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ABSTRACT

An electroplating apparatus for applying uniform metallic coatings that have excellent surface finishes to discrete microparticles is described. The device is used to electrodeposit metals onto thin-walled metal, metallized glass, or plastic mandrels. The apparatus and process were developed for fabrication of microsphere pressure vessels to be used as targets in laser fusion research.

I. INTRODUCTION

In research on laser-initiated pure fusion, target design has been limited severely by lack of sufficiently energetic lasers. The most difficult constraint is that of size. Laser fusion targets are currently 50 to 500 μm in diameter.

Figure 1 shows a hypothetical target.[1] The inner shell is generally obtained from a commercial source, and in many designs it is considered an inert layer, whose sole purpose is to serve as a mandrel upon which to deposit the design layers. Regardless of the coating technique, during deposition, the individual microparticles must be forced to move randomly in the coating medium to ensure wall thickness uniformity and homogeneity of the deposit.

Several techniques for applying metal shells to microspheres have been evaluated,[2-4] including physical vapor deposition (PVD), chemical vapor deposition (CVD), sputter deposition, and electro- and electroless plating. Although plastic shells had been applied successfully to both metal and glass micromandrels by a process called glow-discharge polymerization,[4] no metal deposition processes had been successful heretofore.

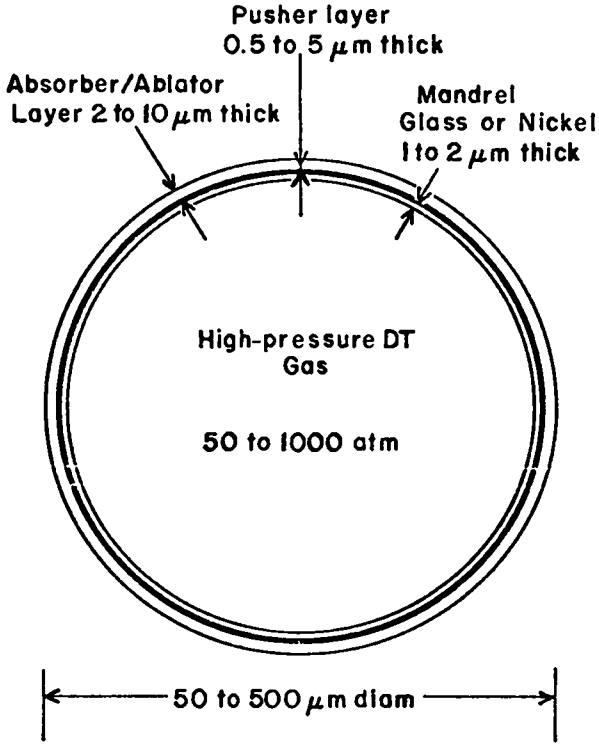

Fig. 1.
A hypothetical structured, multilayered laser fusion target.

It is difficult to determine the design features of laser fusion targets in advance. Therefore, techniques for depositing a variety of metal shells onto a variety of microsubstrates must be developed. Theoretically, the target fabricator should be able to produce targets in a timely fashion by use of available techniques, rather than being forced to develop hurriedly, and often unsatisfactorily, a technique for depositing a specific metal on a specific micromandrel for a new target design.

Electroplating offers the potential for forming shells of more than 25 metals on microsubstrates in a single process. Available plating baths produce coatings of exceptional surface quality. The difficulty in formation of shells for laser fusion targets has been the inability to suspend the microsubstrates in the plating medium to ensure a uniform deposit.

A new apparatus[5] provides the required random motion of the individual microparticles throughout the plating process. The number of microparticles that can be plated is almost unlimited. Several metals, including gold, nickel, copper, and a nickel-iron alloy, have been electroplated using this apparatus.

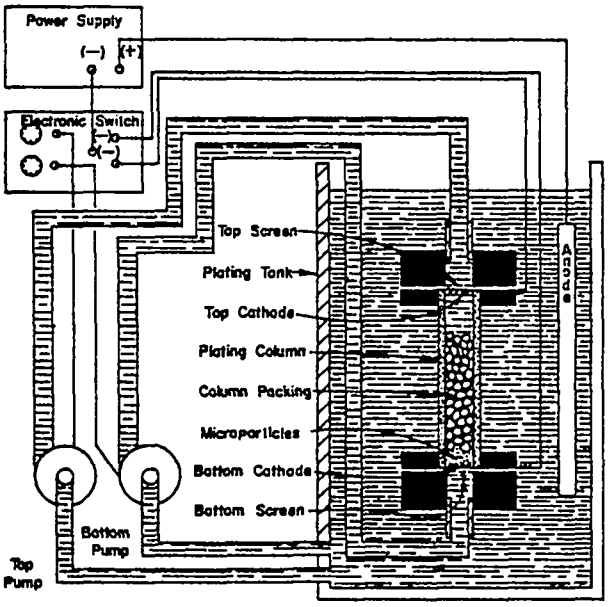

Fig. 2.
Apparatus for electroplating discrete microparticles.

II. PLATING APPARATUS

The pertinent features of the apparatus are shown in Fig. 2. The microparticles are confined in a cylindrical plating column, whose ends are covered with nylon mesh. The column wall is a porous alumina ceramic tube. The plating chamber is approximately three quarters filled with loose packing plastic, glass, or ceramic beads, in addition to the particles to be coated. Each screened base of the column is connected to the discharge line of a separate filter pump. The column is lowered vertically into the plating solution reservoir. The porous alumina wall is saturated with the electrolyte to provide the electrical path between anode and cathode. Anodes are placed concentrically about the chamber and connected directly to the power supply. The cathode wires are mounted adjacent to the screen bases, inside the column. The top and bottom cathode wires are routed to separate terminals of an electronically controlled switching device that has two timers to control the operation of the two filter pumps and simultaneously, in synchronization, flip the cathodic current of the power supply between the two cathodic legs of the plating chamber.

