

Introduction

Building and insulation materials play a critical role in the energy efficiency, durability, and safety of modern constructions. Materials such as mineral wool, glass wool, plaster-based products, and polymer foams are widely used for thermal and acoustic insulation, fire protection, and structural finishing. Their performance strongly depends on internal properties such as density distribution, homogeneity, moisture content, and structural integrity, which are not always accessible through surface inspection alone.

Conventional inspection techniques are often limited when applied to these materials. Optical methods are restricted to surface information, while contact-based or destructive approaches are not compatible with in-line control or large-area inspection. As a result, there is a growing need for non-contact, non-destructive diagnostic tools capable of probing low-density and heterogeneous building materials.

Optikan’s technology, operating in the 60–300 GHz millimetric frequency range, provides a complementary approach for the inspection of construction materials. Based on low-energy, non-ionizing electromagnetic waves, it enables contactless measurements and exhibits strong sensitivity to dielectric properties, density variations, and moisture-related contrasts. These characteristics make it particularly well suited for the investigation of porous and fibrous materials such as mineral wools, as well as layered materials like plasterboards and composite insulation systems.

This application note presents several representative use cases illustrating how Optikan’s technology can be applied to building and insulation materials, with a focus on density assessment, moisture-related effects, and internal structural features. The results highlight the relevance of millimetric inspection both for laboratory characterization and for process monitoring in industrial environments.

uSense



uSense is an all-in-one raster-scan millimeter 3D imaging system designed specifically for scientific applications. It offers unique features and remarkable performance, enabling volumetric control of the structural integrity of any dielectric object.

Highly versatile, uSense can be adapted to numerous studies: detection of cracks, delamination, metallic or wet foreign bodies, extraction of permittivity, optical indices, and even provide density information.

Case study #1 – Detection of Moisture Pockets in Mineral and Glass Wool

In mineral and glass wool insulation materials, localized moisture pockets can form as a result of binder migration within the fibrous structure. The petroleum-based binder is initially used to bond the fibers together and ensure mechanical cohesion. In some cases, following the curing process in the oven, the binder does not dry uniformly. This can lead to post-curing migration phenomena, resulting in localized zones with increased binder concentration.



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These moisture pockets have a dual negative impact: they cause a partial degradation of the expected thermal insulation performance and may also lead to visible aesthetic defects, such as stains or discoloration on the finished product.

The presence of binder-rich zones within the fibrous matrix corresponds to localized concentrations of polar molecular groups, to which the electromagnetic waves deployed by Optikan's technology are highly sensitive. As a result, these moisture-related defects generate measurable contrasts in the millimetric response of the material.

Alternative inspection approaches have been investigated in the past; however, the strong scattering behavior of mineral and glass wool significantly limits defect localization, making precise detection particularly challenging with conventional techniques.

In the present example, moisture pockets were successfully detected in glass wool panels of two different areal weights, corresponding to different material densities. Depending on the material thickness and density, higher frequencies should be preferred to enhance defect localization and contrast.

