

Optical Gaging Products, Inc. Laser Measurement Options

Understanding laser measurement

A white paper prepared by:
Chris Leone, ASQ CQE
Lab Manager



4895 Joliet Street, Unit 7D
Denver, CO 80239-2525
Phone: 303-371-6818
Fax: 303-371-6919
www.actdenver.com

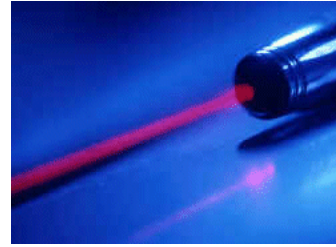
Revision 2 – December 15, 2008

Table of Contents

| | |
|--|----|
| What is a laser? | 3 |
| How can lasers be used? | 3 |
| What makes one laser different from another? | 3 |
| How can a laser be used to measure? | 4 |
| Which type of laser sensors does OGP use? | 4 |
| Laser Sensor Terminology | 5 |
| Does the finish of the surface I want to measure matter? | 6 |
| Does “spot size” matter? | 6 |
| How does laser triangulation work? | 7 |
| How does laser interferometry work? | 8 |
| OGP DRS Laser Sensor | 9 |
| OGP SmartScope Flash TTL Laser Sensor | 10 |
| OGP SmartScope ZIP TTL Laser Sensor | 11 |
| OGP SmartScope Quest TTL Laser Sensor | 12 |

What is a laser?

The word laser is an acronym that stands for: **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. A laser is defined as any of several devices that emit highly amplified and coherent radiation of one or more discrete frequencies.



How can lasers be used?

Lasers are used in hundreds of different applications:

- Commercial: holograms, barcodes, light show
- Communications: fiber optics
- Health & Medical: eye surgery, dentistry, skin treatment
- Home Electronics: DVD, CD, CD-ROM
- Industrial: cutting, welding, heating, alignment
- Measurement & Metrology: range sensing, surveying
- Military Weaponry: targeting, designating

What makes one laser different from another?

Laser radiation can be created using different methods:

- Gas
- Diode
- Semiconductors

Lasers come in different strengths; this power rating is stated in milliwatts (mW). They also come in a variety of different wavelengths, which is expressed in nanometers (nm). The Center for Devices and Radiological Health (CDRH) has assigned all commercial lasers to a class based on strength. Here are the different classes and some examples of their use:

- Class I – CD/DVD player
- Class IIa – Barcode scanner
- Class II – OGP triangulation laser range sensors
- Class IIIa – Laser pointers
- Class IIIb – Laser light show
- Class IV – Surgery

How can a laser be used to measure?

There are many different types of laser range sensors:

- Confocal
- Interferometric
- Null (Foucault, knife-edge, pinhole)
- Triangulation

All laser range sensors work by producing laser light from an emitter, focusing on a surface, and analyzing the light reflected back to a sensor. The method used to analyze the reflected light distinguishes one sensor type from another. This analysis can be performed a number of different ways:

- Displacement
- Interferometry
- Time of flight (TOF)

Which type of laser sensors does OGP use?

OGP offers two different families of laser sensors: off-axis DRS (Dynamic Range Sensor) and TTL (Through the Lens).

The Flash TTL, ZIP TTL, and DRS laser sensors have the following attributes in common:

- Source: Gallium Aluminum Arsenide (GaAlAs) Diode
- Detector: CCD (Displacement)
- Configuration: Triangulation
- CDRH rating: Class II
- Power: 1.0 mW max
- Wavelength: 670 nm



The Quest TTL laser sensor has the following attributes:

- Configuration: Interferometric
- CDRH rating: Class II
- Power: 1.2 mW max
- Wavelength: 650-875 nm

