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Anton Mayer and Duane S. Catlett

ABSTRACT

Use of a novel device for applying uniform metallic coatings to spherical microparticles is described. The apparatus deposits electroless metal coatings on hollow, thin-walled metal or sensitized nonmetallic micromandrels. The apparatus and process were developed for fabrication of microsphere pressure vessels for use as targets in laser-initiated fusion research.

I. INTRODUCTION

In research on laser-initiated pure fusion, target design has been limited severely by the lack of sufficiently energetic lasers. The most difficult constraint is that of size. Present laser fusion targets range from 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 to be 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 the deposition process, the microparticles must be forced to move individually and randomly in the coating medium to ensure wall thickness uniformity and homogeneity of the deposit.

Several techniques for applying metal shells to microspheres[1-4] have been evaluated. They include physical vapor deposition (PVD), chemical vapor deposition (CVD), sputter deposition, and electro- and electroless plating. An apparatus developed to electroplate microspheres for laser fusion targets has been reported.[5] Here, we describe an apparatus developed to electrolessly plate such microspheres.

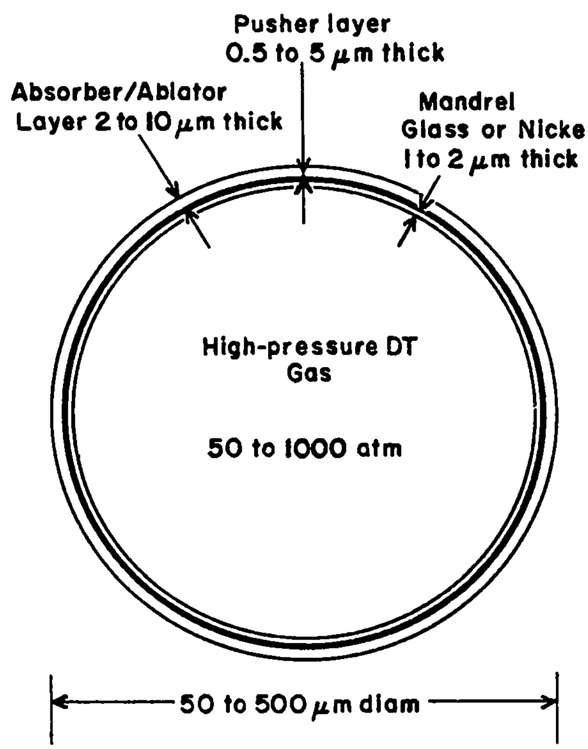

Fig. 1.
A hypothetical structured, multilayered laser fusion target.

II. APPARATUS

Electroless, or autocatalytic, plating has extensive decorative and engineering applications in the metal-finishing industry. Large parts are plated on racks; small parts are efficiently processed in bulk in screen baskets or perforated barrels. Applying thick, uniform coatings to hollow microparticles presented a challenge, because existing techniques could not be applied directly.

The initial approach to coating thin-walled metal or metal-coated glass shells, at both LASL and Bendix Kansas City, was to suspend the particles in the solution vortex or in a vigorously stirred electroless plating solution until the desired coating thickness was obtained. In theory, the particles would ride in the solution vortex and thus be plated uniformly. In practice, however, some particles were drawn into the solution meniscus where their motion and the deposition essentially ceased. As the plating progressed, other particles became denser than the solution medium, sank to the bottom of the plating tank, and agglomerated. A new apparatus[6] makes it practical to electrolessly plate discrete microparticles with uniformly thick deposits.

The electroless plating apparatus is shown in Fig. 2. The microparticles are confined in a cylindrical reaction chamber by fine mesh screens at top and bottom. The cylinder wall extends beyond both screens. The top extension serves as a solution overflow and intake cavity. The bottom extension is fitted over a stationary piston. The plating apparatus is immersed vertically in the electroless plating solution, and the extension rod is attached to a mechanical or pneumatic direction-reversing drive mechanism. The reaction chamber is forced intermittently up and down over the stationary piston. The direction-reversing cycle time is variable from 1 to 10 s. The moving chamber's stroke length is adjusted to purge the reaction chamber with fresh solution continually.

The solution movement through the reaction chamber moves the particles randomly during metal deposition. When the motion is downward, plating solution forced through the bottom screen into the reaction chamber lifts and disperses the particles that are denser than the solution. When the motion is upward, solution drawn into the cavity by suction through the top screen disperses the particles that float. Evolved hydrogen, which normally accompanies electroless deposition, is forced out of the reaction chamber during the downward stroke, thereby keeping the cavity filled with plating solution.

