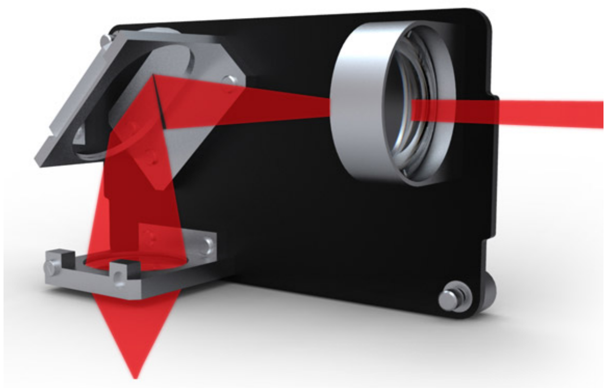
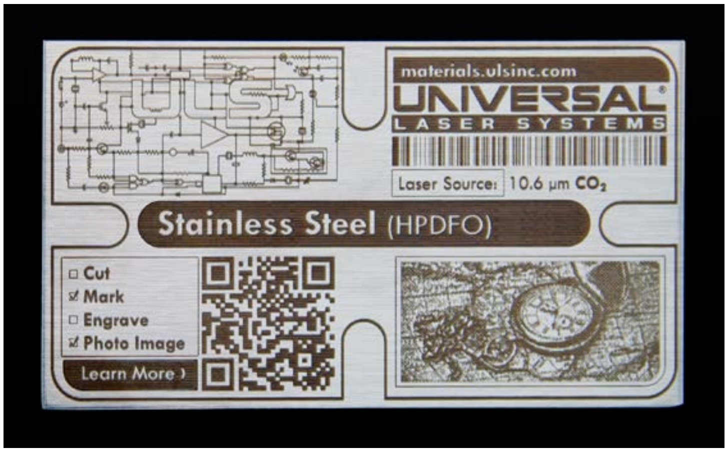
Laser Processing Guide: Working with Metal

There are three options available for marking metal: direct mark using a CO_2 laser and High Power Density Focusing Optics (HPDFO™), metal marking compound using a CO_2 laser, or direct mark using a fiber laser. The fiber laser can also be used to deep engrave metal and cut thin metal foils. This document will provide general information about processing each of these methods, as well as the advantages and limitations for each of these options.

Direct Mark with HPDFO and CO_2 Laser

Using the HPDFO, it is possible to produce a direct mark on metal using a CO_2 laser. The 10.6 um beam produced by the CO_2 laser is typically not absorbed efficiently by metal, so the HPDFO was created to overcome this limitation. This lens concentrates the laser beam to a much higher energy density, heating the metal surface and ultimately allowing selective oxidization in ambient air. This creates a dark oxide over the laser-marked areas; the mark is high contrast and easily legible.





Creating a Mark

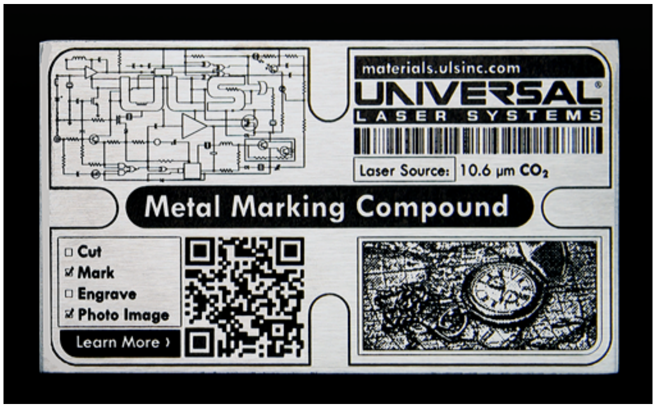
The process of using the HPDFO is very straight-forward. Simply install the HPDFO and focus to the top of your metal. The focal tolerance for this lens is relatively shallow (+/- 0.030”), so this process works best on consistent, level pieces. You can select laser settings from the Materials Database to process your materials. Options include direct marking steel or titanium using this method.

Advantages/Disadvantages

- This is a permanent, direct mark on the metal’s surface.
- This option produces a high contrast dark mark, which can be used for general marking, images, or barcodes.
- The HPDFO and collimator system can be added to any ULS platform to enable this type of marking.
- The spot size for the HPDFO lens is very fine, 0.001”, allowing the user to create intricate details on metal.
- This process will mark bare stainless steel, titanium, chrome, and iron, but not metals such as brass or aluminum (see the Materials Database for settings for each markable metal). Non-polished surface finishes tend to deliver the best results.
- This method is the slowest marking option, but it is available to add to any system and does not require application and cleanup like the marking compound.

