Intellium™ SBSI Overview

The Small Beam Shearing Interferometer (SBSI) is used for wavefront and collimation testing of beams 1 to 8 mm diameter over wavelengths from 180 nm to 1700 nm.

Main Features & Benefits

- Measure collimation to better than 100-300 micro radians (wavelength dependent)
- Wavelengths from 180-1700 nm
- Small beam probe allows measurement between optical components
- Simple operation reduces alignment time to minutes
- Three models available: fluorescent screen, camera, and 8x zoom systems

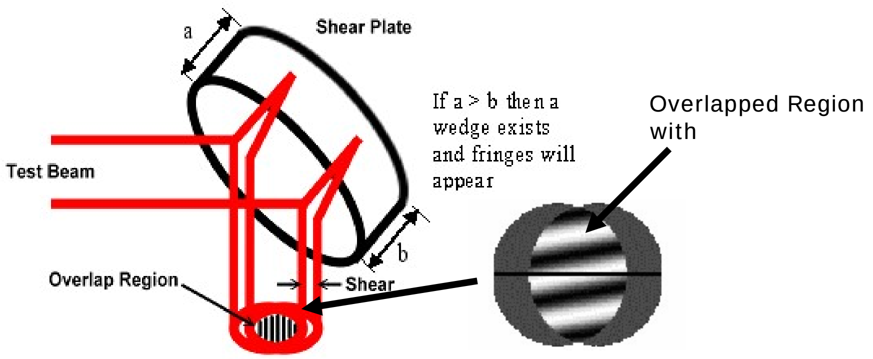


Figure 2: Example of a single plat shearing interferometer

Shearing Interferometry

Shearing a beam involves splitting a single beam into two beams laterally - such that the two beams overlap anywhere from 50% to 95% (see Figure at right). In the overlapped region interference fringes will appear. These fringes can be used to analyze the actual wavefront of the initial beam.

There are problems associated with shearing small beams.

1. Normal single shear plate designs do not work because the shear plate thickness becomes too thin. These thin plates cannot be made in a cost effective manner while maintaining wavefront quality.

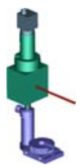
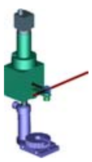
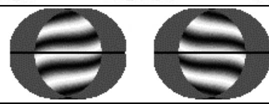
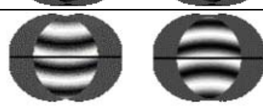
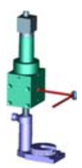
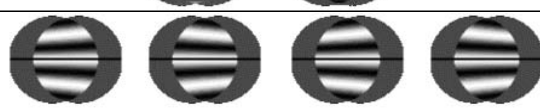
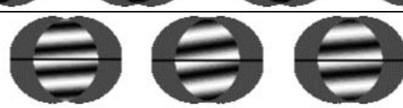
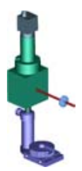
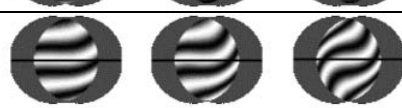
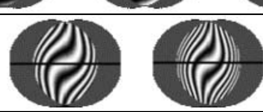
2. There are dual plate designs, where the beam is sheared by a gap between the back surface of one plate and the front surface of a second plate. Typical dual plate designs do not work with small beams, because there is interference from the front and back surfaces of both plates. This means there are four beams interfering, which gives a complex wavefront that cannot be used. Also, the spacing between the plates has to be tightly controlled and maintained to within tens of microns.

The SBSI ™ Solution

The SBSI patented technology allows it to solve all the problems above. The SBSI utilizes proprietary dual technology to eliminate two of the four undesired reflections from a typical dual plate design. The SBSI patented technique allows it to maintain a precise gap spacing in harsh vibration and temperature environments while being able to adjust this spacing during manufacturing to optimize measurement sensitivity to the customers desired beam diameter and wavelength.