When the top pump is on, the particles are forced against the bottom screen and touch the negatively charged cathode so that electrolytic deposition takes place. During this part of the cycle, the top cathode wire is electrically neutral and the bottom pump is off. After this half cycle, the top pump is turned off, the bottom pump is turned on simultaneously, and the cathodic current is flipped to the top cathode wire. The reversal of solution flow through the column drives the particles to the negatively active cathode wire where metal is deposited on them. Each half cycle is kept relatively short (5-30 s) to reduce the particle agglomeration caused by bridging of the deposited metal. The inert column-packing beads facilitate random particle motion as they move between the retaining screens, for uniform deposition thickness. They also provide turbulence in the solution to maintain particle separation, thereby preventing agglomeration.

III. PROCEDURE

Preplating preparation of the microparticles consists of float separation in absolute methanol, alkaline cleaning, and activation in an acid medium. The spheres are loaded into the plating column, and it is immersed in a plating bath. The switching device, which controls the pumps and cathodic current direction, is turned on to start the plating run. The plating rate is a function of the electrolyte type and the applied plating parameters, specified by the commercial bath manufacturers. A typical batch of 25 000-100 000 spheres is plated to 10-μm thickness in 30-60 min.

IV. RESULTS

Hollow microsphere mandrels, 50 to 200 μm in diameter, have been coated with electrodeposits of copper, gold, nickel, and a nickel-30 wt% iron alloy in the device described above.

Figure 3 is a metallurgical cross section of a 200-μm-diam, thin-walled metal mandrel plated with 14 μm of electrolytic nickel. A 15-μm-thick electrodeposit of gold is shown in Fig. 4. The SEM micrograph, Fig. 5, shows the excellent microsphere surface morphology obtainable by this process. This particular micrograph shows a 10-μm-thick nickel deposit.

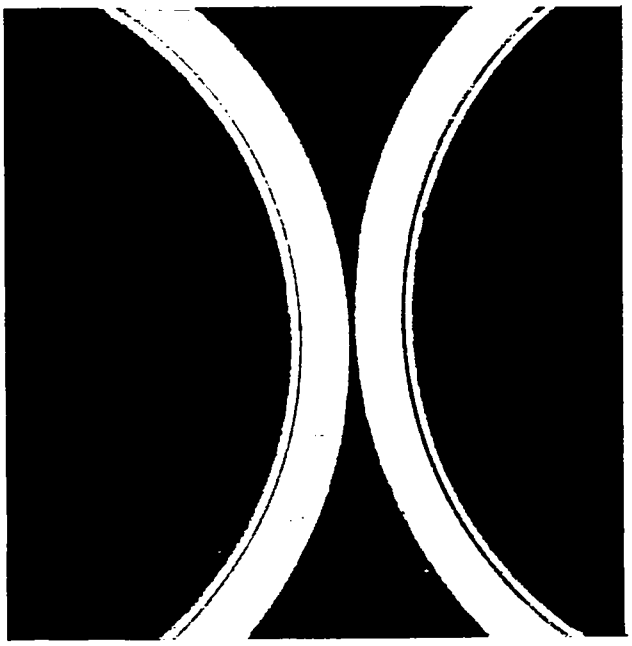

Fig. 3.
Cross section of a 200-μm-diam thin-walled metal mandrel plated with 14 μm of nickel (500X).

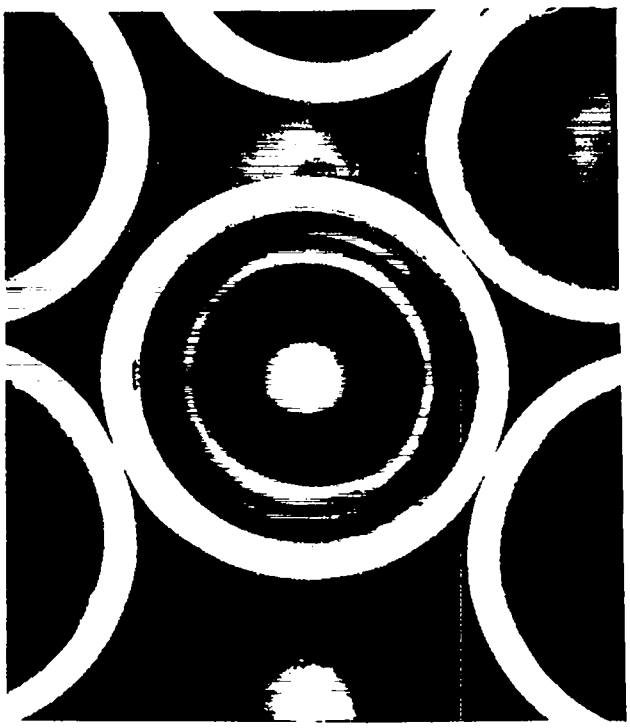

Fig. 4.
Metallographic cross section of thin-walled laser target pellets plated with 15 μm of gold (250X).

Fig. 5.
Scanning electron micrograph of nickel electrodeposited on a thin-walled metal shell (400X).

Development of this apparatus for electroplating microspheres offers designers great flexibility in choosing target materials. In additional to the pure metals, a number of elements lend themselves to codeposition as alloys with desirable material properties. This device is uniquely adaptable for coating hollow particles whose density changes during the deposition process. We are now investigating electrodeposition of alloys on hollow mandrels in an effort to optimize the strength-to-mass ratio of pusher materials.

ACKNOWLEDGMENTS

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