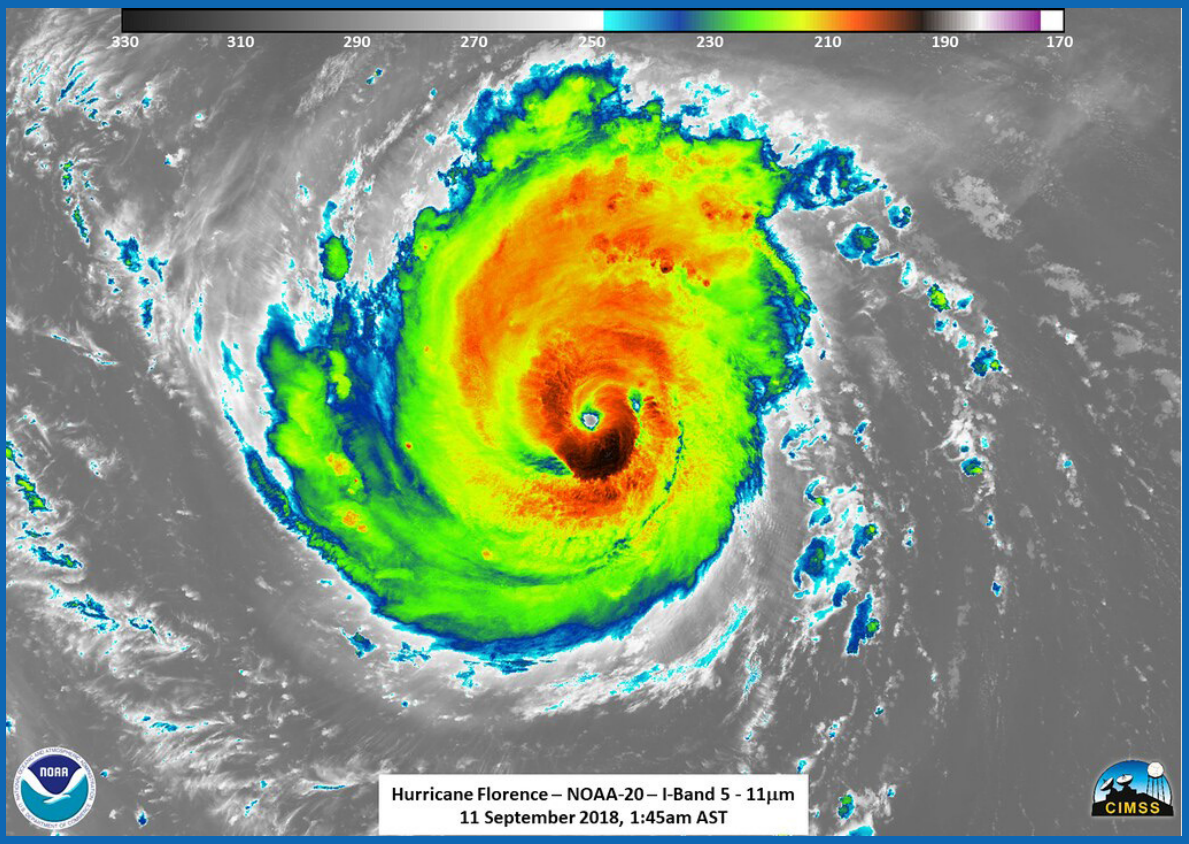

3 Questions to Ask Before Buying Infra-Red Interferometry

A WHITE PAPER

4D Technology
A Nanometrics Business Unit

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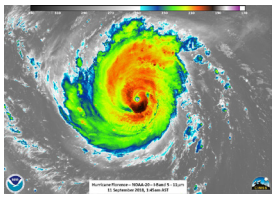


On the cover: NASA-NOAA's image of Hurricane Florence

The orbital platform that provides infrared images like this uses IR optics in a sophisticated optical system.

Download data sheets for IR interferometers:

Click here for the IR interferometer **Data Sheets**

Important considerations in obtaining infra-red optical metrology

3 questions to ask before buying IR interferometry

By Stephen Martinek

Question 1: Are there workarounds?

So, you are weighing whether you need an infra-red interferometer. They're more expensive than visible light instruments. You may already have quality control equipment – time, space and money are all a premium.

You may want to get around the measurement tool, without using IR interferometers.

Surface metrology

Reflective surfaces can be measured in visible light. There's no need for an IR interferometer to measure surface shape of polished or fully reflective materials, even if their operating wavelength is IR.

