

Holographic Interferometry: Nondestructive tool

While holography is often used to obtain recreations of 3-dimensional objects, many industrial applications of

holographic interferometry gives an accuracy better than a half wavelength (about 10 millionths of an inch), and both qualitative and quantitative information can be derived from the fringe patterns. This allows us to look at the effects of vibration, temperature, stress and strain, and other physical forces in an entirely nondestructive way. A powerful feature of holographic interferometry is that information is obtained over the entire illuminated surface of the object being studied as a full and continuous field, which is important in understanding what is happening to the object as a whole.

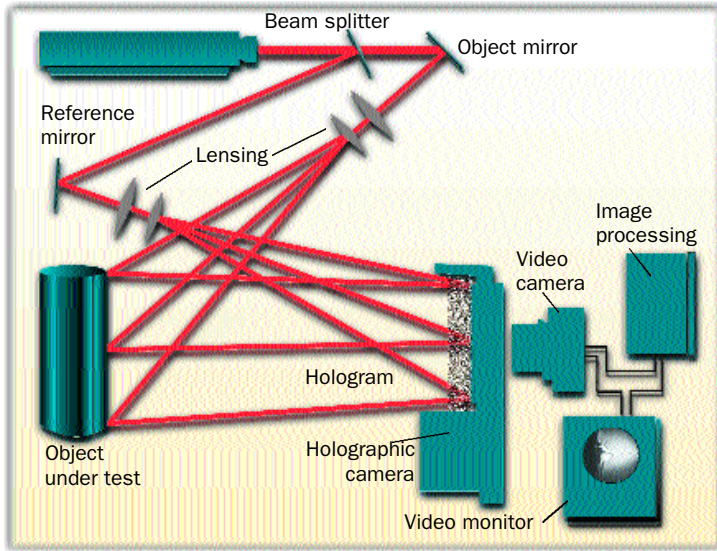


Figure 1. Holographic interferometry setup

holography make use of its ability to record two slightly different scenes and display the minute differences between them. This powerful technique, called interferometry, is an invaluable aid in design, testing, quality control, and analysis (Figure 1). Holographic techniques are nondestructive, realtime, and definitive in allowing the identification of vibrational modes, displacements, and motion geometries.

If the object under study is changed or disturbed in some way during the hologram exposure or from one exposure to the next, then a pattern of "fringes" will appear on the image itself, making the object look striped. These fringes really represent maps of the surface displacement caused by the force or stress that disturbed the object. Such a displacement map represents an extremely sensitive picture of the actual motion the object has experienced, with a single fringe contour representing lines of equal displacement.

Holograms can record motions and displacements, deformations and bends, and expansions and contractions on virtually any object. The typical optical laser used in

Interferometry

Holographic interferometry is used in vibration and modal analysis, structural analysis, composite-materials and adhesive testing, stress and strain evaluation, and flow, volume/shape, and thermal analysis.

All these applications derive from one or more of the three basic methods of applied holographic interferometry: real-time, multi-exposure, and time-average holography. Interferometric nondestructive testing can be accomplished with either continuous or pulsed lasers of almost all wavelengths. Continuous lasers are ideal for real-time studies of displacement and motion. Pulsed lasers can be synchronized with motion and also can record holograms of extremely fast transient phenomena.

Real-time holography allows one to observe instantaneously the effects of minute changes in displacement on, or in, an object as some stress affects it. This is done by superimposing a hologram of an object over the object itself while it is being

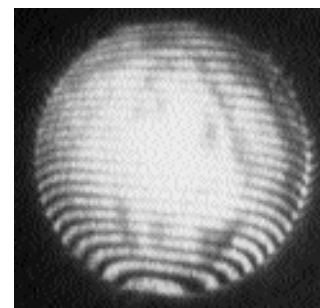
subjected to some small force or stress.

Multiexposure holography creates a hologram by using two or sometimes more exposures. The first exposure shows an object in an undisturbed state. Subsequent exposures, recorded on the same image, are made while the object is subjected to some stress. The resulting image depicts the difference between the two states.

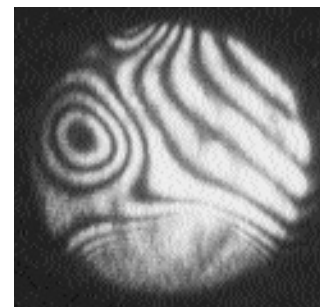
The third technique, **time-average holography**, involves creating a hologram while the object is subjected to some periodic forcing function. This yields a dramatic visual image of the vibration pattern.

