Laser Processing Tips For ALUMAMARK

By Geoff Thompson & Gary Sheriff

If you have ever tried to mark aluminum with a CO2 laser, then you have experienced the reflectivity challenge of the CO2 laser beam and metals. Fortunately, there is one product, AlumaMark, that has overcome these challenges and has made marking aluminum possible using a CO2 laser. AlumaMark is a product line developed by Horizons Imaging Systems Group.

The product uses a proprietary coating on aluminum that absorbs the CO2 laser energy, resulting in a black mark on any of its coated aluminum materials. Typical applications include trophies, plaques, data plates and flow diagrams, but the one application that is becoming very popular is label marking for UID (2D) barcodes.

Results with AlumaMark can achieve even "A" grades (with special software) when measuring a 2D bar code's contrast and cell-to-cell print growth; however, there are definite laser formulas that must be followed in order to achieve best results due to the sensitivity of the coating.

Finding the right process can be complicated by the fact that individual lasers with the same power rating from the same manufacturer can vary. Users can also expect variations from the actual mechanical design of a laser vendor's machine, including worktable flatness and motion system. Other factors to consider are laser beam quality and beam divergence. All factors can help cause inconsistencies, especially when marking a sensitive material such as AlumaMark.

Our objective is to better understand how changes in machine parameters affect the results and therefore give users a general overview how to best adjust their individual laser machines.

TEST FILES

We selected three different files for processing that would demonstrate not only typical applications, but also illustrate the problems that many encounter when processing AlumaMark products.

Flow Chart: The project was an 8" x 4.5" graphic centered on a 12" x 10" sheet. The graphic consisted of vertical, horizontal and diagonal lines, text as small as 3.5 pt. and a logo with bold text .5" in height.

Data Plate: 3.5" x 2.0" with fine text and bold borders.

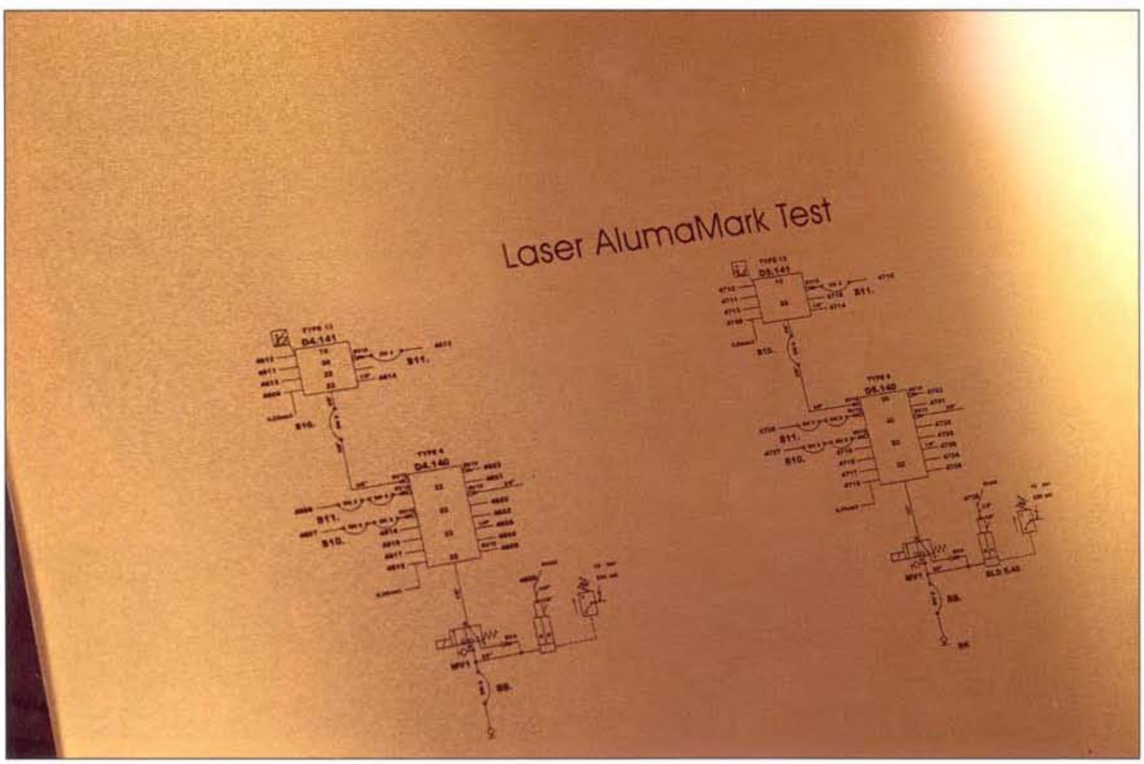
Bar Code Marking: Both 2D Matrix required for UID and traditional 3 of 9 barcode.