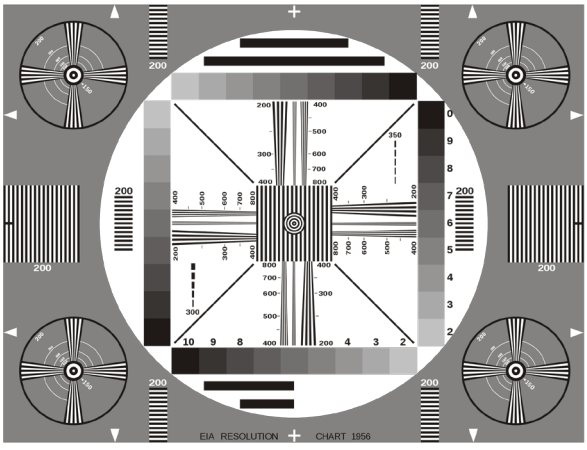
A special case is rougher, unpolished surfaces. Pre-polish shape measurement is the most common use for 10.6 µm IR interferometers. Long IR wavelengths are capable of measuring the shape of an incompletely polished surface, even though there are large departures from an ideal—regardless of the operating wavelength of the material. Optics production customers use IR interferometers for a preliminary check of many different materials before committing time and effort to final polishing processes.

Specify transmission parameters

You can order individual components with a transmission quality specification. It at least ensures the elements are known good, albeit at a higher cost—as a rule of thumb, the more things you ask your optical supplier to control, the higher the cost of the element. Knowing that the elements are good doesn't help you install them, align them, and qualify the system, however.

Target tests

Illuminate a resolution target with an IR source, then look through your optical system at the target and determine if the image is clear enough to meet your requirements. This can work as a pass/fail, but it does nothing to determine failure, because it provides no analysis. That means you don't learn what corrective measures you need take to fix a failed optical system—your options are to scrap, or rebuild and hope for better results.



A resolution target.

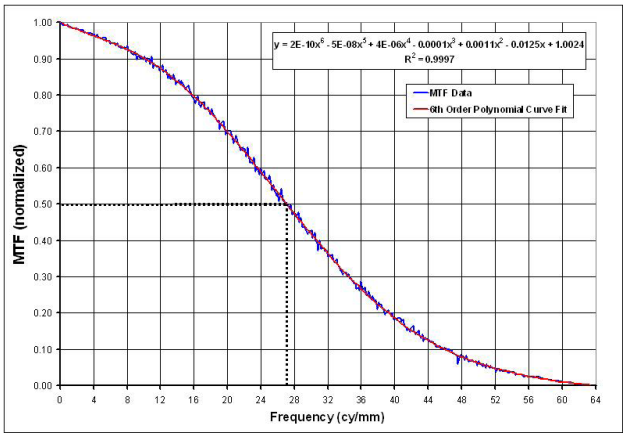
Question 2: When is IR interferometer testing unavoidable?

Short answer: when you need to test the optic(al system)'s ability to transmit an IR wave. Whenever you're testing transmission of wavefronts, it's best to do it at operating wavelength. One might attempt to align an IR system using visible light—assuming the IR materials are transmissive in visible spectra—but then you need

to make assumptions, and calculate the amount of power needed at visible wavelengths to be collimated in IR waves. It introduces larger margins for error.

Cases where transmission tests are required:

- Testing the quality of your optical materials, as when testing homogeneity
- Assessing (or aligning and focusing) a whole system's performance at operating wavelength



Determining MTF data, which corresponds to optical performance requires transmission measurements.

You'll want an IR interferometer on hand when:

- Superior results are needed—such as when you want in-depth analysis of a system's optical performance
- Throughput is an issue—commercial systems are fast, and minimize your overhead in calculating the true meaning of the measurement results

Question 3: Sourcing: homebrew, custom or off-the-shelf?

When considering how your instrument should be built, there's a simple caveat: it's harder than it looks. 4D Technology has been building IR interferometers for over 15 years, and have a substantial installed base of products, which we continue to support.

Things to overcome

Those with minimal experience in building an interferometer would find the challenge of an infra-red instrument daunting. Infra-red wavelengths introduce some complications, both in design and logistics, that can't be handled in the same way as building a visible light system.

