Tutorial – Caution: Lasers Can Seriously Damage Instruments

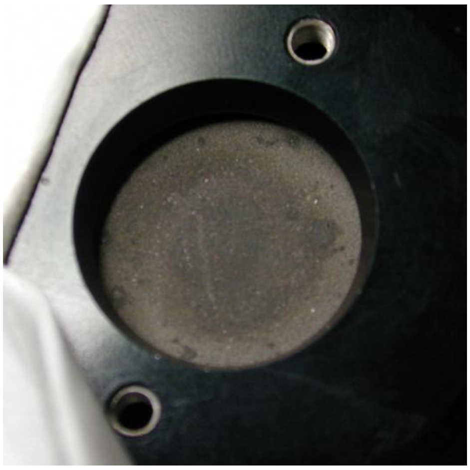
A common thread running through many Frequently Asked Questions relates to damage of measuring sensors.

Many applications involve considerable powers and/or energies; since laser measurement has us deliberately putting a measuring instrument in harm's way, let's have a look at the various effects a laser beam can have on an instrument in its path.

1. **Average power too high**: Sensors are designed to dissipate heat at a rate suitable for the power level for which they are specified. If incident average power is too high, the resulting heat will build up in the sensor faster than it can dissipate and the sensor will overheat and eventually fail. The failure mechanism is usually internal to the sensor and does not necessarily result in any visible damage such as burn marks on a surface. Various cooling mechanisms are used depending on the specified power level, including convection, fan cooling, and water cooling. In some cases, a sensor may have a detector that is able to handle higher power than the sensor body can dissipate; in such cases, the sensor can be used for intermittent measurements of higher powers, with a suitable duty cycle that allows enough cooling down time to keep the sensor from overheating. Similarly, some water-cooled sensors can be used intermittently or at low average powers with reduced or no water flow, the idea again being to keep the sensor from overheating. Sensors that are designed to enable this are specified as such.

2. **Average power density too high**: A laser beam may have average power lower than the maximum specified for a given sensor, but if the beam is focused down to a small spot the local power density could still damage the detector surface. Such damage would consist of a usually visible burn mark. We specify "Damage Threshold" as the maximum average power density above which there is a risk of such damage. It should be noted that sometimes one may observe a visible mark or stain on the detector surface

which does not in fact affect the reading. We consider a mark as "damage" (as opposed to a purely cosmetic effect) if it affects the localized reading by more than 1%.



Burn mark on an absorber surface

The maximum average power density depends, among other things, on the average power level. At high powers, the detector surface around the spot is relatively hot, making heat propagation away from the spot more difficult and increasing the risk of damage. At lower powers, heat can move away from the spot more easily, allowing the surface material to withstand higher power density. We always specify maximum average power at the highest average power for which a given sensor is rated, so that the spec sheet is as useful as possible to the user. This is why a high-power sensor using a certain absorber type, for example, will have a lower maximum average power density specified than a lower-power sensor with the same absorber.

3. **Energy density too high**: In general this can result in effects similar to those caused by average power density being too high, i.e. a burn mark. In some cases the damage can consist of an actual fracture of the absorber material. The risk of such damage is a function of pulse width. Short pulses, where the energy is deposited over a short time (so that the resulting heat does not have time to flow away), pack more of a punch in this regard than longer pulses, though high density long pulses present their own challenges. We have a variety of absorber types, each of which is optimized for a different set of conditions.

A very commonly asked question is, in generalized terms, "I was within spec, so why did my sensor get damaged?" There are a number of possibilities, including:

- The average power density might have been within spec, but perhaps the energy density of individual pulses was not – or vice versa. One needs to check both of these parameters.
- The beam may have "hot spots," small areas within the beam cross section in which the local power density is higher than the overall average power density might suggest. Unfortunately, this happens much more often than many people realize. In many such cases a beam profiler might be the correct (and often only) tool to check this.

When choosing a sensor for a given application, all of the above parameters should be taken into account. Generally our Sensor Finder application (available on our web site for online use or for downloading) does most of the work for you. But as always, a basic understanding of the issues can go a long way in helping insure a smooth and trouble-free measurement.

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