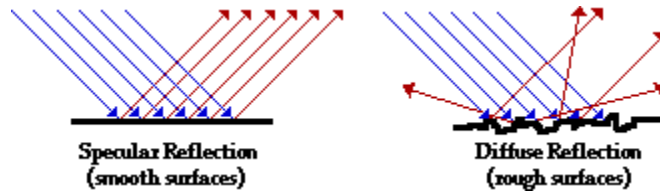


Laser Sensor Terminology

- **Accuracy** – The combination of uncertainties that come from both the dynamic resolution of the laser sensor and the movement of the stage. For example the accuracy specification of an OGP SmartScope Flash 200 with the TTL laser and the 5.0x objective is $2.0 + 6L/1000$. This equation contains a dynamic resolution component (2.0) and the uncertainty contributed by Z-axis movement ($6L/1000$).
- **Capture Range** – The Z-range over which there is no uncertainty about which direction the surface lies, but a portion of which may be non-linear and un-calibrated.
- **Dynamic Resolution** – The smallest detectable change in height when the sensor is moved horizontally over a NIST traceable step gage of known height without moving the sensor in the Z-axis. This value is independent of capture range but includes any unintentional Z-axis movement based on temperature or other physical variations.
- **Measuring Range** – The Z-range over which the performance of the sensor is linear and calibrated. The measuring range lies within the capture range.
- **Spot Size** – The diameter of the laser spot at the standoff.
- **Standoff** – The distance from the sensor housing to the center of the measuring range
- **Triangulation Angle** – The angle between the laser beam and the sensor viewing axis. The term does not apply to an interferometric based laser sensor such as the Quest TTL.
- **Working Distance** – The clearance between the optics (TTL lasers) or the laser sensor (DRS lasers) and the part.

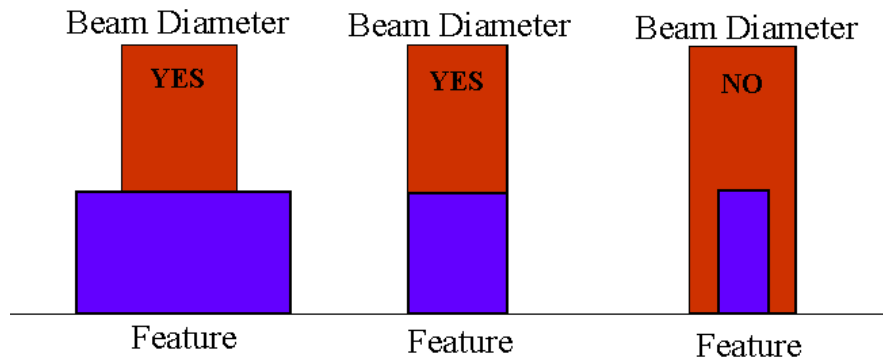
Does the finish of the surface I want to measure matter?

When a laser is reflected off a surface the light is returned in two components: a diffuse component and specular component. With a shiny or mirror like surface the reflection is mostly specular. While with dull or rough surfaces the reflection is mostly diffuse. OGP offers laser sensors for both types of surfaces.

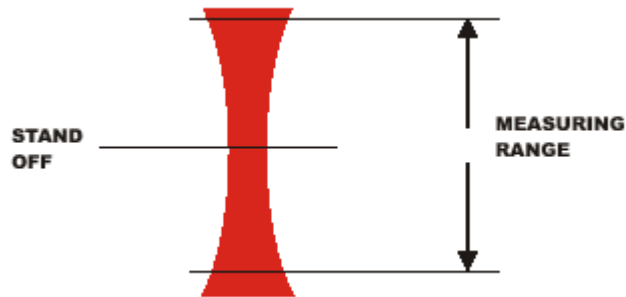


Does “spot size” matter?

The diameter of the beam (also known as the spot size) does matter. The spot size can be no larger than the feature to be measured. A good rule of thumb is that the spot size must be less than one-tenth the size of the smallest feature to be measured.

