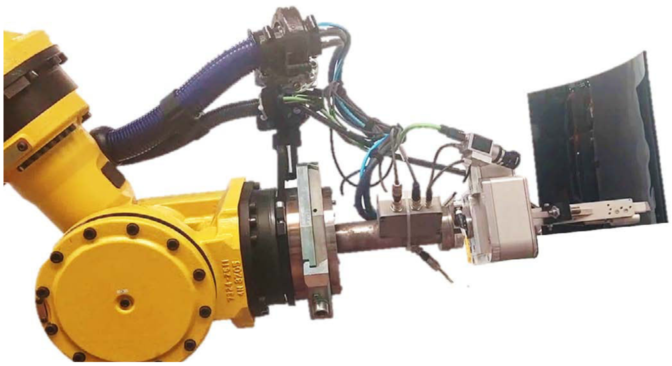

Figure 6: Robot arm inspecting a curved test plate. This automated system enables fully robotized inspection and reliable flaw detection directly on the production line, showcasing advanced automation in NDT. Precise and efficient automated inspection is possible because XARION's inspection method works without contacting the component.

Figure 7: XARION's LEAstudio software has been developed with a 3-dimensional world in mind. A 3D C-scan image allows for straight-forward identification of defect positions on arbitrarily shaped components.

Robot-based LEA provides a versatile NDT solution for composite materials. It can be used for automated inspection solutions even in complex scenarios where other methods fail. With technological innovation, flexible applications, and a clear focus on customer needs XARION Laser Acoustics is a key player in the industry. Their solutions help address the challenges of modern production while setting new standards for quality and efficiency. Supplying renowned companies like Airbus and leading American aerospace manufacturers with solutions for their R&D as well as production facilities highlights the significance and potential of this technology.

"We empower aircraft manufacturers to inspect entire components for internal defects quickly and effectively while keeping our customers' costs and competitiveness in mind," explains Michael Keller, Application Engineer at XARION Laser Acoustics. "Our customers especially appreciate our flexibility. With the same sensor, we can inspect metals, carbon fiber joints, open-porous components, and honeycomb structures without a coupling medium like water or gel."

What's next for XARION LEA?

While automated production is already the standard, automation in testing has been trailing behind. With its newest developments, XARION is about to change that: the possibility to combine LEA inspection probes with industrial robots enables cost-efficient, scalable, and sustainable NDT solutions. They not only can replace and excel existing air-coupled or water-based ultrasound solutions but also open up the possibility for automated testing in scenarios where conventional systems couldn't be used, especially where accessibility is limited or liquid couplants cause significant challenges.

XARION is in a position to provide solutions for a huge variety of non-destructive testing scenarios: with through-transmission, pitch-catch, or pulse-echo configurations, with 8-channel or even 16-channel inspection heads for high-speed scanning of large surface areas, with eye-safe laser configurations for easy integration on the production floor, or with the possibility to use any brand of industrial robot or cobot for automated NDT tasks: the possibilities are more appealing than ever.

About XARION Laser Acoustics GmbH

XARION Laser Acoustics GmbH, based in Vienna, was founded in 2012 by Dr. Balthasar Fischer. The company developed a laser-based Optical Microphone that sets new standards in non-contact ultrasonic testing and industrial process monitoring. Its users include automated manufacturing operations whose products and materials must meet high-quality standards; specifically, the automotive and aerospace industries, as well as metalworking companies that use the Optical Microphone for material and tool inspection. Two renowned investors, the laser and machine tool manufacturer TRUMPF and H.P. Porsche, a supervisory board member of Dr. Ing. h.c. F. Porsche AG and Porsche Holding Salzburg, have invested in the company. The scientific advisory board is chaired by Nobel Prize-winning physicist Prof. Dr. Theodor W. Hänsch. Since its founding, the company has won numerous awards for its patented measuring instrument, including the AMA Innovation Award from the Association for Sensors and Measurement Technology e.V., the code_n award, the Berthold Leibinger Innovation Prize, and first place in the GEWINN Young Entrepreneur Award.

XARION employs 43 staff members at its Vienna location.

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