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FABRICATION OF LASER-TARGET COMPONENTS
BY SEMICONDUCTOR TECHNOLOGY

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"How To Do It"

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FABRICATION OF LASER TARGET
COMPONENTS BY SEMICONDUCTOR TECHNOLOGY*

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Abstract

This paper describes the design and fabrication of a unique silicon substrate with which laser-target components can be mass produced. Different sizes and shapes of gold foils from 50 to 3000 microns in diameter and up to 25 microns thick have been produced with this process since 1976.

Introduction

The Lawrence Livermore Laboratory's laser fusion research project requires a variety of components to fabricate the many different targets used to study laser beam propagation and laser-plasma interaction. Among them, gold foils of various thicknesses and sizes in the shape of a disc and a donut are required. One method of producing a gold disc of this type would be to use the standard photolithographic technique. This approach uses a photolithographic mask to reproduce the disc on a gold substrate. The problem in

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using this method is that 25 microns is a very thick film to etch chemically, due to the severe problems of photoresist adhesion and undercutting. Also, it can be very difficult to remove the gold discs from the substrate after they are etched.

What is presented here is a method that will eliminate the chemical etching and also allow the easy removal of the gold discs from the substrate. Since gold does not adhere very well to SiO_2 , a silicon substrate was designed to allow the gold to be sputtered on the substrate and then simply peeled off, giving you the finished parts.

Design and Fabrication

The basic idea was to etch out the needed patterns on a 2" Si wafer by the standard photolithographic technique. The patterns stand out from the Si wafer body and the entire surface was covered by SiO_2 . Gold film sputtered onto the wafer can be peeled off later because Au does not adhere to SiO_2 very well. Owing to the specially designed etch pattern, the step coverage at the edges is minimum allowing easy release of the desired components from the 2" gold foil.

We started with 2" Si wafer, typically "p" type (1-1-1) 8-12 ohm-cm. A sequence of processing steps is required to complete a Si substrate and the steps are listed below.

Step Number

1. Grow a one micron thick thermal oxide. Fig. 1A.
2. Apply negative resist and spin at 3000 RPM. Fig. 1B.
3. Soft bake at 90°C for 10 min.
4. Repeat step 2 and 3.
5. Photolith pattern from mask using a 5 second exposure time @ 10 MW/cm². Fig. 1C.
6. Develop using a 25 second develop time, 25 second rinse time and 30 second N₂ dry.
7. Hard bake @ 150° C for 15 min.
8. De scum in O₂, 1 torr, 100 watts 2.5 min. in plasma etcher.
9. Chemically etch the one micron oxide in a 6:1 (NH₄F + HF) solution. Fig. 1D.
10. Plasma etch in Freon + O₂ @ 0.5 torr pressure and 150 watts power for 80 minutes. This etches ≈ 15 microns into the silicon. Fig. 1E.
11. Plasma strip resist in O₂ @ 1.3 torr pressure and 200 watt power for 15 minutes. Fig. 1F.
12. Grow 4200° Å thermal oxide. This is necessary to prevent the gold from sticking to areas that were plasma etched. Fig. 1G.

A typical pattern on Si wafer is shown in Fig. 2.

Results and Discussion

The finished profile (Fig. 1G) is a pattern of $\text{SiO}_2 \approx 15$ microns above the silicon substrate. Notice the undercut to allow the evaporated gold film to be separated in the necessary areas. To date, several gold dot and donut shaped discs from 50 to 3000 microns in diameter and up to 25 microns thick have been made and the process appears to be quite successful. Fig. 3 shows a photomicrograph of a 8 micron thick gold donut that is 550 microns O.D. x 150 microns I.D. The yield on a new Si substrate approaches 100% and it can be used more than once. On the average, after the substrate has been used 5 times the yield will drop below 50% owing to breakage at this over-hanging "lip" which forms the undercutting profile.

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Figure 1. Profile of Steps in the Fabrication of Silicon Wafer Prior to Gold Deposition.

Figure 2. SEM micrograph of a typical etched silicon dioxide on silicon pattern. ID is 200 μ , OD is 500 μ . The oxide thickness is 1 μ . The etched depth into the silicon is 12 μ .

Figure 3. SEM Photomicrograph of an Au Disc 8 Microns Thick and 550 Microns O.D. X 150 Microns I.D.