MATERIALS

Currently, Horizons Inc. offers Satin Silver, Satin Gold, Satin Brass, Satin Bronze and Matte Silver, and they will be introducing three more substrates this year.

LASER SYSTEM

Our test system was a 75W Trotec Speedy 300 that was running 90W +/- 1.5W at the lens over the entire 29" x 17" work area. For comparative purposes, this laser has a maximum speed of 140 ips.



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METHODOLOGY

We started with the satin gold product, since the manufacturer states this is the easiest color to process. Past experiences dictated starting parameters (below). We began with the flow chart file on this material and achieved an excellent, black result.

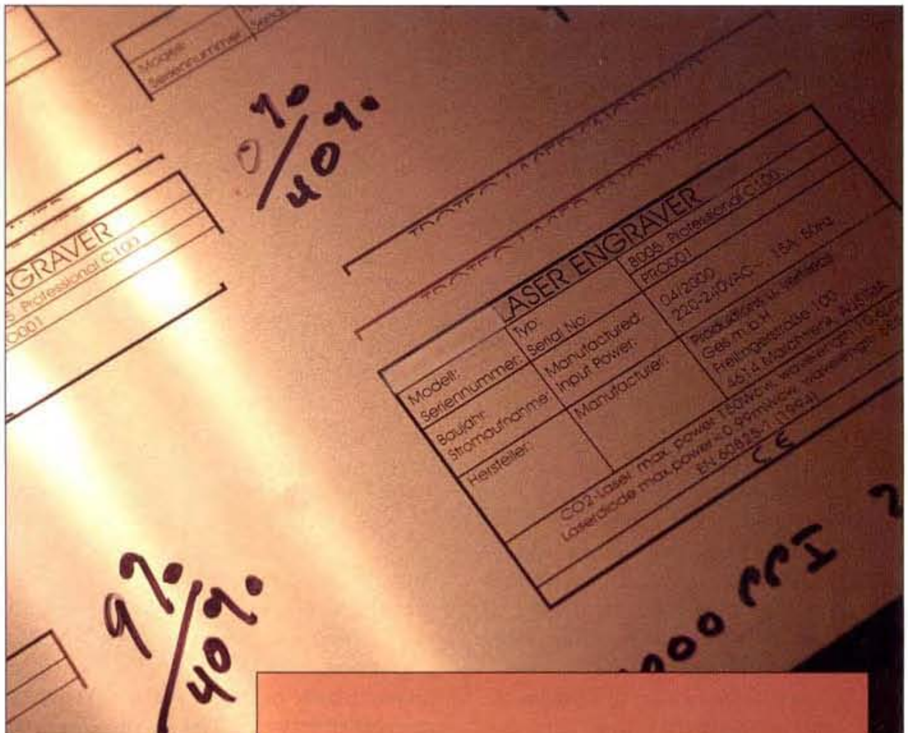
13% Power
20% Speed
1000 DPI
1000 PPI
1.5″ Lens
.040″ Out of Focus
High Quality Engraving Turned On
45 Minutes Processing Time

Regarding our choice of lens, we selected the 1.5″ for this file because of the small characters and fine lines. Other experiments used lenses with longer focal lengths with interesting results that will be discussed later.

Since we had achieved excellent results, we wanted to see how speed and power adjustments would affect the quality. We were not able to achieve a better result than our first attempt, but soon discovered that the relationship between power and speed was not linear. Our data plate file was more appropriate for further parameter testing (described later) since its thicker lines give a better chance for visual inspection.

