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B. W. Weinstein, C. D. Hendricks and J. T. Weir

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LASER MICRODRILLING IN THE FABRICATION OF LASER FUSION TARGETS

B. W. Weinstein, C. D. Hendricks and J. T. Weir
University of California
Lawrence Livermore Laboratory
Livermore, California 94550

Laser target fabrication often demands the construction of tiny, intricate parts of various materials. Laser drilling is a useful method for fabricating some of these.

Figure 1 shows a "ball-in-plate" target designed for use with a two-beam laser. The target consists of a hollow glass fuel ball filled with deuterium-tritium gas, and a "halo" of glass around the center of the ball. When the target is fired on in a laser fusion experiment, the halo of glass forms a plasma which helps heat and compresses the mid-section of the ball.

This target is fabricated as follows: First a series of large holes, approximately the size of the DT filled ball, is drilled in a glass sheet which is less than 1 μm thick. Figure 2a shows the appearance of a typical hole. These holes are then examined and one is selected which is sufficiently round and is the correct size for the fuel ball available. A guide pattern of holes is then cut out around the large hole (Figure 2b). Most of the bridges between the guide holes are cut with another series of shots (Figure 2c). Finally, a thin glass capillary is inserted through the main hole to catch the glass piece when the last supports are shot out. Figure 2d shows a finished "halo" on a glass capillary. The glass piece is removed from the capillary with micromanipulators, the fuel ball is glued in place, and the entire assembly is mounted on another glass stalk (Figure 2e,f). A "ball-on-disc" target for use with a single beam laser can be constructed similarly.

Other uses which we have had for the laser drilling facility include: drilling a small hole in the side of a fuel ball to remove the fill and allow a check on what portion of the observed x-rays are caused by tritium in the walls of the ball (Figure 3); and removing a fuel ball from a stem.

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The physical arrangement of the laser drilling system is shown in Figure 4. We used a normally pulsed ruby laser, which has a wavelength of 0.6943 \text{nm}, but there is probably no particular advantage to this wavelength. The laser beam was focused with an ordinary microscope objective onto the object to be drilled. At the low power settings which we used, no damage occurred to the lenses. At higher power settings, air gap lenses would be necessary. The object being drilled is viewed by means of a telescope and prism as shown in Figure 4. The prism is mounted on a track and is moved out of the beam path when the laser is fired. With this arrangement, the telescope viewing system is focused on precisely the same spot as the laser, which makes positioning of the target very easy. We used a high quality rifle telescope for viewing, and resolution was equal to that of a good conventional microscope. With proper alignment, the holes can be placed with an accuracy of \( \pm \frac{1}{2} \text{\mu m} \), and on a given sample, hole size can be controlled within about 20% from 2 \text{\mu m} to more than 250 \text{\mu m}.

Ordinary thin glass has a very low absorption coefficient for visible light. To increase the efficiency of the laser drilling, we therefore applied a very light carbon coating to the glass before starting. Only enough carbon was applied to cause a barely perceptible darkening of the glass, about 50-100 \( \text{Å} \). A thicker carbon layer tended to flake off during the drilling process, making recoating necessary.

Figure 3 shows an electron microscope picture of one of the laser-drilled holes. This particular hole is about 100 \text{\mu m} across. The important thing to note is the thickness of the rim around the hole. The drilling process occurs primarily by melting the glass, which then retracts to the edge of the heated area. Little if any glass is actually lost during the process. From a standpoint of strength, this is a definitive advantage, since the holes are quite strong, and are not likely to start cracks. However, if one does not wish to have a thick rim around a large hole, then the large hole must be cut out with a series of small holes.

One of the primary advantages of the laser drilling technique is that it is very flexible. New dimensions and forms can be selected at
will with little or no change in fixturing. Also, the laser drilling process is applicable to materials other than glass. Thin sheets of metal or plastic can also be cut in the same manner.

In summary, laser drilling provides a versatile method of fabricating small, intricately shaped parts required for the fabrication of laser targets.

REFERENCES

FIGURE 2: (a) Initial large hole; (b) Guide pattern of holes; (c) Disc just prior to removal, held into glass sheet by one fiber on the "handle"; (d) Completed disc, held on a glass fiber; (e) and (f) finished target
FIGURE 3: Laser fusion fuel ball (80 µm diameter) with a hole drilled in the side to remove the DT gas.
FIGURE 4: Physical arrangement of laser drilling apparatus.
FIGURE 5: Scanning electron microscope photograph of a laser drilled 100 μm hole in 0.5 μm glass.