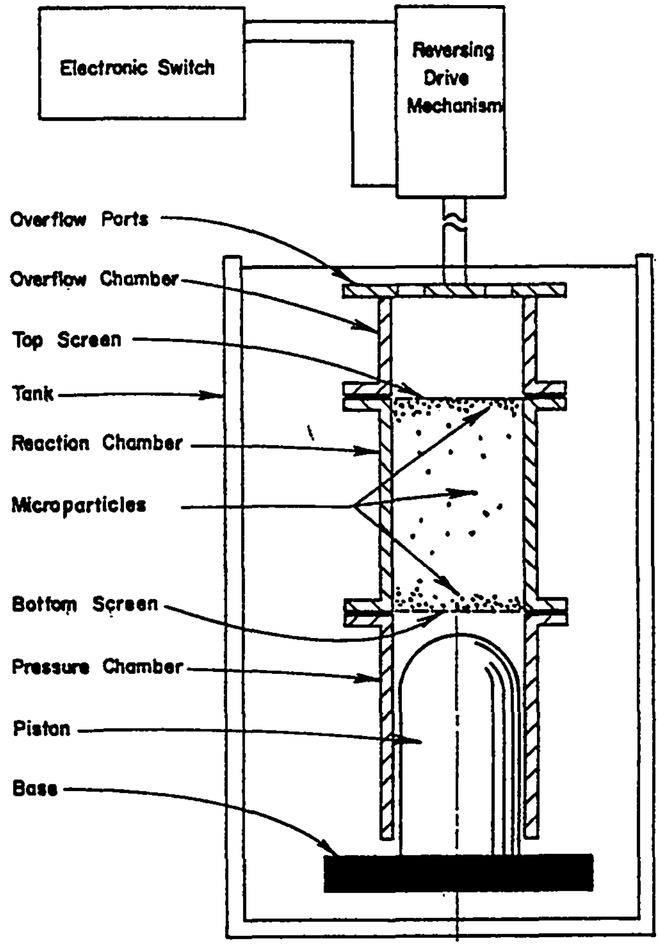

Fig. 2.
An apparatus for autocatalytic plating of discrete microparticles.

III. RESULTS

Uniform, fully dense deposits with excellent surface smoothness have been applied to 50- to 200-μm-diam spherical mandrels. The agglomeration inherent in previous techniques has been virtually eliminated. Metal distribution from particle to particle within the same batch is excellent.

Figure 3, a metallurgical cross section of an experimental laser-fusion target, shows a uniform coating of 16 μm of electroless nickel over the thin-walled (2-μm) spherical glass mandrel.

Figure 4 is a scanning electron micrograph of an electroless nickel coated laser target. The surface finish of particles coated in this apparatus is as good as, or better than, that of the starting substrate.

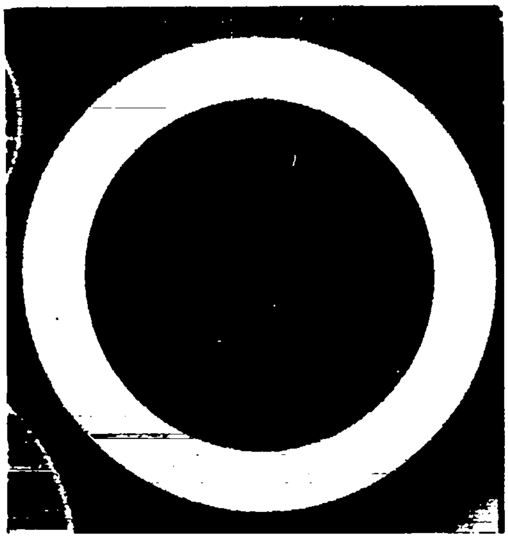

Fig. 3.
Metallographic cross section of 16 μm of electroless nickel plated on a thin-walled glass mandrel. (500X)

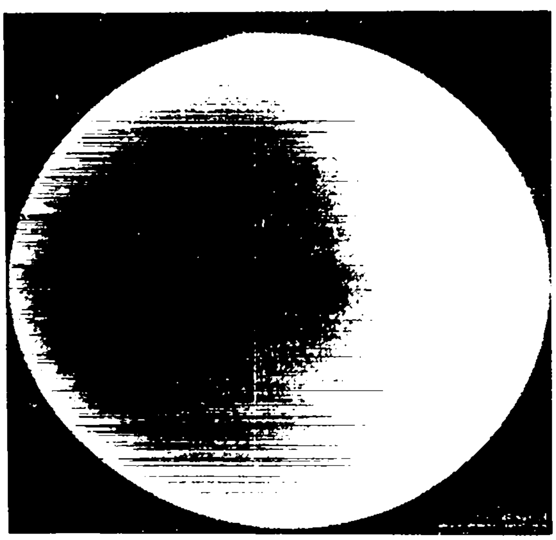

Fig. 4.
Scanning electron micrograph of an electroless nickel-coated laser target. (550X)

We have thus far applied electroless nickel coatings to both metal and metallized-glass spheres, 2 to 22 μm thick. Proprietary baths from the Shipley Company and the Sel Rex Corporation were used as plating solutions. Exceedingly fine-grained, smooth coatings have been deposited from the Shipley "Niculoy 22" bath and the Sel Rex "Lectroless Ni" process. The Shipley bath deposits a nickel-phosphorous-copper alloy that is typically about 12 wt% P, 1 wt% Cu, and 87 wt% Ni. The Sel Rex solution deposits a nickel-phosphorous alloy whose phosphorous content is <2 wt%. Batch sizes range from only a few spheres to over 100 000.

IV. SUMMARY

We have developed a method and apparatus for applying very uniform coatings to discrete microparticles by electroless techniques. Agglomeration or bridging of the particles is prevented by moving them randomly during deposition. The microparticle density is not critical and may be less than, equal to, or more than that of the plating solution. Although all particles coated thus far have been hollow spheres, the method is applicable to discrete irregular microparticles.

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