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Optic Cleaning Manual

Zinc Selenide (ZnSe) Lenses & Contamination

Zinc Selenide is a relatively soft compared with other optical materials. Consequently, great care should be made in handling and cleaning the lenses. Incorrect cleaning can lead to surface damage that in turn will reduce the component lifetime. Zinc Selenide lenses should receive the same amount of care as an expensive camera lens, perhaps even more so, because camera lenses do not have to cope with several kilowatts of power!

Surface contamination can be considered in three broad classes:
1. Contamination from the laser process i.e. burned-in particles of back-spatter.
2. Dust, grease and contamination by air-borne particles.
3. Human/biological stains caused by talking, coughing or sneezing near the exposed surfaces.
The cleaning techniques described later are intended to minimize surface damage and prolong the lifetime of the lens.

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Contamination from the Laser Process

Some forms of back-spatter can be removed by using the cleaning techniques described later. These may be from processing plastics for example or where a dusty residue is produced. The residue from a perspex mode burn is a common contamination to find on beam expander output lenses, for example.

The processing of metals however, generally leaves burnt-in metal fragments that cannot be removed by any normal cleaning method. It is likely that any method employed to remove it will cause its own severe damage.

If the extent of the contamination is sufficient to cause process problems, then consideration should be given to replace the lens. Where back-spatter build up is more rapid than usual, you should also review the process control parameters just in case these have changed and led to less efficiency.

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Contamination from the Laser Process

Dust, Grease and Contamination by Air-borne Particles

The extent to which these affect the optics depends on the environment in which the laser is in use. A slight positive air pressure within the enclosed beam path helps to keep dust away from the optics, but is no guarantee.

The use of grease at some places in a laser system can eventually lead to the contamination of the optics. This includes the cavity optics where deposits of vacuum grease can 'bake' themselves onto the surfaces.

Human/Biological Stains

The most common example is human spittle. It tends to dry leaving small circular areas with a uniform appearance. The marks are commonly mistaken for coating damage since they are not possible to remove using the most common solvent, acetone. Stains of this sort are usually removed with distilled water/vinegar.

Cleaning Notes and Methods

1) Solvents

Those solvents you actually need will depend on the nature of the contamination. For CO2 laser optics useful solvents have generally found to be acetone, alcohol (e.g. propanol), hexane, distilled water, dilute white vinegar with a few % acidity.

SLR grade solvents are recommended.

You should also consult the relevant safety information from the solvent supplier.

The purpose of using a solvent is to dissolve the contamination so as to produce a solution that is easily soaked up. Rubbing the contamination to dislodge it without dissolving is not the ideal answer, since the solid particles are more likely to scratch the surface. Therefore, identifying a suitable solvent for the contamination present is an ideal situation. It is often a trial and error process

because the contamination itself is usually not known. The list of solvents above is a good starting point for CO2 laser optics and coatings.

2) Preparation

It is recommended that optics be removed from their mounts prior to the cleaning procedures where possible. This is particularly true if the whole optic requires cleaning. If the lens is part of a multi element optical assembly (e.g. a beam expander), then it is not a good idea to remove it; to reassemble may involve some alignment or calibration procedure the user is not familiar with.

If the optic can be removed from its mount make a note of which way round it is orientated. Also remember that it is a good idea to clean the mount itself; if the lens is dirty, the chances are that the mount is also dirty. Dust and dirt will quickly find its way back onto the lens and any pieces of grit may prevent the proper seating of the lens and in turn will cause uneven clamping and stress.

Firstly, use gloves to handle the optics. Work over a clean, clutter-free surface. Put several lens tissues on the surface in order to lay the lens on them. Never lay a lens or mirror with a convex face downward on a hard surface. The very small contact area and correspondingly high pressure will mark the surface. If you need to rest the lens with convex side down (to clean the other face) use a soft cloth folded several times to support the lens.

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3) Remove Dust with the Rubber Blower

Hold the lens by its edge and with the surface vertical while using the rubber blower. Do not let the nozzle touch the surface. If the lens is still mounted, it may be an advantage to use the blower on the surface facing downwards. Any dust blown from the surface will then drop away.
In many instances, it is likely that this is all the cleaning required. Never use shop floor air lines since these contain oil and other contaminants.

4a) Using Q-tips to Remove Contamination

Wet the cotton tip with solvent. Gently wipe the surface with the cotton tip but do not scrub. Repeat as necessary using fresh Q-tips and to finally remove any solvent marks. Use this method with any of the solvents or water/vinegar but finish with a clean Q-tip using acetone. or use the following alternative method ...

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4b) Using Lens Tissues with the Drag Method

This is a useful method to clean the whole surface but can require a bit of practice to get it correct. It cannot be used unless the optic is unmounted. Also this method may not work very well if the lens surface is too steeply curved.

Lay a lens tissue across the surface of the optic. From the dispensing bottle, squeeze out enough acetone to wet the tissue over the complete surface. Carefully drag the tissue across the surface. With some practice of dragging at the right speed, the acetone and dirt is pulled with the tissue to leave a dry, streak-free surface behind.

5) Using Q-tips with Polishing Compound

This is a last resort method! It should only be used when all the other techniques fail with all solvents.

The bottle contains a very fine polishing compound mixed with distilled water (if this is the first time you have used this, then you will need to fill up the bottle). Shake the bottle before use, holding down the cap to prevent leakage.

