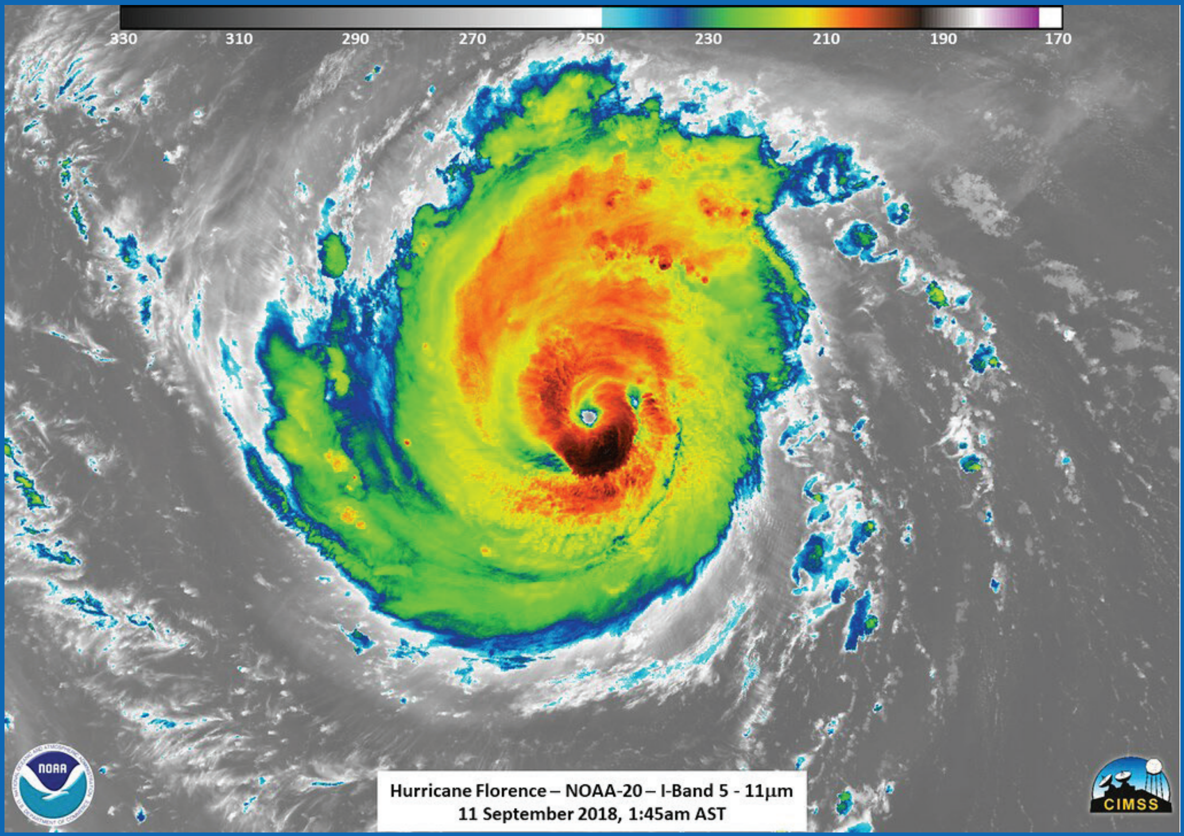
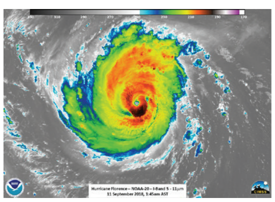


3 Questions to Ask Before Buying Infrared Interferometry

A WHITE PAPER

4D Technology
An Onto Innovation Subsidiary

Table of Contents



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 infrared 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 infrared 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.

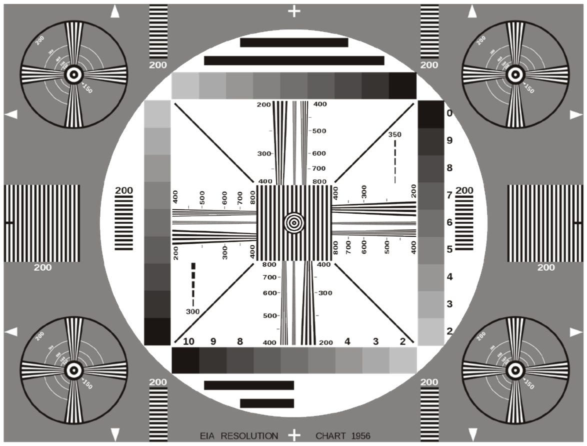
A special case is rougher, unpolished surfaces. Pre-polish shape measurement is the most common use for 10.6 µm IR interferometers. Long IR wavelengths are capable of measuring the shape of an incompletely polished surface, even though is it rough, and there are large departures from an ideal—regardless of the operating wavelength of the material. Optics manufacturers use IR interferometers for a preliminary check of many different materials to help direct the final polishing process and ensure the right amount of materials are removed.