Interpreting Sheared Interferograms

Interferograms from a shearing interferometer represent the slope of the actual wavefront in the direction of shear. If the input beam is sheared in the x-direction, then the slope phase map is associated with the x-direction. To get the actual wavefront, it must be integrated over the entire image. For many applications this is not necessary. Simply viewing the slope-fringes allows the user to diagnose the wavefront and if required determine some action to correct it. For example, if the fringes are rotated relative to the shear direction (a reference line is provided) then the beam is not collimated (defocus aberration). By collimating the beam, the fringes will rotate and become parallel to the reference line. U-shaped fringes represent coma aberration, and S-shaped fringes represent spherical aberration. Astigmatism is simply defocus in a single direction, and since the SBSI shears in only one direction, the instrument or beam must be rotated 90 degrees to differentiate astigmatism from defocus. The table below shows interferograms with various amounts of aberration (right). The next table shows SBSI configurations.

	**Laser Beam Diagnostics**	***Intellium™ SBSI* Images** Computer-generated images shown below simulate the ***Intellium™ SBSI*** display and illustrate the sensitivity of the ***Intellium™ SBSI*** to various aberrations in a beam.	
			From left to right: no aberrations (perfect focus), .25 waves of defocus (diverging beam), and -.25 waves defocus (converging beam).
	**In line Beam Monitoring**		.25 waves of spherical and -.25 waves of spherical.
			.25 waves of coma at 0° and -.25 waves of coma at 0°.
	**Surface Diagnostics**		-.25 waves of coma at 90°, .25 waves of coma at -90°, -.25 waves of coma at -90°, and .25 waves of coma at 90°.
			.25 waves of astigmatism at -45°, .25 waves of astigmatism at 0°, .25 waves of astigmatism at 22.5°.
	**Lens Diagnostics**		.25 waves coma and .25 waves spherical at 0°, .5 waves coma and .5 waves spherical at 0°, and 1 wave of spherical.
			3 waves of spherical and 5 waves of spherical.

Achieving Best Sensitivity

How the SBSI sensitivity is optimized for wavelength and beam diameter.

What is Sensitivity?

Sensitivity is the ability of the SBSI to detect changes in the collimation or aberrations of the input beam. If the sensitivity is too low, changes in the beam wavefront will not affect fringes on the SBSI view screen. Perfect sensitivity cannot be achieved due to the requirements of balancing a set of design variables.

How to Achieve the Best Sensitivity

1. Setting the *wedge* amount (angle between front and back surfaces of the plate in Figure 3A) is a function of the desired *wavelength* and *sensitivity*.
2. If the *wedge* (Figure 3A) is constant, then the number of fringes decreases as *wavelength* increases.
3. If the *wavelength* is constant, then *sensitivity* decreases as *wedge* increases.
4. The *shear distance* is the *ratio* (*d/D*) of the sheared beam and the original beam (see Figure 3B).
5. The *shear distance* is set as a function of *beam diameter* and desired *sensitivity*.
6. If *shear distance* increases, the instrument *sensitivity* increases, but the sheared beam becomes smaller.
7. To optimize instrument sensitivity, the *wedge* must be *minimized*, and the *shear distance* is *maximized*.
8. The *wedge* and *shear distance* are optimized to give the best balance of instrument *sensitivity*, *sheared beam size*, and *visual detection of fringes*.
9. If the SBSI is used for more than one *wavelength* or *beam diameter*, then the balance in Item 8 above becomes more difficult to achieve.
10. For a single wavelength and beam diameter, the optimum SBSI *wedge is set for 3.5 fringes*, and the *shear ratio is set to 25%*.
11. For multiple wavelengths, a maximum of 33% difference between the wavelengths is recommended.
12. For multiple beam diameters, a maximum of 33% difference between the diameters is recommended.
13. ESDI sets all the parameters above during production based on the customer's beam specifications.