Using the same flow chart file on the satin bronze, silver and matte silver finishes determined that the settings for the gold worked equally well with the bronze. The resulting marks were dark black, and the quality of the mark was excellent; however, it was immediately clear that some adjustments were required with both the satin and matte silver.

We conducted a number of tests at different settings and determined the best results were achieved by reducing the power to 8%, but leaving all the other settings the same. The best results we could achieve with these products were not as black as with the gold and bronze, but were satisfactory enough, in our opinion,



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to meet the requirements of most demanding customers.

In our next series of tests, we ran the data plate file and adjusted parameters such as pulsing (PPI), speed and focal length. Knowing that best results are achieved using the highest resolution(DPI), highest pulse setting (PPI), long dwell time (slower speeds) and .040" out of focus, we wanted to reduce process time without sacrificing quality. We tried increasing power proportionally, but found that quality deteriorated rapidly.

We then tried different power settings at a constant speed and discovered that when we doubled the speed a better result was achieved by increasing the power only 25%. Ultimately, we found that we could not achieve an acceptable result when speed increased more than 100% of the ideal setting, but this reduced processing time 45%. We tried adjusting other parameters (PPI, DPI, focal length) but found that quality was unacceptable with only nominal reductions in processing time.

At this point, it seems logical to discuss factors which are related to laser processing in general and to the processing of AlumaMark specifically. This material is sensitive but knowing its idiosyncrasies and laser tendencies, one can usually choose correct parameters fairly quickly.

CO2 lasers pulse a beam of light energy. Some lasers are equipped with a PPI (pulses per inch) feature that allows the laser to fire at different intervals as the laser head moves along the X axis. Depending upon speed and resolution of the processing, it may make sense to increase or decrease the PPI in order to achieve a truer lasing action.

AlumaMark is a sensitive material that requires a long dwell time or heat period for a proper reaction to take place. Since slower speeds are defined as longer dwell times, it makes sense to increase the PPI to maximum (1000) to maximize the heat effect.

Continuing the thought of dwelling the heat, larger lenses have a longer focal distance and a longer depth of focus and the benefit in this case—a larger spot size. The larger spot size equates to a larger heat zone. The laser beam diameter is larger, but the energy density of the beam decreases, so power must be compensated when using a larger lens or marking slightly out of focus. (Slightly out of focus marking is a method to simulate a larger focal length lens in order to achieve a larger spot).

Using a shorter focal lens (smaller spot size) is required for marking small characters down to 4 point (.040") and sometimes smaller. This is also the case for marking standard 1D type bar codes where vertical lines are very close to each other such as a 3 of 9 bar code similar to bar codes used in grocery stores. The 1.5" lens is critical for a thin, fine line. The lines must be very straight for the reader to make a proper read.

Our test system can compensate so that a very straight line is marked. Other types of lasers may need to process a 1D bar code by turning the material 90 degrees to mark each bar horizontally. For more advanced users that are marking and grading 2D bar codes, smaller spot sizes may also be required in order to minimize the print growth.

A 2D bar code is made up of marked and unmarked squares (cells). The shape of the bar code can either be in the shape of a square or a rectangle. A rectangular 2D bar code is typically for marking on a cylindrical item in order to keep the code within the glare zone for the reader to see the bar code.

The marked cell and unmarked cell must be the same size and must be a certain size all together so that when the special grading software reads the mark, this relation and size of the cells stays within an acceptable print growth as defined by the reader software. The smaller, focused lens has the best chance to mark the code and stay within the print growth range for an "A" grade.

The test system we used can interactively adjust the Z axis in increments as small as .001" and go back again for other less-sensitive areas in order to find the exact focal distance needed to achieve our goals. Using this feature eliminated guessing focus distance and allowed us to confidently choose .040" as a general rule, if an out-of-focus mark is desired.

Now that we have described a few of the critical parameters for marking AlumaMark, let's focus on some other critical factors that have just as much importance when marking AlumaMark. The actual laser beam quality, the laser's divergence and flatness of the process table can be culprits if inconsistencies in the mark are present and if the processing is done using a large portion of the process table.

