TN2016-02: Surface Cosmetics of Laser Optics

The surface of optical components plays an integral part in their overall performance as scratches and digs on an optical surface not only increase scatter losses. They can also significantly reduce the coating adhesion as well as reducing the laser-induced damage threshold (LIDT) of a coating.

Therefore, especially when optical components are required to withstand high laser power, a cosmetically suitable substrate surface is essential. The surface standards (MIL and ISO) dealing with surface cosmetics date back to times before the development of powerful lasers and still contain a 'human element', relating to the 'visual appearance' of a surface defect. By comparison, interferometric measurements to determine the surface flatness do no longer rely on the manual evaluation of interference fringes.

The surface cosmetics of optical components is defined in ISO 10110-7 and MIL-PRF-13830B. For catalogue optics the MIL specification is most commonly used, though Manx Precision Optics works according to both ISO and MIL specifications, depending on the customer requirement.

The MIL specification defines the surface cleanliness as 'scratch-dig', two dimensionless numbers relating to the visual appearance of the size of scratches and digs when compared to a reference sample. For example, a typical scratch-dig specification for high power laser applications is '10-5', while consumer optics are often specified as '60-40'.

The following two tables illustrate the permissible scratch and dig denominations in more detail:

Scratch denomination	maximum width in mm	maximum width in inches
80	0.08	0.0031
60	0.06	0.0024
40	0.04	0.0016
20	0.02	0.0008
10	0.01	0.0004
5	0.005	0.0002

The total length of all scratches of maximum size must not exceed 25% of the diameter of the clear aperture.

Dig denomination	maximum diameter in mm	maximum diameter in inches
50	0.50	0.020
40	0.40	0.016
30	0.30	0.012
20	0.20	0.008
10	0.10	0.004
5	0.05	0.002

The sum of the diameter of all digs must not be greater than twice the diameter of the size of the maximum dig size.

The relevant inspection methods require an inspection using either a 40W incandescent light source to illuminate the component from behind or a 15W cool white fluorescent light approx. 3" from the component. The component is inspected against a black background.

While this is a useful method, it can be improved where a very high surface cleanliness is required and the 40W standard light source does not show up smaller defects sufficiently. This is, for example, important when manufacturing optical components for fibre lasers.

As the table above shows, a size 5 dig is permissible to have a diameter of 50µm. If a powerful laser beam with less than 1mm beam diameter was to hit such a dig, the optical coating would most likely be damaged. Hence, it is important to improve the surface cleanliness even further.

For this reason, all optics at MPO are inspected against a black background, illuminating the optics from the back, but instead of using a 40W incandescent light source MPO uses a 50W halogen light source. This makes a huge difference as many optics passing the 'standard' 10-5 scratch-dig requirement would easily fail this much more rigorous inspection. MPO refers to this much more stringent inspection method as '10-5 scratch dig laser grade'.

With MPO being a manufacturer of high end, high-LIDT optical components, this is the general standard that is applied to our optical components to ensure that they can be used in the world's most powerful laser systems.

For further information, please do not hesitate to contact us.
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