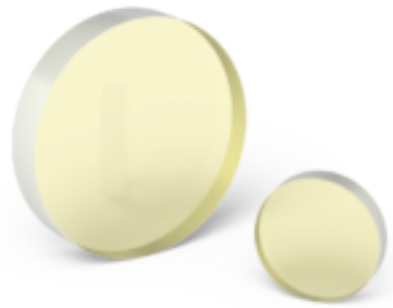
Squeeze some drops onto the cotton tip and then very gently wipe the contaminated area. *Applyingmuch pressure will scratch the lens surface and remove the coating. If this starts to happen, stop immediately.*

Do not let the compound dry on the surface. Add some drops of water if it does.

If the lens is unmounted, then to remove the polishing compound, first hold the optic vertically and squirt some distilled water over the surface and allow it to run off. This will wash away much of the compound. Use clean Q-tips with water to remove the rest. Finally, clean with acetone.
If the lens is mounted, you can only use Q-tips to wipe up the polishing compound. Finally, clean with acetone.
Give the lens an inspection. If the contamination is still present or the surface is damaged, you should consider replacing the lens.

6) Clean the Lens Edge
If your lens is unmounted, give the edge a wipe using a lens tissue and solvent.

7) Clean the Mount
Before re-installing the lens, use a lens tissue and solvent to wipe the lens mount, including threads, seals, etc. This is also a good time to clean other associated pieces of equipment, such as gas nozzles.



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Laser Damage

Thermal Lensing

Keeping a lens clean and free from scratches and digs is a good starting point to maximize its lifetime. Contamination, scratches and digs can act as sites for absorbing laser power that heat up the lens. It is inevitable that there will be a build-up of these on a lens during its lifetime and consequently a gradual increase in absorption. Eventually there may come a time when the lens 'fails to cut properly'. This is likely to be because of 'thermal lensing'; a process where the heat generated in the lens from absorption produces a temperature gradient between the center and edge. This causes the focus to shift slightly towards the lens. The correct focus setting is therefore lost whenever the laser beam passes through the lens. Sometimes it is possible to see the process occurring at the workpiece, since it takes a second or two to happen.
Whenever a lens is suspected of thermally lensing, the first thing to do is to clean it as described earlier - even if it looks clean to the eye. Of course, if there is some obvious back spatter from molten metal or a large number of scratches, then it is unlikely that cleaning will help and a new lens is the best answer.

However, it is possible to have a lens that looks clean on visual inspection and subsequently still looks the same after cleaning, but had suffered from thermal lensing before cleaning! (e.g. condensed vapour from perspex mode burns can sometimes appear invisible to the eye yet absorb greatly in the far infrared).

It is also essential to bear in mind that it does not have to be the focusing lens that is thermally lensing. It can be any lens or mirror* in your laser system. In fact, the effects of thermal lensing are usually more obvious when the laser beam is collimated. Cavity optics and beam expander lenses are examples; if these thermally lens, then the beam propagates differently to the cutting head and the result is a focus shift and/or spot size change.

* Thermal lensing of a mirror is more correctly referred to as 'thermal distortion', since the mirror surface distorts from the temperature gradient. With ZnSe lenses however, most of the effect is as the result of changes in the refractive index with temperature and less due to distortion of the lens shape.

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Stress Induced Birefringence

Another reason why a focusing lens may 'fail to cut properly' is due to stress. Such a lens can look perfectly good to the eye, but view it between crossed-polarizing sheets and you may see a fringe pattern similar to those shown here. The appearance of a fringe pattern denotes the existence of 'birefringence' within the ZnSe material - the refractive index can have two values depending on the polarization direction. Needless to say, this has a detrimental effect on the focusing properties of the lens.

The exact process by which this occurs is not certain, but is suspected to be linked to long-term exposure to a laser beam and clamping the lens too tightly in its mount. Under such situations, migration of the ZnSe crystal grain boundaries could take place. No amount of cleaning or optical reworking can repair a stressed lens, since it is the bulk material that is affected. The only solution is to replace the lens.

Catastrophic Laser Damage

If a large piece of dirt or other contamination drops onto a lens, then the sudden large rise in absorption can cause a lens to 'blow-up', leaving a burnt hole and/or cracks. The original piece of dirt was vapourized with some of the lens material, making it impossible to identify the cause. Cases of unexplained lens failure have lead, in the past, to investigations of the *intrinsic* CW laser damage threshold of ZnSe optics. That is, given a typical clean, unstressed ZnSe lens with no scratches etc, how much CO2 laser power would it take to destroy it? The answer proved to be much larger than expected; namely 3kW/mm of beam diameter (note that the units are not of intensity -
kW/mm2). In other words, it would take a 3kW beam focused down to 1mm diameter to damage the lens or a 1kW laser focused to 0.33mm and indeed a 500W laser focused to 170µm!
Normal power densities encountered are more likely to be in the range of 100 to 200W/mm (e.g. a 3kW laser with a 15mm diameter beam or 1kW with a 10mm diameter beam). Therefore sudden catastrophic damage to a lens was not because the intrinsic power limit had been reached. There had to be an external factor.

One of these external factors, as mentioned above, can be some contamination or dirt suddenly dropping onto the lens. Another, which can quickly contribute to the destruction of a lens, is mechanical stress, created by clamping the lens too tightly or unevenly.
It is known that the mechanism for the intrinsic laser damage, is itself stress, caused by the thermal gradients. If the lens is pre-stressed mechanically, then the laser power needed to reach the elastic limit is lower. Clamping stresses can easily lower the laser damage threshold to the power levels seen in laser systems.
Consequently, it is very important that lenses are only lightly clamped in their cells!