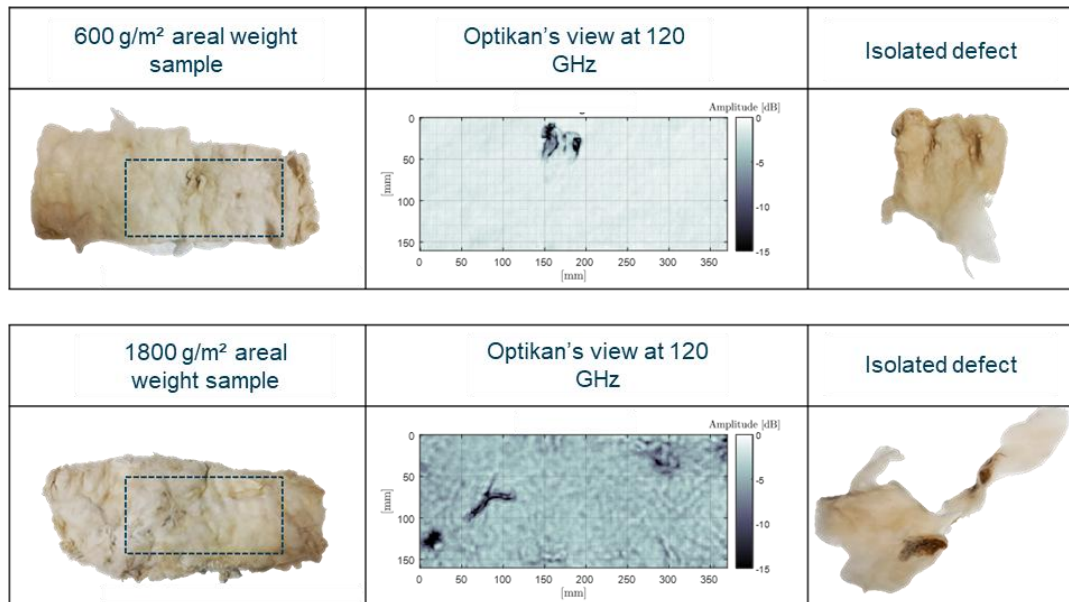


Figure – Moisture Pocket Detection in Glass Wool

Case study #2 – Density Assessment in Insulation Wool Materials

This second use case addresses the assessment and monitoring of density variations in insulation wool materials. Density is a key parameter governing the thermal, acoustic, and mechanical performance of fibrous insulation products. Local density deviations may result from process instabilities, compression effects, or non-uniform fiber distribution, and can lead to degraded product performance or out-of-spec materials.

Using Optikan's technology, density variations can be inferred from the attenuation behavior observed at the pixel level within millimetric images acquired over insulation panels. Changes in local attenuation are



directly related to variations in effective dielectric properties, which in turn correlate with fiber concentration and material density.

This approach can be applied both to static panels in laboratory conditions and to in-line inspection scenarios, such as monitoring insulation materials during manufacturing on a conveyor. In a production context, spatial maps of attenuation provide real-time insight into density homogeneity across the width and length of the panel.

The technique is compatible with a wide range of insulation materials, including glass wool, rock wool, wood fiber, flax, hemp, and coconut fiber wools. This broad material compatibility stems from the common fibrous and porous nature of these products, which exhibit dielectric responses well suited to millimetric inspection.

This use case demonstrates the ability of Optikan's technology to provide non-contact, spatially resolved density indicators for insulation wools, supporting applications such as process monitoring, quality control, and product qualification across diverse insulation materials.

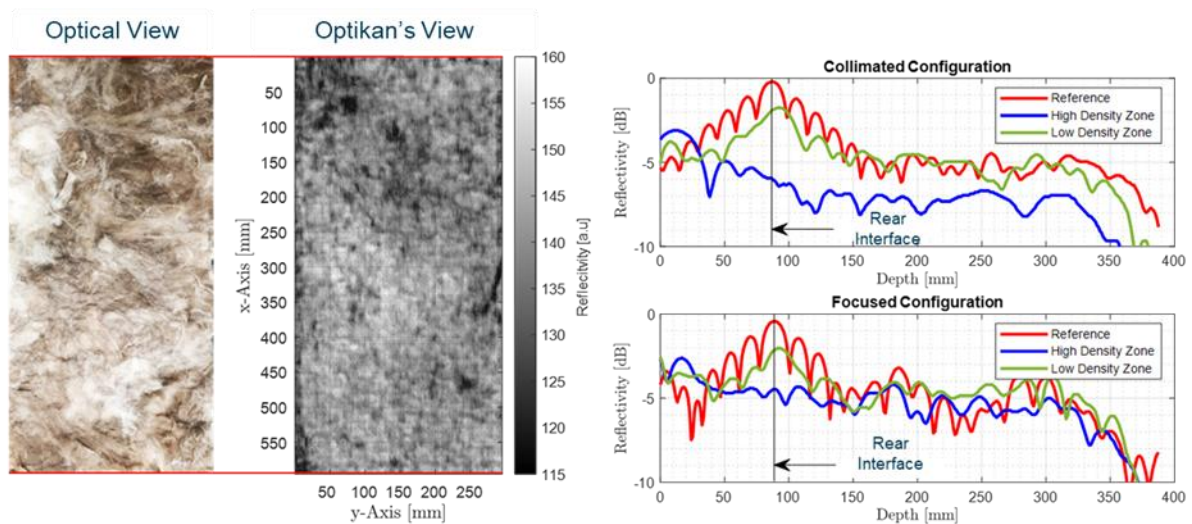


Figure – Millimetric Imaging Insights (left) & Density-dependent Attenuation Monitoring (right)

Case study #3 – Internal Imaging and Inhomogeneity in Plaster Materials

Plaster-based materials are widely used in the construction industry for wall systems, boards, and finishing elements. Their mechanical performance and long-term durability depend on internal homogeneity, proper hydration, and controlled material distribution during manufacturing. Local inhomogeneities, such as density variations, inclusions, or hydration-related defects, can lead to reduced mechanical strength or dimensional instability.