- In IR imaging, heat becomes light. That means that the traditional black enclosure's wall become radiant light sources to the IR sensor. As structure, electronics and components heat up from wattage, strays and reflections, light leakage is added into the imaging beam. Strays become heat sources, and complicate the problem
- IR sensors detect the entire thermal image of the scene. The signal in the interference pattern must be strong enough in that thermal background to get a measurement of the surface. Temperature increases in the room, or inside the instrument, can reduce that signal. Both environments need to be controlled.
- Compensating for ambient heat with fans or refrigeration is likely to introduce vibration into the system
- Selecting a sensor that will match your system's optical performance—ideally, permitting diffraction-limited imaging—is a technical and purchasing challenge.
- Longer wavelengths diffract at steeper angles than visible light, meaning even small surface defects on an optic will produce greater ringing than is seen in visible systems.
- Infra-red optical components aren't cheap, and the specifications for quality must be higher than in visible

light. Having a good relationship with optics manufacturers for your components will reduce costs and risks.

Acquisition and analysis software that works

Optical, electronic and mechanical design considerations addressed, the next big consideration will be operating and analysis software. Working with a well-established interferometer firm increases your chances of a hardware control and data analysis system that will be optimized for speed, and elegant in execution, as a result of years of field testing and improvements. Writing code for control of the system, and depending on a third party analysis application to integrate and work well is a high cost and increased risk, versus the proprietary investment in software development that comes packaged with a commercial interferometer.

Product support for the long term

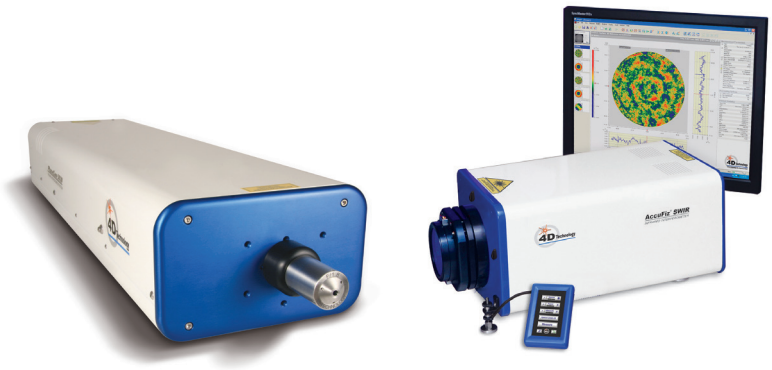
Whether buying from a startup or trying to build a breadboard system, consideration for long term support becomes a risk. For many companies, purchasing an interferometer rises to a capital-expense level of investment. Working with a metrology company with both a robust base of installed product, and strong financial reserves helps ensure you'll have access to outside support, technical expertise, warranties and extended service for your capital investment in the long term.

No need to compromise

It may be that your application requires custom engineering, because nothing is being offered on the market that fits the need. If so, be prepared to pay for the work. Look for a vendor with a robust custom engineering commitment, that also has a well-established product line.

A custom-made dual-band infra-red Fizeau interferometer

These may be able to take on one-time projects, while having a variety of known-good designs from previous work that can be adapted for a custom configuration.



Left: An off-the-shelf Twyman-Green IR interferometer. Right: An off-the-shelf Fizeau IR interferometer

Yet, a surprisingly wide variety of commercial infra-red interferometers—with diffraction-limited performance—are now available. Consider:

- Large spherical optics may best be measured by a Twyman-Green system
- Flat optics that are larger than a few millimeters in diameter may best be served by a Fizeau system
- If your instrument life plan demands repurposing the interferometer, a Fizeau system offers the greatest flexibility in reconfiguring tests of different transmission optics
- Available wavelengths of source lasers will affect price and availability
- Spatial resolution: for highly sloped and aspherical optics, ask for a high-resolution imaging sensor
- If your test environment involves a large cavity, a test chamber or mechanical separation between the interferometer and the optic, inquire about whether dynamic measurement acquisition modes are available
- If your optimal choice is a Twyman-Green system, you can gain greater flexibility using a dual-port system that is compatible with off-axis parabolas, for beam expansion

Call to Action:

Get IR interferometer data sheets from 4D Technology

4. A Bonus Question:

How tightly should an IR interferometer's laser source match my operating wavelength?

Click here for the answer to the **Bonus Question**

Download the data sheets:

Click here for IR interferometer **Data Sheets**

Get the surface and wavefront data you need for IR systems, with highest precision, versatility, and ease of use. Only 4D offers dynamic IR interferometry for fast, accurate measurements in long paths, vibration and turbulence.

See for yourself. Get a demonstration. Measure optics precisely, in high resolution. Surface shape, wavefront transmission, mid-spatial frequencies and surface roughness instruments for a wide range of applications and spectra.

4D is the first name in dynamic metrology.

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