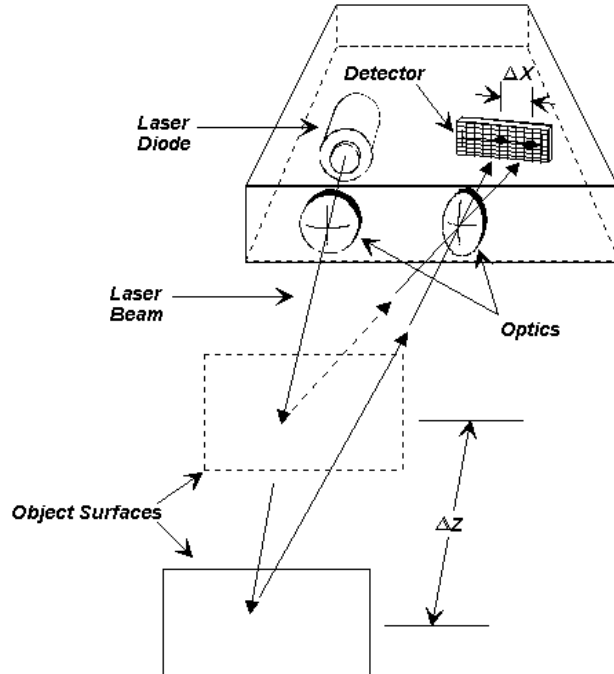


Triangulation sensors are designed to focus the laser beam to create the smallest spot at the sensor standoff distance. The standoff is defined as the distance from the front of the sensor to the middle of the measuring range. This is the point where the laser spot size is specified. The size of the beam is smallest at the standoff point, but it is larger both inside and outside this point. So, the sensor with the smallest spot size will also have the smallest standoff and working range.

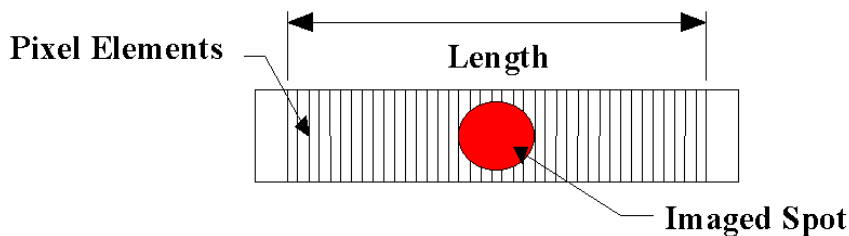


How does laser triangulation work?

Laser triangulation sensors determine height by analyzing reflected light using the principle of displacement. The sensor's laser diode projects a beam of light onto the target object. Some of the light is reflected off the object onto a light-sensitive detector built into the sensor. The detector records the position of the reflected beam and reports a height measurement. If the target or the sensor moves, the position of the reflection on the detector changes (ΔX). The sensor calculates the amount of change (ΔZ) based on the new spot position on the detector.

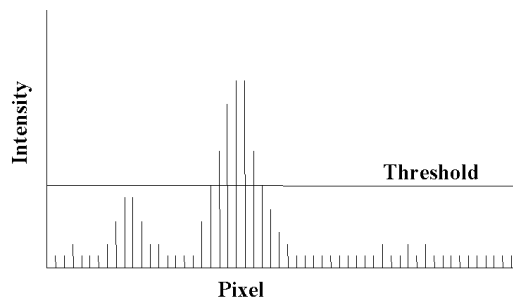


The CCD detector consists of a row of discrete photodetectors, referred to as pixels. When the reflected light hits the detector the sensors electronics determine the center of the imaged spot by looking at the intensity of each pixel. One of the advantages of this type of detector is the ability to set a threshold. A threshold is a moveable limit below which extraneous information, or noise, can be ignored. The detector can also be set to ignore a condition known as multiple spots. This condition arises when a surface reflection, or other light source, creates a second center on the sensor.



