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LASER BEAM PRODUCTS

CO_2 Laser Reflective Mirrors:

Quality

Interferometry

The specifications of most optical surfaces involve sub micrometer dimensions, too small to measure mechanically. Interferometry uses laser light to generate interference patterns that can be interpreted to measure the flatness, curvature, or angle of optical surfaces as well as other properties.

For the majority of mirrors a Fizeau interferometer is used for quality assurance. With software analysis of the interference pattern, a hard copy of the results is available to customers. This demonstrates that surface form specifications such as power and irregularity have been met. This measurement of the spacing and curvature of the black and white lines (or "fringe pattern") can be used to calculate the optical properties of the surface under test. It is also useful to measure and align optical assemblies with an interferometer.

Of great interest has been investigating the mounting of optics and observing the deformation that can occur with poorly designed mounts or excessive mechanical force.

Laser Beam Products can supply mirrors complete with mounts and water connections checked by interferometer that the assembled mirror has not been deformed.

Polishing

The surface quality of a polished optic far exceeds anything even the very best diamond machining can offer. Where surface quality is important, many diamond machined optics are "post polished" to improve them.

With a polished optic there are no cutting arcs, target patterns or chatter marks that are so easily visible on the surface of a diamond machined optic. These unwanted surface faults can initiate laser damage, and cause diffraction of the laser beam. In some cases the diffraction and scatter of diamond machined optics is so great a visible alignment beam is completely lost after reflecting off a few mirrors. Sometimes a spike of metal can be left in the center of the mirror due to poor machining.

Laser Beam Products has taken the performance of the conventional polishing of metals even further by developing the chemical polishing of metals. Chemical polishing relies on chemical reactions rather than fine abrasion to leave a flaw free, smooth surface.

Many laser companies are aware of the importance of surface quality and specify surface roughness as Ra (an average roughness) or Rrms (a root mean square). By both measurements Laser Beam Products offer the smoothest metal surfaces available.

	Ra	RrMS	Laser Damage Threshold
Laser Beam Products	1-3nm	<5nm	>40Jcm2
Diamond Machined	5-25nm	7-35nm	<10Jcm2

Calorimetry

With high power lasers any part of the beam that is absorbed by an optic will cause that element to heat up. No mirror is 100% Reflective, and no lens is 100% Transmissive. The power not transmitted or reflected is absorbed. (Scattering is negligible at infrared wavelengths)

Metal mirrors are particularly rugged; 1% absorption (i.e. 99% reflective) is perfectly acceptable even with 25KW lasers. Zinc Selenide components such as lenses and output windows are much more sensitive; 0.2% (just 2 parts per thousand) absorption can cause optical distortion or catastrophic failure.

This critical specification of a laser optic is not easy to measure, requiring a "calorimeter". The optic under test, which could be a mirror, lens, output couple or beam splitter is exposed to a stablized and accurately known laser power. The test optics rate of heating is measured continuously for a minute or two. The test optics rate of cooling is also measured to allow for correction of the heating rate. Then by simply knowing the mass and heat capacity of the test optic the amount of power absorbed can be calculated.

LBP's calorimeter uses a 150Watt CO_2 laser and a 20 bit A/D PC controlled data logger. This automates the measurement process, and produces a hard copy of the absorption measurement.

Laser Damage

LBP in partnership with UK and European Universities has investigated the causes of Laser Damage and measured the Laser Induced Damage Threshold (LIDT) of many CO_2 laser optics.

This work has been published by SPIE:
Proc. SPIE Vol. 3244, p. 188-198, Laser-Induced Damage in Optical Materials: 1997, Gregory J. Exarhos; Arthur H. Guenther; Mark R. Kozlowski; M. J. Soileau; Eds.
Proc. SPIE Vol. 2714, p. 281-281, 27th Annual Boulder Damage Symposium: Laser-Induced Damage in Optical Materials: 1995, Harold E. Bennett; Arthur H. Guenther; Mark R. Kozlowski; Brian E. Newnam; M. J. Soileau; Eds.

The most important result is that Copper mirrors and ZnSe lenses in a typical industrial laser operate well within their Laser Damage Threshold. The reason(s) optics fail is entirely due to external factors from their operating environment. In particular,mechanical forces from mounting, clamping, etc significantly reduce the lifetimes of ZnSe lenses. Increased absorption from external contamination can quickly lead to laser damage. The difference between a good lens and a poor lens can be an increase in absorption of just 1 part per thousand.

Fortunately, the situation with copper mirrors is more forgiving as their ability to "sink" heat is so much better. Gold coated copper mirrors are used on lasers of 40 KW power, and for 5 KW and above copper mirrors are the only realistic choice. Such a large power handling ability means that even when damaged or dirty, copper mirrors continue working with high power lasers.

For a laser with a 20mm beam diameter copper mirrors work at just a fraction of their potential:

Working power of copper mirrors				
Laser Power	2KW	4KW	5KW	20KW
Fraction of Laser Damage Threshold	2%	5%	6%	25%