Technology FAQ
Comparing the OTS-1000 to µ-CT

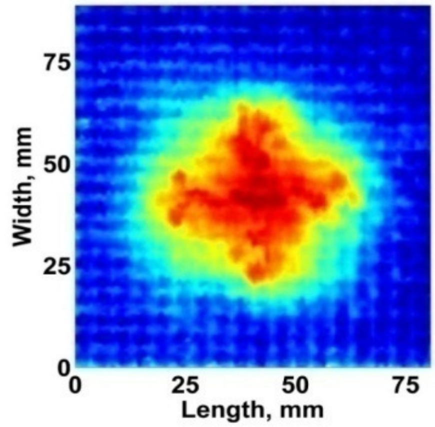
Overview

Optical Transmission Scanning (OTS) is based on transmission measurements using ultraviolet (UV), visible (VIS) or near Infrared (NIR) light sources. OTS techniques originated in lab environments as a cost-efficient alternative to current methods. The principles, validation, and comparison with conventional NDT techniques are published in several peer-reviewed publications.

Although OTS can be treated as radiography or through-transmission UT using the light instead of X-ray radiation or sound waves, respectively, it is less intrusive than radiography and less affected by UT air/material interfaces.

As an alternative to X-Ray devices, OTS has a key advantage: it can differentiate material based on the chemical structure, not simply the mass density. This means, for example, that OTS can reveal two different resins in the same composite, as one might find in a repaired structure.

For flat composite samples, a two axis flat scanner system is simple and cost effective. Implementing OTS for more complex structures will involve more costly robotics, however the core technology is expected to produce the same high resolution measurements.



Repeated impact damage to GFRP is shown to be distributed quasi-uniformly in the circumferential direction.

Basics of Radiographic Testing (RT)

When we visit a dentist we see that X-ray radiation can penetrate both hard objects (“teeth”) as well as soft objects (“gums”) and generate useful images. The essential physics is that X-ray radiation and its kin are short wavelength electromagnetic energy that can penetrate solid material and based on the differential absorption of the material produce images on film or screens.

NDT testing of composites with X-rays or gamma rays allows detection of voids and porosity, inclusions, trans-laminar cracks, resin-to-fiber ratio, non-uniform fiber distribution and fiber misorientation. With computed tomography (CT), 3D visualizations of a sample’s interior are possible and with the latest micro focused CT (µCT) micron level resolution is possible.

• *Defect analysis*: CT scanning can detect and quantify percentage porosity in a composite part, measuring void diameter and volume, as well as distance from the edge of the part. It also can be used to walk through the layers of a part from any direction, enabling visualization of how porosity, weave structures and fiber orientation change from top-to-bottom and side-to-side.

• *Resin/Fiber Analysis:* CT can detect different densities of material within a part, enabling the removal of resin digitally to analyze fiber distribution in the as-made part, including calculation of resin/fiber content and measurement

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against set thresholds to flag where the part is not to spec. Fiber orientation and fiber length distribution also can be analyzed and flagged against specifications.

• *Wall thickness:* the thickness of every wall throughout an entire part can be measured - regardless of the number of cavities, stringers and complex ribs/stiffeners. A visual plot similar to finite element analysis, with colored indicators showing any compromised wall thickness can be created.

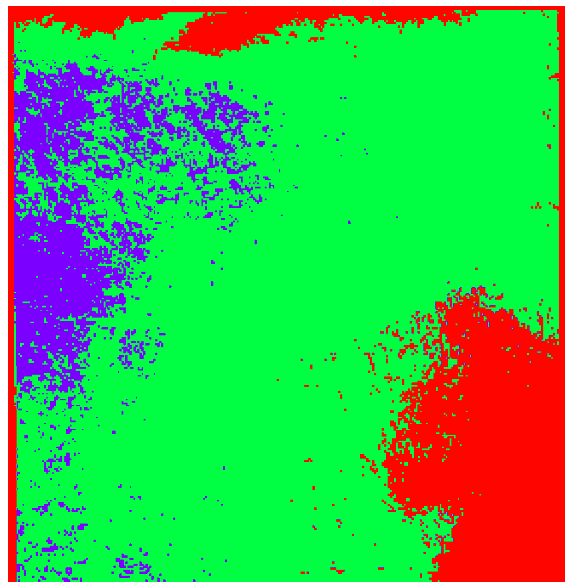
• *Damage mechanism and failure analysis:* CT enables the identification of failure modes in even the most complex structures, without destructive testing that might compromise data.

OTS compared to μ-CT, or X-ray Tomography

The main differentiator between X-Ray systems and OTS is that while OTS cannot analyze opaque samples such as metal or carbon fiber, the technology is superior for analyzing translucent materials such as GFRP. And, of equal importance is that the new, low cost lasers and detectors allow General Photonics to manufacture OTS equipment that is far less costly than specialized X-ray systems.

By combining lasers and processing software that can run on inexpensive laptop computers, quantitative analysis of composites can be quickly accomplished.

In the image to the right, a 3 mm thick sample of chopped fiber is scanned and processed with General Photonics software to reveal that 72.3% of the sample is within a specified 30% above/below average. The OTS also calculates that 10.4% of the sample is rich in matrix ("blue") and 17.3% is filler rich ("red").



Summary OTS Advantages compared to X-ray Tomography

1. **Chemical versus Mass Density:** just as spectroscopes can identify the various chemicals in a sample their absorption lines, the OTS can differentiate one resin from another in a composite sample.
2. **Sample Size:** OTS handles samples up to 40 cm × 80 cm. Sample size for μ-CT is limited by the chamber capacity, which is usually less than 2000 cm^3.
3. **Operability:** μ-CT systems require specially trained personnel and must be operated in dedicated locations with restricted access due to strict safety regulations.
4. **Cost:** Typical μ-CT system costs $500,000 or more; and charges for out sourced testing are typically $500 to $1,000 per sample. OTS costs less than 10% of a modest μ-CT system.
5. **Time of Measurement and Data Processing**: μ-CT data acquisition time is measured in hours. Huge data files can exceed 100 GB and may take up to 10 hours to process (particularly when high resolution is needed). By comparison, the OTS scans and analyses samples in minutes.

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