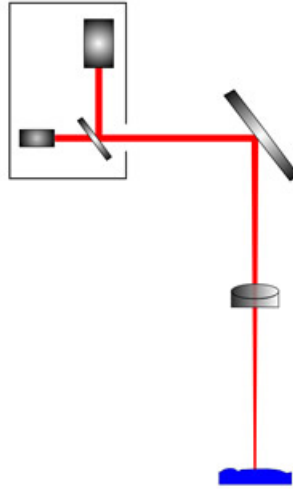
This condition arises when a surface reflection, or other light source, creates a second center on the sensor.

surface reflection, or other light source, creates a second center on the sensor.



How does laser interferometry work?

OGP interferometric laser sensors use a patented and proprietary technology by which the emitted laser light is split into two coherent beams. One beam is used as a reference and the other is sent to the part surface.



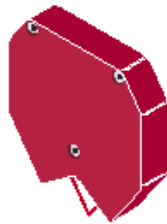
Using interferometry (the technique of superimposing, or interfering, two or more waves, to detect differences between them) the signal returned from the part is compared to the reference signal and a distance is determined.

OGP DRS Laser Sensor

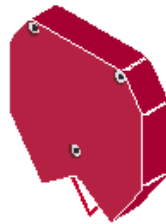
Adding an OGP DRS™ (Digital Range Sensor) laser sensor to your OGP SmartScope Flash, ZIP, or Quest provides non-contact, high resolution surface profiles through sophisticated laser triangulation. Both linear and area scans are easily programmed into automatic measurement routines for accurate measurement of surface contours.



A variety of DRS laser sensors are available, each with its own unique capture range, standoff distance, and resolution. On most SmartScope models, the DRS laser sensor is deployable and retractable under program control for uninterrupted, unattended measurement.



DRS-300



DRS-500



DRS-2000

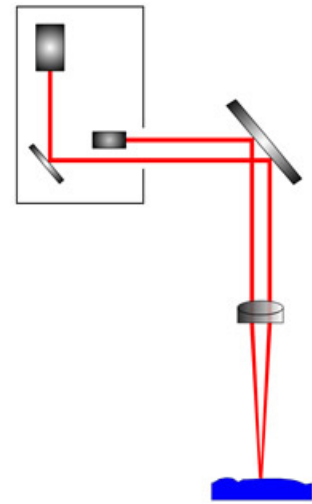
| Available for | OGP SmartScope Flash, ZIP, and Quest | | |
|--|--------------------------------------|---------------------|---------------------|
| Type of surface | Any | Any | Diffuse only |
| Capture Range | 300 μm | 500 μm | 2000 μm |
| Z Accuracy within Capture Range | 1.0 μm | 1.0 μm | 10 μm |
| Dynamic Resolution | 0.125 μm | 0.125 μm | 1.0 μm |
| Standoff Distance | 17 mm | 17 mm | 31.5 mm |
| Triangulation Angle | 70° | 70° | 35° |
| Spot Size | 7-12 μm | 16-23 μm | 32-48 μm |

Specification subject to change without notice

OGP SmartScope Flash TTL Laser Sensor

The Flash TTL laser is designed exclusively for OGP SmartScope Flash optical systems. This non-contact point sensor can focus its light very precisely, providing a small spot size and extremely accurate surface focus. With a working distance as large as 38 mm the Flash TTL laser sensor provides a comfortable clearance between optics and part.

TTL laser light is projected through the imaging optics to the surface being measured. The light is reflected from the part surface, through the lens, into a dedicated detector. The steep imaging angle of TTL laser provides access to surface features that are recessed or located adjacent to vertical surfaces.