Specify transmission parameters

You can order individual components with a transmission quality specification, provided your vendor has an infrared interferometer. Tight specifications ensure 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 overall system, however.

Target tests

If you do need a way to test the overall system resolution after you build it, and don't have an infrared interferometer, you can use test targets. 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 the failure mechanism because it provides only an overall resolution limit. 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.



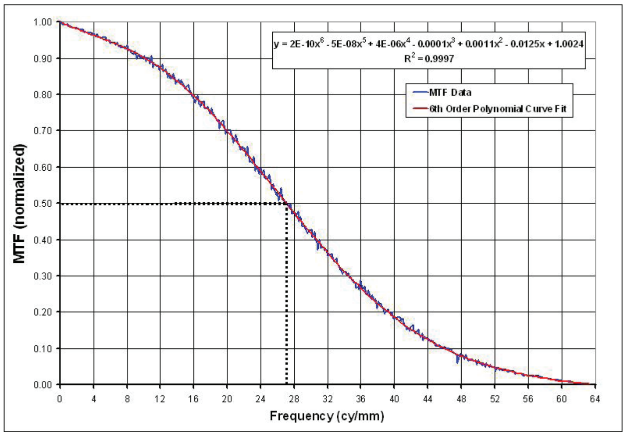
A resolution target.

Question 2: When is IR interferometer testing unavoidable?

Short answer: when you need to test the quality of a transmitted IR wave through one or more elements. Whenever you're testing transmission of wavefronts, it's often essential to do it at the operating wavelength, especially since most optics that transmit in the infrared do not transmit in the visible spectrum. Even if you have IR materials that are transmissive in the visible, aligning and qualifying the system at such a different wavelength involves many assumptions and calculations of how deviations at the visible wavelength relate to deviations at the use wavelength. This introduces large uncertainties in the results.

Cases where transmission tests are required:

- Testing the quality of your optical materials, as when testing homogeneity
- Determining the sensitivity of the overall system performance to displacements of each of the optical components.
- 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.

Hardware challenges

Those with minimal experience in building an interferometer would find the challenge of an infrared instrument daunting. Infrared 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 the system enclosure can become a source of IR light that diminishes the signal quality on your IR camera. Additionally, electronics can heat up and further reduce the signal to noise if not properly shielded and baffled.
- IR sensors detect the entire thermal image of the scene. The interference signal from the test setup must be much stronger than the thermal background to get a high-qualty 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. Thus, using dynamic interferometry, as opposed to traditional phase-shifting interferometry, can be essential to achieve good measurement quality.
- Achieving an optical design that provides diffraction-limited imaging and finding a sensor that meets your spatial resolution requirements is a challenging technical problem.
- System cleanliness and optics with minimal defects are important to reduce measurement artifacts. Both system design, and specification of the interferometer components, must be optimized to ensure minimal ringing from edges and defects.
- Infrared interferometers are expensive investments, and one must ensure that there is long-term support to protect that expense. Using a commercial interferometer maximizes the likelihood of continued support for years to come.

Optimal acquisition and analysis software

Once optical, electronic and mechanical design considerations are addressed, the next big consideration will be operating and analysis software. Having seamless, intuitive controls for the camera, laser, and other hardware elements are important to rapidly achieve the best measurements possible. Once data is acquired, robust, flexible analyses for calculations such as Zernike terms, point spread function, encircled energy and more will be needed to properly assess the test system's quality. Having one entity responsible for the seamless integration of hardware controls and analyses reduces risk and ensures rapid time-to-results.

Product support for the long term

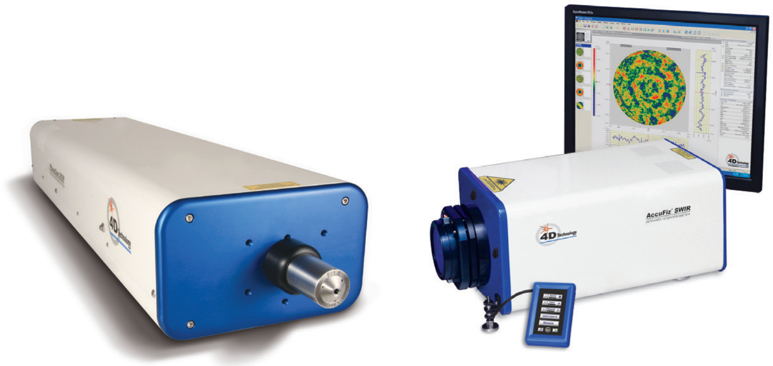
Whether buying from a startup or trying to build a breadboard system, long term support becomes a risk. For many companies, purchasing an interferometer rises to a capital-expense level of investment. Working with a metrology company with both a large installed base, strong financial reserves, and proven track record of world-class customer support ensures you'll have use of your system for 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. Look for a vendor with track record of innovation and commitment to providing custom, yet fully-supported, solutions to customers when required.