Metal Marking Compound with CO_2 Laser

Metal marking compounds are chemically based, thermally activated laser marking products that contain ceramic particles. In this case, the compound is applied to the surface of bare metal and allowed to dry. As the laser beam heats this compound, the ceramic particles fuse to the surface of the metal, creating a very high contrast black mark. This mark is nearly permanent: it cannot be removed without excessive friction and force, usually resulting in damage to the underlying metal.



Creating a Mark

The process for creating a mark using a marking compound is fairly straight-forward, but it does require additional setup and cleanup time. The compounds are available in a variety of forms, including aerosol sprays, pastes, and tapes. It is best to clean the bare metal prior to applying the compound to ensure a consistent bond. Once the compound has dried, the part can be laser marked using any CO_2 system with any lens option (HPDFO, 1.5, 2.0, 2.5, 3.0 or 4.0). Your lens should be selected based on the level of detail required for the job (spot size) and any focal tolerance or focal distance requirements due to part shape. The Materials Database includes settings for using metal marking compounds with the 2.0 lens, so some adjustments may be required to achieve the best results with other lens options. Once the laser marking is complete, remove the part from the laser system and clean it according to the package directions (typically washing with water or a wet towel will suffice). The compound will only adhere in the laser marked areas, producing a sharp, high-contrast mark.

Advantages/Disadvantages

- This option produces a high contrast black mark, which can be used for general marking, images, or barcodes.
- The compound can be used with any Universal Laser CO_2 system and any lens option for added versatility.
- The compound will work with a variety of bare metals, including stainless steel, brass, aluminum, titanium, tin, copper, and nickel.
- The compound requires less intensity to bond to the surface than direct marking, allowing

for higher marking speeds. However, the compound must be applied prior to laser processing and the excess must be cleaned from the metal afterward, adding to the total processing time.

- The mark is a raised surface, due to the ceramic-based compound fusing to the metal. This may not be suitable for some applications.

Direct Marking with Fiber Laser

The 1.06 um wavelength of the fiber laser is very efficiently absorbed by metals. The laser is able to quickly heat the surface of the metal, causing oxidization in ambient air to form a permanent mark. Additional processes are also possible using this laser type that cannot be accomplished with CO_2 systems, including deep engraving of metals and cutting thin metal foils.

Creating a Mark

Creating a surface mark on metal is very straight-forward using the fiber laser. Lens selection will vary depending on the metal you plan to work with as well as any focal tolerance or focal distance considerations due to part geometry. Typically the 4.0 lens produces the best results on steel and titanium, while the 2.0 lens will work well for most other metals. The focal tolerance for the 2.0 lens is +/- 0.02" while the tolerance for the 4.0 lens is +/- 0.04"; make the appropriate selection based on the shape of your part. Settings for various metals are available through the Materials Database, and are specific to the fiber laser wavelength.

Deep Engraving with Fiber Laser

It is possible to engrave into the surface of metal using the fiber laser. It is a slower process than marking and requires iterative passes to achieve depth. While it is possible to achieve greater depth with additional engraving iterations, the best results exist around 0.003" to 0.005" into the material. To create this depth, install the 2.0 lens to provide sufficient energy density for engraving metal. Next, prepare your file by creating one raster version of your graphic in black, then copying and pasting a duplicate image over it in blue. These images should be aligned directly over one another. Print both images to the UCP using the appropriate Materials Database selection for your metal. Each time your file is run, the laser will engrave over the graphic twice: once as a high intensity pass that removes material, and the second as a low intensity cleaning pass. This second pass ensures that your deep engraving is crisp and the bottom of the engraving area is more smooth and consistent. Each of these pairs of passes (or one run on the laser) will produce between 0.0005” and 0.001” of depth, depending on the metal. Continue to repeat these passes to achieve greater depth in your material.

Cutting with Fiber Laser

Metal foils can also be cut using the fiber laser. These are typically limited to a thickness of 0.005” or less for best results. To cut, install the 2.0 lens to provide sufficient energy density for cutting and focus to the top of your material. Ensure your material is flat to maintain consistent results. Some metals may warp during this process, due either to material properties, intricacy of the cut graphic, or the thickness of the material. If this happens, either clamp or weigh down the material to maintain a consistent focal distance. Settings can be selected in the Materials Database for a variety of metal foils.

