

The Cleaning of Optics:

An Overview

1. A brief overview

Throughout manufacturing, an optic must be frequently cleaned to ensure it is free from dust and other contaminants throughout. Dust contamination can affect the polishing process by causing scratches on the optics. While dust contamination during the coating process can lead to inclusions in the optical coating, thereby rendering an expensive optical component worthless.

Cleaning takes place at multiple points during fabrication, often before and after key processes. It is important to keep in mind that once a product reaches a customer it should be handled with great care and kept clean to ensure optimal functionality. This is even more critical in the case of high LIDT components as even a small amount of dust can scatter laser light and drastically reduce LIDT, risking irreversible damage to the part.

MPO's coatings come in two classifications with regards to handling and cleaning: durable and ultra-hard. Durable coatings correspond to some protected metal or fluoride-based coatings, and ultrahard coatings are fully dielectric, but also include specific metal and metal-hybrid coatings. For a durable coating, dust should be removed from the surface by gently blowing with Nitrogen or other inert gas. Wiping may damage the coated surface. An ultrahard coated surface may be wiped clean with lint free tissue, dampened with pure methanol or Isopropanol. Care should be taken, although moderate pressure may be applied when cleaning ultrahard coating.

2. Cleanrooms

Under the open sky, a typical cubic metre of air contains 30 - 40 million dust particles of 0.5mm diameter or larger. It becomes immediately apparent that such an environment is unacceptable for the manufacture of precision optics. Hence, an environment needs to be created that reduces dust contamination to a suitable level. Any reader who has visited a semiconductor manufacturing plant cannot fail to be impressed by the extensive cleanroom facilities that such factories have. In general, a cleanroom can be described as an environment with a low level of pollutants.

ISO14644-1 is an international standard that defines nine classes of cleanrooms, with class 1 being the highest and class 9 the lowest standard. The standard defines the number of particles per size allowed within one cubic metre of air. While many newer specifications refer to ISO14644-1 when specifying a manufacturing or packaging requirement, older drawings often refer to an old US standard (US FED STD 209E) which was cancelled in 2001. To allow cross-referencing, table 1 below lists the equivalent of the old US standard in relation to the ISO standard.

Iso Class Number	Maximum allowable concentrations (particles/m ³)						FED STD 209E equivalent
	0.1µm	0.2µm	0.3µm	0.5µm	1µm	5µm	
1	10						
2	100	24	10				
3	1'000	237	102	35			Class 1
4	10'000	2'370	1'020	352	83		Class 10
5	100'000	23'700	10'200	3'520	832		Class 100
6	1'000'000	237'000	102'000	35'200	8'320	293	Class 1000
7				352'000	83'200	2'930	Class 10000
8				3'520'000	832'000	29'300	Class 100000
9				35'200'000	8'320'000	293'000	Room Air

Figure 1: An example of microscopic laser damage morphology. Fluence 0.372 J/cm², damage after 933 pulse(s).

Most coating chambers are single door chambers, which means that they get loaded and unloaded through the same door. This requires cleaning to be done from the room where the coating chamber is situated and loaded/unloaded.

The protective shields inside a coating chamber get coated during the normal production process and therefore require regular removal and cleaning. During the removal it is unavoidable for coating particles to flake off the shield surfaces and increase the dust contamination inside the coating department. Hence, care must be taken to avoid contamination of other parts of the department.

For this purpose, optics are cleaned and stored within the department in laminar flow cabinets. These are enclosed benches, where air is drawn in through a particle filter (generally situated above the bench or behind it) and blown towards the user in a smooth, laminar flow (vertical or horizontal, depending on type of cabinet). Typically, laminar flow cabinets are available in cleanroom classes of ISO 4 or ISO 5. When operating laminar flow cabinets, it is important to follow the manufacturer's requirements on maintenance. These usually ensure that the filter and air intake seals are regularly checked and that the filters are cleaned/changed at regular intervals to maintain the required cleanliness standard.

In practice, a critical interface is the process of loading the optics into the coating chamber prior to coating. During this process, the optics are being removed from the laminar flow cabinet and positioned into their respective positions in the calotte within the coating chamber. To minimise the risk of dust settling on the optics surface and then getting embedded in the coating during the coating process, it is important that particular care is taken during this step. The optics need to be transported in an enclosed box and the surfaces protected by caps, which are only removed immediately prior to closing the coating chamber door and putting the chamber under vacuum.

During the cleaning of the optics, which will be covered in a separate technical note, it is important that the correct materials such as lint free cleaning tissue and chemically pure cleaning solvents are being used. A thorough inspection of a cleaned optic, usually under a bright halogen light against a black background, is vital.

References

BS EN ISO 14644-1:2015, Cleanrooms and associated controlled environments, Classification of air cleanliness by particle concentration, ISBN 0 9267107062
Fabrication Methods for Precision Optics, H. H. Karow, Wiley Series in Pure and Applied Optics, John Wiley & Sons, Inc (1993)