A custom-made dual-band infrared 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 near-IR interferometer. Right: An off-the-shelf Fizeau LWIR interferometer

However, chances are that a custom interferometer is not necessary, as a wide variety of diffraction-limited commercial interferometers of varying wavelengths and aperture sizes are available. Consider:

- Large concave optics may best be measured by a Twyman-Green system
- Flat optics from a few millimeters to a few hundred millimeters in diameter may be best served by a Fizeau system
- If your instrument life plan demands repurposing the interferometer, consider two options:
  - a Fizeau system offers great flexibility in reconfiguring tests of different transmission optics
  - a dual-aperture Twyman-Green interferometer offers a variety of concave optics measurements, while the side port offers a variety of off-axis parabolic collimators
- Available wavelengths of source lasers will affect price and availability
- Spatial resolution: for highly sloped and aspherical optics, ensure for a high-resolution imaging sensor and appropriate diverging lenses or transmission spheres
- 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. Dynamic interferometers provide vibration immunity from cooled lasers and cameras or from long test cavities and also where the test optics may be in an environmental chamber or otherwise separated from the interferometer.
- 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

Learn more right now:

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

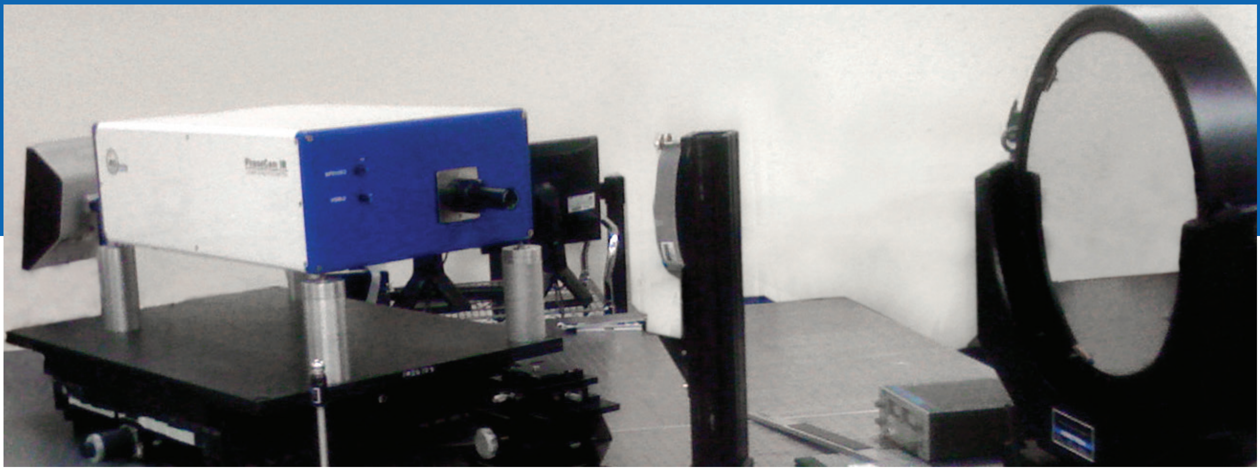
Get the surface and wavefront data you need for IR systems, with highest precision, versatility, and ease of use. Only 4D offers dynamic IR interferometry for fast, accurate measurements in long paths, vibration and turbulence.

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.

info@4DTechnology.com
(520) 294-5600
www.4DTechnology.com

Measure infrared optical systems faster and better than ever



An infra-red PhaseCam Twyman-Green interferometer in an off-axis parabolic measurement is installed at a customer's lab and gets its first measurements.

Download the data sheets:

Click here for the
Infrared interferometer
Data Sheets

IR FIZEAUS:
High performance, quality and value for accurate, repeatable measurement at infrared wavelengths. Laser sources wavelengths from 1.55 µm through 10.6 µm enable measurement of IR components and systems at their functional wavelength, as well as measurement of rough polished optics. Internal optics and accessories to match. Near Infra-Red (NIR) wavelengths are available as well, including 1.053 and 1.064 µm.

IR TWYMAN-GREEN INTERFEROMETERS:
PhaseCam IR systems employ Dynamic Interferometry® to acquire measurement data in less than 1 millisecond. Because acquisition time is so short, the instruments can measure accurately despite vibration and air 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.

info@4DTechnology.com
(520) 294-5600
www.4DTechnology.com

4D Technology
An Onto Innovation Subsidiary