Working with a Fiber Laser Source

Advantages/Disadvantages

- This laser produces a permanent, direct mark on the metal’s surface. It can also create depth into the surface of the metal for additional durability.
- This option produces a high contrast black or dark mark (depending on the metal), which can be used for general marking, images, or barcodes.
- Settings can be altered to produce a broader variety of marks on metals, including permanent light, midtone, or dark marks. These lighter marking options can be used to improve throughput.
- The fiber laser will react with most metals to provide marking, deep engraving, or cutting of thin foils.
- This laser produces extremely fine detail, with spot sizes ranging from 0.00025” to 0.0025”.
- It is possible to cut thin metals (0.005” or less) using this laser.
- The fiber laser is only available as an option on the PLS6MW system. This is due to added safety features on that platform intended for the use of 1.06 um wavelength light.
- Direct marking using the fiber laser is a faster marking option than HPDFO with a CO_2 laser, however it is not as fast as marking using metal marking compound with a CO_2 laser.

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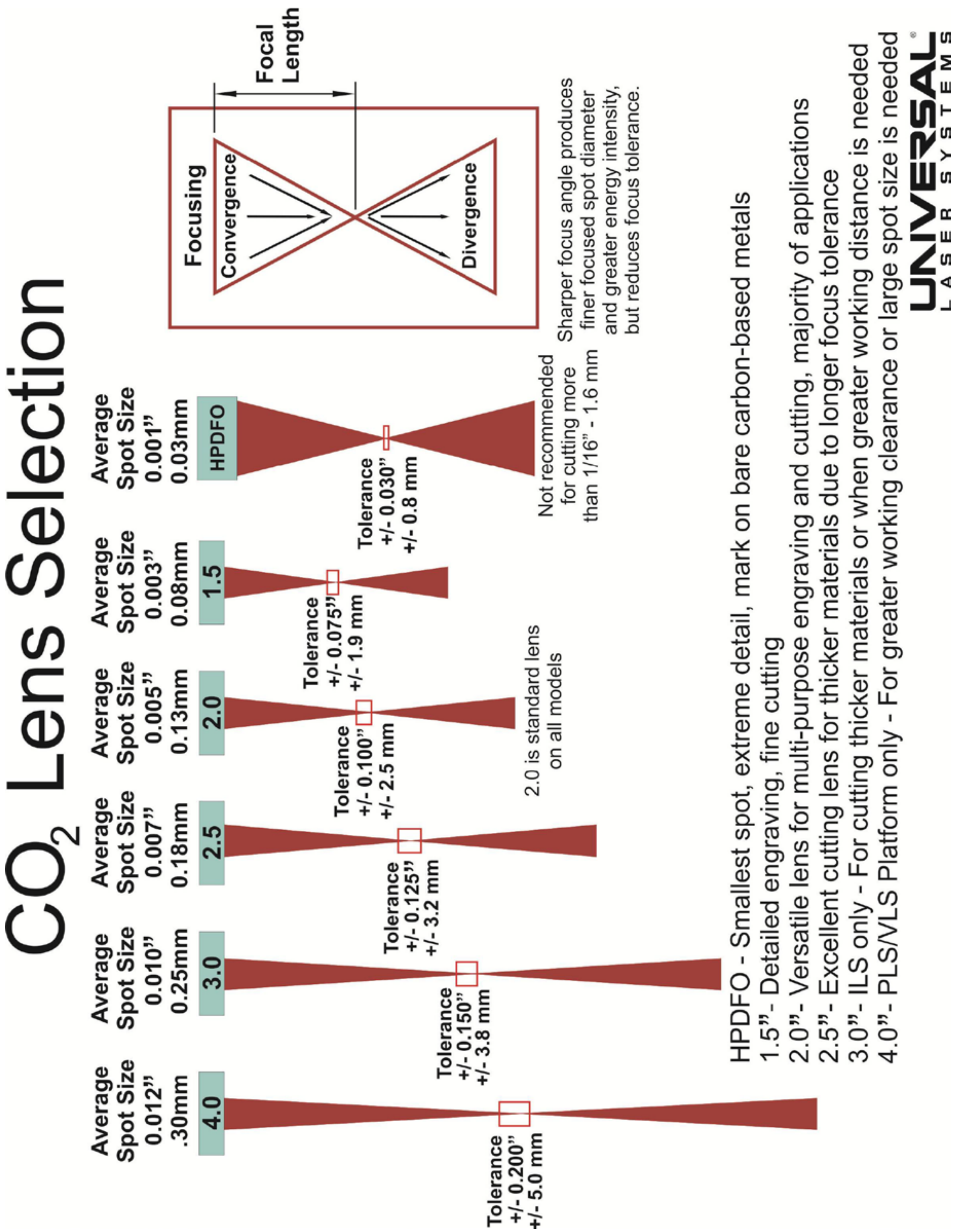
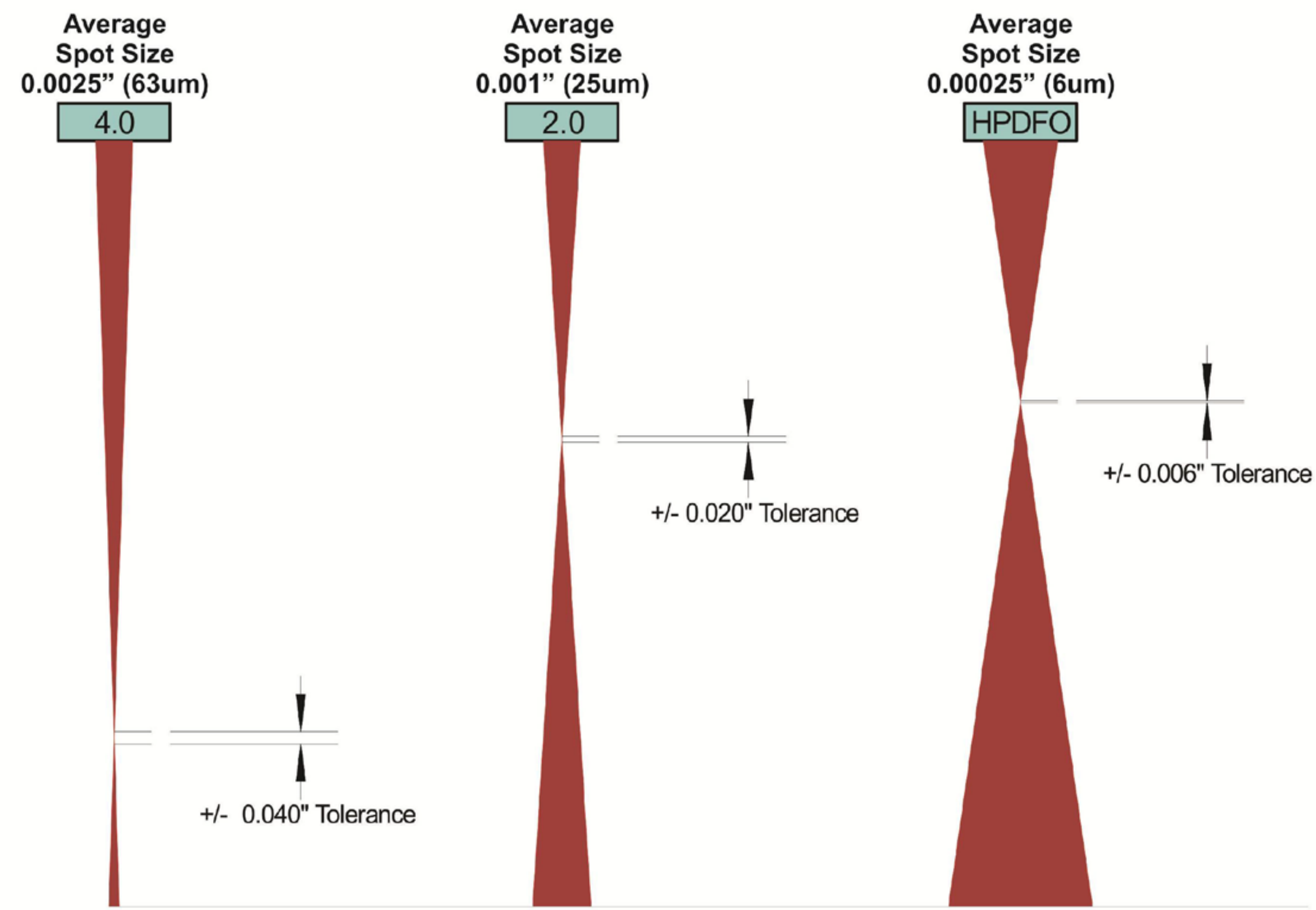


Fiber Laser Lens Selection



Focal tolerance ranges are material dependant. Some applications will be more sensitive to focus than indicated on this chart.