Using Optikan's technology, plaster materials can be investigated through internal millimetric imaging, providing access to structural features that are not visible from surface inspection alone. The technique is sensitive to dielectric contrasts arising from variations in density, composition, and moisture content within the plaster matrix.



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Millimetric images acquired over plaster samples reveal internal heterogeneities distributed throughout the material thickness. These inhomogeneities may originate from non-uniform mixing, air entrapment, or local variations in hydration during setting. The ability to visualize such features enables early identification of process-related deviations.

This approach can be applied both to static inspection of finished plaster products and to process monitoring during manufacturing, where spatial mapping of internal structure provides insight into material uniformity across large areas. The non-contact nature of Optikan's technology makes it compatible with fragile or freshly formed plaster elements.

This use case demonstrates the relevance of Optikan's technology for the non-destructive internal inspection of plaster materials, supporting quality control, process optimization, and material development in the construction sector.

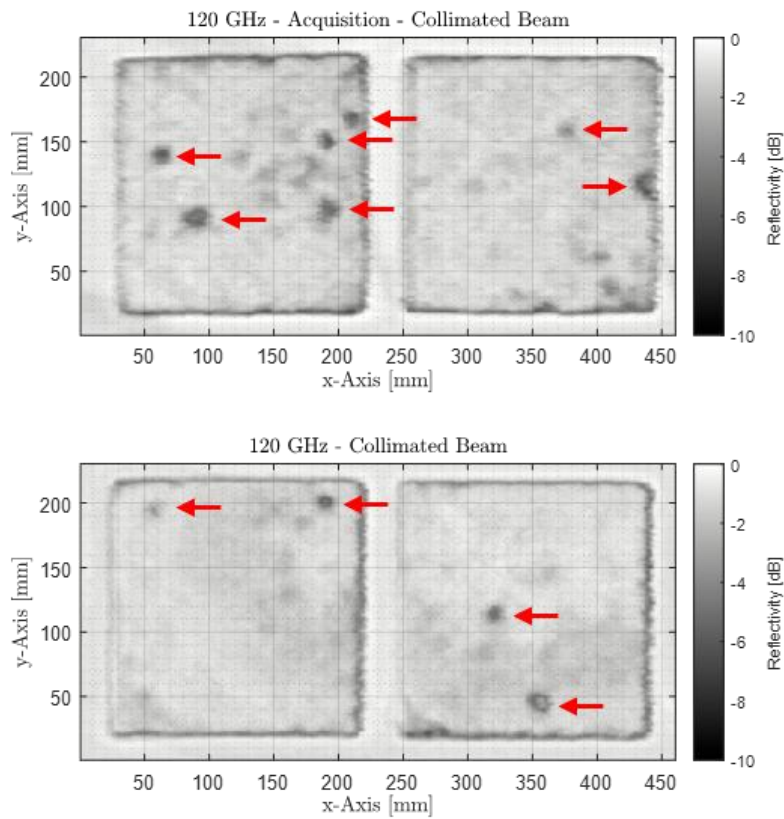


Figure – Plasterboard with Highlighted Heterogeneity Spots



Case study #4 – Crack Detection in HDPE Pipes

This fourth use case addresses the detection of cracks in high-density polyethylene (HDPE) pipes, a critical issue for applications involving fluid transport and structural reliability. The reported example concerns the inspection of a polymer pipe with a wall thickness of approximately 10 cm, containing two cracks located on the internal surface, with respective depths of 1 mm and 4 mm.

The probing beam was focused on the internal surface of the pipe. When a crack is present, it induces scattering of the incident electromagnetic wave, due to the relative size of the defect compared to the probing wavelength. This scattering results in a loss of coherent reflected signal, which is captured by the detector as a localized contrast variation.

Although the cracks are located on the inner surface, the detection is achieved after approximately 20 cm of electromagnetic propagation through the material, corresponding to a round-trip path (10 cm forward propagation and 10 cm return). This demonstrates the ability of Optikan's technology to detect shallow internal defects after significant propagation through thick polymer structures.

This method is particularly relevant for polymer pipes joined by mirror fusion welding, where the presence of cracks or incomplete bonding can compromise mechanical integrity and long-term durability. Comparative tests have shown that the detection performance achieved with Optikan's technology is at least equivalent to that obtained with ultrasonic inspection, while offering the advantages of contactless operation and simplified implementation.