All these techniques reveal the shape, direction, and magnitude of the stress-induced displacements in the structure under study. An important key to holographic interferometry's success is that it allows the use of very low-level, nondestructive stress to gather data that once required destruction of the material.

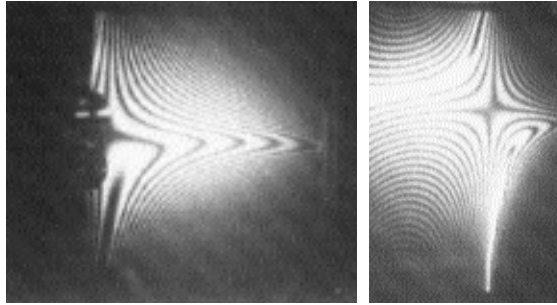
Holography solved an expensive bonding problem for a major defense contractor. Titanium and aluminum were bonded together with a special thin rubber layer to create a large "sandwich." Conventional tests, such as X-rays and ultrasound, could not show if the bonding was complete because the materials and thicknesses were



Holographic image of a correctly bonded structure (Figure 2, top) contrasts with irregularities in the fringe pattern



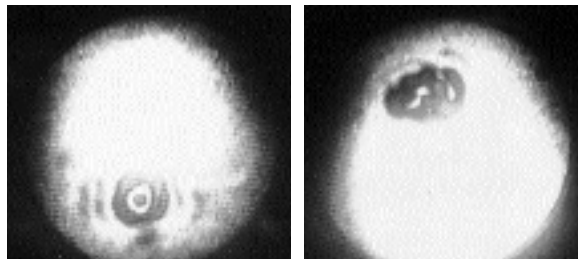
caused by defects in a poorly bonded structure (Figure 3).



Holographic images of modal patterns on a vibrating rocket guidance fin (Figures 4 and 5) helped determine the best design to ensure stability.

so different. Holography, however, offered complete visualization of debonds, flaws, and irregularities in the assemblies (Figures 2 and 3). This enabled the company to redesign and ensure 100% bonding on shipped products.

An aviation manufacturer turned to holography to solve the mystery of “exploding” microchips. A particular large microprocessor chip regularly shattered on circuitboards used in an airborne system. Holographic analysis of the circuitboard vibrations found that the microprocessors experienced a very large vibrational stress during operation. Slight modifications in the component layout corrected the problem.



Uniform fringe pattern (Figure 6, left) shows correctly distributed stress on a sonar system used in a U.S. Navy torpedo. Figure 7 reveals distortions caused by flawed internal parts.

Holographic testing helped determine the best design of some rocket guidance fins. The high speeds of even small rockets requires that the guiding fins open and stay stable during flight. If they do not, vibrations will tear the fins off the rocket body. A major defense contractor used holography to study how fin parts behaved while vibrating (Figures 4 and 5). This resulted in the successful design of fins that snap open and remain sta-

ble during flight, a uniquely stressful environment.


Elements of advanced naval sonar units must operate perfectly. If any of the individual components are damaged or flawed, then the sonar assembly will typically overheat and cause catastrophic failure by burning or melting internal parts. Holography was the only test method used that successfully identified flawed and damaged

parts in a sonar system used in a Navy torpedo (Figures 6 and 7).

A major automotive manufacturer uses holography to analyze the source of noise in electrical motors. It found conventional testing methods inconclusive, but holography could show how motors generate noise during use and how the noise is transmitted. This pointed to design modifications that have led to quieter motors.

It is easy to observe the slightest structural deformations caused by temperature changes in components such as circuitboards and mechanical housings. Even the results of ongoing chemical reactions have been observed with holography.

The aerospace industry, automotive manufacturers, and many other commercial and defense-related industries rely on holographic interferometry to investigate and test everything from microscopic computer chips and circuits to automotive components and even large sections of entire aircraft and spacecraft. These sophisticated tests have become useful in developing quieter machinery, lighter and stronger materials, and successful

assembly of systems that will experience great stress. Holographic interferometry is a powerful ally in the field of nondestructive testing and inspection. 

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