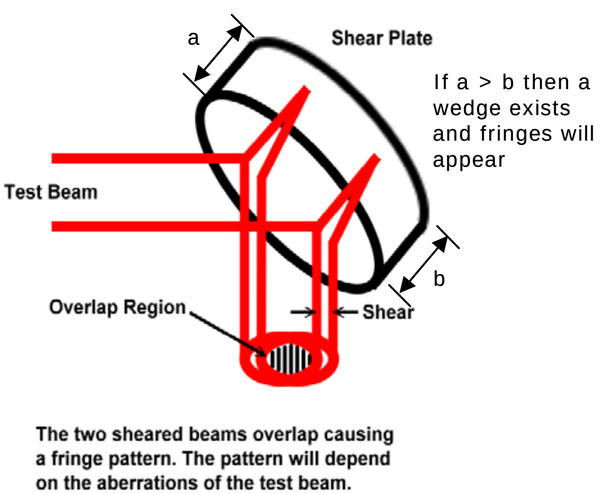


Figure 3A: A simple shear plate explaining how some shearing interferometers work.

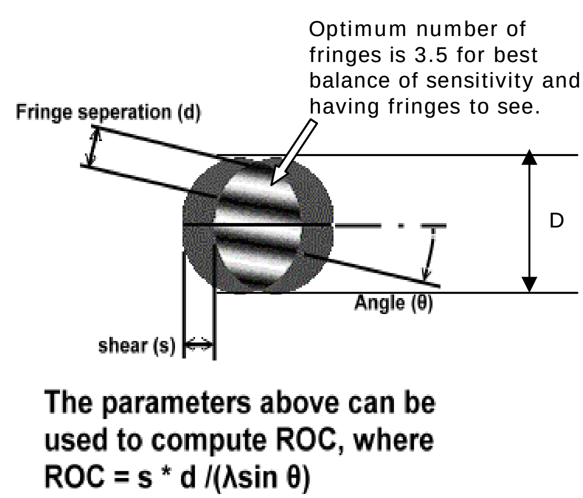


Figure 3B: Interferograms generated from a shearing interferometer.

Typical SBSI ™ Questions

1) Can SBSI be used for 405 and 605nm?

Yes, but there will be some compromise.
An SBSI is optimized for the wavelength by adjusting the wedge for 3.5 fringes (when collimated).
Around 3.5 fringes give the best *sensitivity* for collimation and ROC measurements.

CASE 1: If we optimize for 405 nm, then there will be:
 3.5 fringes at 405 nm
 2.3 fringes at 605 nm

CASE 2: If we optimize for 605 nm, then there will be:
 5.2 fringes at 405 nm
 3.5 fringes at 605 nm

In Case 1, there are only 2.3 fringes at 605 nm. So visualization (seeing fringes) will be more difficult than Case 2 at 605 nm.

In Case 2, there are 5.2 fringes at 405 nm. So collimation *sensitivity* is 33% less than optimum (at 3.5 fringes).

2) Can SBSI be used for 3 to 5 mm?

Yes, but again there are a few compromises.
Your best option is to optimize for 4 mm.

The compromise is because the *shear ratio* is different at each beam diameter.
The *shear ratio* (SR) = s / (2 * D)
Where "*s*" is the shear distance and "*D*" is the original beam diameter as shown in Figure 3B.

The cases below, assume optimization for a 4 mm beam.

CASE 1: 4 mm beam
 SR is 25% (this is the optimum ratio)

CASE 2: 3 mm beam
 SR = 25 * 4/3 = 33%
 The *shear ratio* is now 33%, which means the fringe area is smaller and more difficult to see.

CASE 3: 5 mm beam
 SR = 25 * 4/5 = 20%
 The *shear ratio* is now 20%, which means the sensitivity is 20% ([1-[20/25]]*100) less than if we optimized for 5 mm with a 25% shear.

3) Other Wavelengths and Beam Diameters

You can use the above examples, to determine the compromises made for any set of *beam sizes* or *wavelengths*.