LBP Optics

Cleaning of CO_2 laser optics

Cleaning of lenses and mirrors

The principles of cleaning optical elements outlined here apply broadly to all optics, regardless of the conditions they operate under.

With an imaging system, increasing detector amplification can offset absorption of light by optical elements. With high power systems, however, that absorbed light will lead to heating of the elements and a level of distortion is inevitable as the optic changes shape, or refractive index, with temperature.

In laser processing this can have a positive feedback effect. As optical elements distort, the focussed spot or beam alignment drifts away from the predetermined conditions and process back spatter can increase, causing even more contamination and debris.

All optics from the moment of use, and occasionally in storage, will acquire a level of contamination. A cutting lens close to plastic being cut, will be contaminated with condensates and smoke that are essentially organic in nature, whereas a dental laser system will see contamination that is essentially aqueous, or watery, in its nature.

It is not realistic that a single prescriptive cleaning technique could deal with such diversity.

Few optics can be mechanically abraded or soak cleaned, so everyday cleaning is limited to wiping with a solvent and a swab.

There are several reasons for doing this:

1) **The optic is not mechanically damaged by scratching.**
2) **The optic is not chemically damaged by etching or other chemical attack.**
3) **Absorption is lowered (transmission increased) to a suitable level for a lens or window.**
4) **Absorption is lowered (reflectance increased) to a suitable level for a mirror.**

Given that physical removal of the debris or contamination by rubbing is not feasible, cleaning is reliant on the solvent dissolving the contamination, allowing the resulting solution to be soaked up and removed by the swab. The essential point here is that the solvent dissolves the contamination, resulting in a solution of dissolved dirt that can be taken away from the optics surface.

Consider an everyday example, washing car bodywork. Rock salt is obviously easily dissolved into water, but no matter how many gallons of water were used, no one would expect it to dissolve even a fleck of tar. However, a drop of paraffin results in complete removal of tar. This shows how successful the approach is of knowing the properties of the contamination, and then choosing the appropriate solvent.

The only restrictions in choosing a solvent are avoiding chemical damage to the optic and it's coating, and Health and Safety guidelines. Even the most exotic solvent will cost just a few pence per optic cleaned.

Choosing a solvent

A good rule of thumb is 'like dissolves like', although how a solid can be 'like' a liquid is not immediately obvious.

The answer is to do with electrical field distribution at a molecular level; this is termed 'polarity'. A better adage would be 'highly polar liquids dissolve highly polar solids; non-polar liquids dissolve non-polar solids'.

In our car-washing example, salt is highly polar solid, water a highly polar liquid. Tar is non-polar, as is paraffin, thus ideal for its removal. It is sufficient merely to have an "instinct" for the polarity of the contamination to choose a solvent, as there is a broad overlap.

The following table gives a feel for polarities of everyday solids and liquids.

Matching contamination to solvent for cleaning optics

SOLID	POLARITY	LIQUID
Salts/water residue	HIGH	Water/Vinegar
		Alcohol
Light Oil		Acetone
		Methyl Ethyl Ketone (MEK)
Heavy Oil		Ethyl Acetate
	MEDIUM	Trichloromethane (Chloroform)
		Dichloroethane
Light Grease		Trichloroethane 'TRIKE'
		Xylene
Heavy Grease		Toluene
		Hexane
Tar, Fat, Plastic Residue	LOW	Octane

All these solvents should be readily available, but the user should check with the optics supplier for compatibility, and be aware of Health and Safety issues.

Even if you are lucky in choosing just the right solvent, it is likely to dissolve just a fraction of its weight in solids. So, several repeated applications will be needed to effectively remove a high proportion of the contamination. At no time is mechanical pressure needed, the solvent does the work, frantic rubbing will not increase its dissolving power in the slightest.

The cleaning process

1) We prefer to use a swab such as cotton wool, which will hold a large volume of solvent. Use natural cotton wool, rather than man made mixtures which will cause scratches. The swab needs to be free from all particles, and kept in a sealed bag. Check for seeds and knots before use. The swab should be well wetted, but capable of absorbing a little more liquid. Use a piece at least as large as the optics diameter so only a single wipe is needed for the entire surface.
2) Firstly, blow particulate matter off the optic with canned air, all shop air lines contain oil vapour, no matter how well filtered. Don't forget to check the sides/chamfers and back of the optic where debris can be attached. This can be caught up into the swab and then dragged unobserved across the surface.
3) The solvent soaked swab is dragged slowly across the optic under its own weight ONLY. The solvent at the leading edge will dissolve the dirt and the trailing part of the swab will absorb the resulting solution back off the optic. This should be repeated several times. It is important that the solvent is absorbed back onto the swab and not allowed to dry into a tide mark of concentrated dirt. Change the swab every time, as fresh solvent will dissolve the contamination better. Also, particles picked up in the swab cannot be repeatedly dragged back across the optic.
4) Check the optic is clear and free from stains and tide marks. Again, don't forget the back and sides of the optic or locating holes. These can retain liquid that can later leak out unobserved during mounting or installation.
5) If this approach is not familiar, then try a few tests on some "dead" optics first to a get a feel for the technique.

JUST HOW MUCH CARE IN CLEANING IS NEEDED?

Two questions should be asked when cleaning optics:

1) Have I scratched the optic unduly?

2) Has the absorption of the optic returned to a low enough level to allow it to function well?

Considering scratching:

Optics for high power lasers will be of good quality despite a small number of scratches that appear to be no more, than say, 2-4 microns wide. With perfect eyesight, and good natural lighting, unskilled examination will easily detect scratches of this level. The absence of scratches when viewed in this way indicates a good quality surface.

If after cleaning the optic passes this test, then well done. There is in general no need for artificial lighting or viewing aids in most situations.

Considering absorption:

For high power infrared laser lenses, such as ZnSe, a lens absorbing 0.2% of the beam will generally prove serviceable. Note this is a very small figure, just 2 parts in a thousand. Beyond this thermal effects are likely with very high power systems. A 100-watt system will be one tenth as sensitive as a 1000-watt system, so owners of high power cutting systems need to especially careful.

Metal mirrors are less sensitive, Molybdenum and Copper mirrors for example can often absorb 2.0% of the beam quite happily, ten times that of a lens. Output windows are particularly important, as the laser cavity is sensitive to misalignment and shifting waist locations that occur as the window distorts.

Of the two factors here, low absorption is the more difficult to assess, and achieve. Unfortunately lowering absorption is often the factor that determines the success of cleaning. As an optical manufacturer, LBP Optics can justify the use of sensitive PC based temperature logging; this can measure precisely the amount of a probe laser beam an optic absorbs.

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Working with LBP Optics

- We are a well-established, friendly business with over 28 years' experience and expertise.
- Fabrication, polishing and coating is performed in-house ensuring consistent high-quality products.
- Unique manufacturing methods allow us to give outstanding service and prices on small volume custom mirrors, as well as large volumes.
- We will meet your shipping dates and we regularly export all over the world.
- Our rigorous packing procedures ensure all products arrive in perfect condition for immediate use or storage.
- We supply standard production parts as well as prototypes for research and development.
- We have extensive in-house testing and measurement capabilities including phase shifting interferometry, measuring microscopy and laser calorimetry.
- LBP Optics is an ISO 9001 registered company, underlining our commitment to quality and customer service.

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