The measurements were performed using both the uSense laboratory station and the uSense LITE portable system. For the portable configuration, the mechanical shoe can be adapted to match the pipe diameter, while the focal length of the focusing lens is selected according to the pipe thickness. This flexibility allows the inspection approach to be tailored to a wide range of pipe geometries and installation conditions.

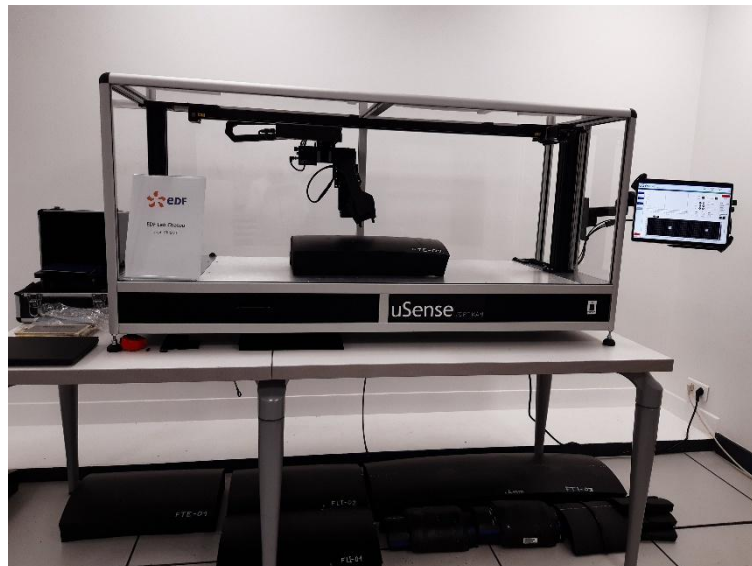


Figure – Laboratory Analysis of a HDPE Pipe Section



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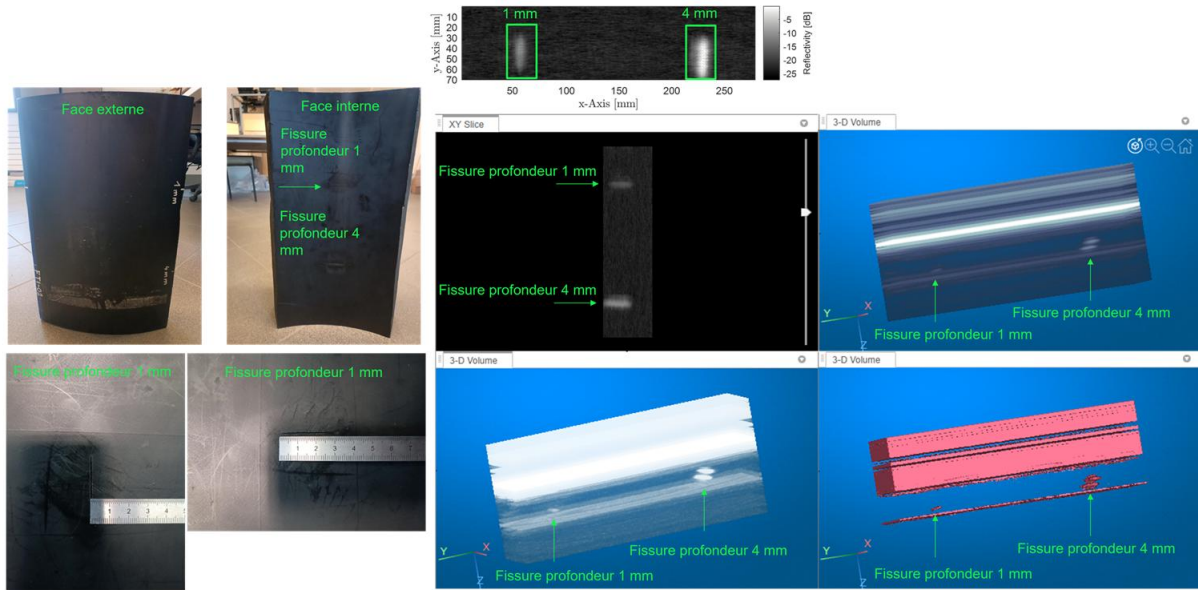


Figure – HDPE Pipe Section Analyzed (left) – HDPE Pipe Section Reconstruction with Internal Cracks

For more information, please contact Optikan at: contact@optikan.com.