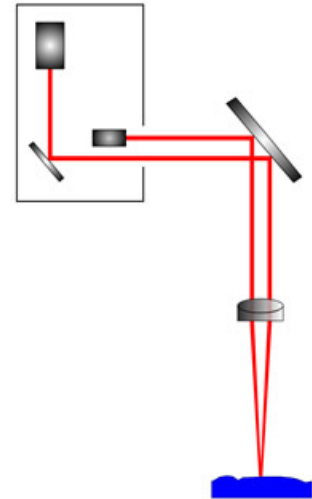
| Available for | OGP SmartScope Flash systems | |
|----------------------------|------------------------------|-------------------------|
| Replacement Lens | 2x (Standard) | 5x (Optional) |
| Working Distance | 38 mm | 19 mm |
| Measuring Range | 500 μm | 80 μm |
| Triangulation Angle | 14° | 35° |
| Capture Range | ± 3 mm | ± 400 μm |
| Spot Size | 8x6 μm | 3x1.2 μm |
| Resolution | 0.4 μm | 0.4 μm |

Specification subject to change without notice

OGP SmartScope ZIP TTL Laser Sensor

The ZIP TTL laser is designed exclusively for OGP SmartScope ZIP Zoom 70 optical systems. The ZIP TTL laser sensor supports two modes of operation, depending on the kind of parts being measured. Choose high throughput, with large working distance and measuring range, or high resolution for verifying tighter tolerances.

This non-contact point sensor can focus its light very precisely, providing a small spot size and extremely accurate surface focus. It offers a working distance as large as 38 mm – large enough to focus on part surfaces that are recessed.

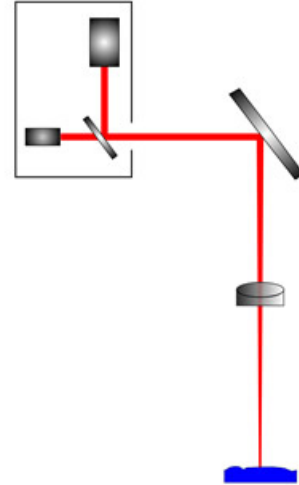


| Available for | Any new OGP SmartScope ZIP 250 or 300 system | | | |
|---|--|--------------------|-------------------------|-------------------------|
| Replacement Lens (TTL Laser Switch Position) | 2x (Standard) | | 5x (Optional) | |
| | (High Speed) | (High Res.) | (High Speed) | (High Res.) |
| Working Distance | 38 mm | 38 mm | 19 mm | 19 mm |
| Measuring Range | 500 μm | 10 μm | 80 μm | 4 μm |
| Triangulation Angle | 14° | 14° | 35° | 35° |
| Capture Range | ± 3 mm | ± 1.2 mm | ± 400 μm | ± 170 μm |
| Spot Size | 8x6 μm | 8x6 μm | 3x1.2 μm | 3x1.2 μm |
| Resolution | 0.4 μm | 0.25 μm | 0.4 μm | 0.25 μm |

Specification subject to change without notice

OGP SmartScope Quest TTL Laser Sensor

The innovative Quest TTL laser sensor is available exclusively for the TeleStar metrology zoom lens in the OGP SmartScope Quest family of systems. Its unique interferometric sensing technology yields high measurement resolution. Its through-the-lens, coincident optical path design eliminates the potential for blocking a light beam as is possible with triangulation lasers. Its long working distance allows it to measure surfaces not accessible to other sensors and with less risk of contacting the part or fixture when scanning.



The Quest TTL laser sensor is ideal for measuring diffuse “scattering” surfaces and machined metal parts.

| Available for | OGP SmartScope Quest & Specialist systems | | |
|-------------------------|---|-----------------------|-----------------------|
| Laser Lens | 1x (Standard) | 0.5x (Optional) | 0.45x (Optional) |
| Working Distance | 68 mm (nominal) | 130 mm (nominal) | 200 mm (nominal) |
| Measuring Range | 800 μm | 1400 μm | 2000 μm |
| Capture Range | 800 μm | 1400 μm | 2000 μm |
| Spot Size | 5x8 μm | 7x13 μm | 12x20 μm |
| Resolution | 0.2 μm | 0.3 μm | 0.5 μm |
| Accuracy* | $\pm 0.5 \mu\text{m}$ | $\pm 1.5 \mu\text{m}$ | $\pm 2.5 \mu\text{m}$ |

* Using high quality, specular surface, 2σ
Specification subject to change without notice