The flatness of the worktable in relationship to the motion system and beam divergence are all interrelated in determining how much of the worktable can be used to process AlumaMark or other sensitive materials. Beam divergence is the tendency for the beam to increase in size the farther it travels from the source. Focus point and energy densities will be dynamically changing and causing different results, especially when processing sensitive materials.

This difference will become more prevalent on larger files since more of the process table will be used. If the system has a hardware component called a telescope or sometimes called a beam expander or collimator, the effect of beam divergence can be minimized.

Our test system process table was within .001" from one end of the table to the other and has a telescope as a standard feature, thus helping to eliminate divergence issues. This, combined with the rigid construction of the chassis, a magnetic worktable specifically designed for flatness over the entire work surface, allowed us to produce consistent results in all four quadrants without any adjustments of machine parameters.

Your system may not be able to do this, so it will be necessary to find the area of the worktable that produces the most-consistent and high-quality results. If divergence is an issue, the entire process area will be affected. This may limit the size of the AlumaMark piece, since any given process area will always have a changing focus point.

Another factor to consider is the flatness of the material. We worked with 12" x 10" sheets and found some were slightly warped. Since our table was ferromagnetic stainless steel, we used magnets to hold the material flat to the table in order to minimize warping.

Regarding the actual laser beam itself, the AlumaMark manufacturer recommends lower power systems for processing. Higher-powered lasers can become unstable when operating at the lower range of their rated output. Certainly, below 5% of the rated output can start to cause instabilities of the laser beam performance and sometimes below 10%. This is not unique to AlumaMark material, and the effects of this phenomenon can be seen with other sensitive materials, too.

We experienced some banding when processing one sheet of matte finish, but there may have been a problem with the material, as there were inconsistencies in the surface. The same file run on different sheets worked fine. We also experienced some color-consistency problems with large bold letters on the satin silver, but we were using the 1.5″ lens in focus because the graphic contained extremely small characters. Changing the focus point of the 1.5″ lens and leaving the DPI and PPI at 1000 helped resolve the issue, though we did lose some resolution in the small characters since the spot size slightly grew.

One can draw conclusions about using AlumaMark with a CO2 laser. Any CO2 laser should be just fine to mark the AlumaMark product, as long as the mechanical and optical aspects of the laser are known and the user is aware of his system's limitations. To start, the appropriate lens must be chosen. If small characters or bar codes will be marked, it is appropriate to use the smallest lens possible to mark with the best possible resolution.

A slower speed is most likely needed for the best results, since this file will most likely need to be marked in focus, but be aware of the heat-affected zone, especially if bar codes are marked. For larger, thicker lines and larger characters, it is appropriate to use a larger lens.

Generally speaking, marking AlumaMark effectively and robustly requires a relatively large, slowly heated and critically focused laser beam. A correctly marked piece should be black in color. If the focus is off or if the focus changes over the course of the marking, the resulting color could be different shades of brown, due to different heat effects. This may also cause line thicknesses to differ, which may cause difficulties if marking and reading bar codes.

SETTING UP YOUR SYSTEM

First determine the limitations of your system. Begin testing in the quadrant closest to the next to last mirror (number 2 or 3 depending on the system).

Use the highest DPI and PPI settings possible.

Begin with the settings recommended by Horizons Inc. or your laser system's manufacturer.

Using gold or bronze material, work to achieve a consistent black mark with high-quality small characters. For this test, use the shortest length lens available.

Begin with the system in focus and experiment with small adjustments taking it out of focus.

Once you know the highest level of quality possible, try increasing the speed and power until you reach the point where quality is no longer acceptable.

Remember that using the longest length lens appropriate for the file will help improve results, but you will need to increase the power, as the power density decreases as the spot size becomes larger.

Now run the same file in the other 3 corners of the table to see how much of the work area is usable.

Gary Sheriff is Vice President of Shertec, Inc., a manufacturer's representative group based in southern California; he can be reached at garys@sbcglobal.net. Geoff Thompson is Vice President of Trotec Laser, Inc.; he can be reached at geoff.thompson@troteclaser.com or visit the website www.troteclaser.com. AE