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LASER FUSION TARGETS

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INTRODUCTION

The laser driven implosion of deuterium-tritium (DT) filled glass microsphere targets compresses the DT fuel to high densities and temperatures where thermonuclear reactions are initiated.^{1, 2} To achieve high energy gain from the targets, the compressed density of the DT fuel must be many times the density of liquid hydrogen. High

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compressions can be attained only with ablatively driven targets. Diagnosis of high compression is, in part, based on spectral line broadening of argon which is added to the DT fuel. The shell surrounding the DT fuel in ablatively driven targets must be relatively thick. Thick glass shells would absorb the argon emissions; this would be a serious handicap in experimental targets since the density diagnostic tells us much about the success of the implosion. A solution to this is to coat thin (0.5 to 2 μm) glass shells with low atomic number material to thicknesses of, typically, from 15 to 20 μm .

Target coatings must satisfy a number of special conditions. It must have the same density as glass and must be very smooth and uniform to minimize fluid instabilities that would prevent compression. Also the method for coating must not heat the glass shells enough to cause their DT fuel fill to escape. Plasma polymerization³ coats the glass shells without overheating the shells and simultaneously permits a wide choice of monomer materials.

Most previous investigations and applications of the plasma polymerization process have neglected surface smoothness. The object of the present investigation was to identify, understand and control the parameters governing the formation of defects in plasma polymerized surfaces. There are two sources of defects in the plasma polymerization process. The first of these we call the process variables. These are

the variables that control the nature of the plasma. They include power dissipated in the discharge, pressure and rate of monomer flow. Defects arising from these conditions described by the process variables are independent of the nature of the substrate. A second important source of defects in plasma polymerized coatings is preexisting irregularities on the substrate. The relationship between the size of a substrate irregularity and the defect it generates is of vital importance in setting cleanliness specifications for the glass microshells. Substrate irregularities ranging in size from several microns to one tenth micron were used to determine their effect on coating smoothness.

EXPERIMENTAL

An inductively-coupled discharge was used, as previously described, as the source of activated monomer.⁴ The perfluoro-2-butene (PFB) was purchased from Columbia Organic Chemicals while the other fluorocarbon gases were purchased from Matheson. Each of the remaining reagents used in this work (for example the chloroform used as a chain transfer reagent) were either ACS analytical reagent grade or better.

Four types of well characterized surface irregularities were produced on glass slides which were subsequently fluorocarbon coated. Scratches were produced with a diamond stylus on a pyrex substrate. Latex spheres 1.10 μm (Dow Chemical Co. Lot #Ls1166B) were another

source of artificial irregularities of known character. Sieved metal powders with a narrow range of particle sizes were the third kind of irregularity which were coated. Finally a tungsten surface was prepared, photographed, coated and photographed again. It was possible to index the precoating and post coating photographs on the rough tungsten surface.

RESULTS AND DISCUSSION

We have found that although the process variables are not independent, orthogonal parameters we can optimize the combination under our control. Figure 1 shows a fluorocarbon coated glass microsphere whose surface is typical of those produced without complete optimization of process variables. The improvement which can be seen in Figure 2 is a direct result of addition of C_2F_6 as a chain transfer agent to the plasma during coating. We have found a marked improvement in the coating surface by modulated ion bombardment of the coating during deposition. A pulsed discharge also produces much smoother coatings than a continuous discharge because the formation of polymer particles in the gas phase is inhibited.

Control of the process variables and careful optimization of these variables did improve the surface uniformity of our fluorocarbon coatings, however, we still were unable to consistently meet the high

tolerances required for ablatively driven laser targets. Since substrate effects had not been addressed during the optimization of process variables we began an investigation of well controlled artificially produced coating defects. The coating surface replicated both spherical latex defects as well as sharp irregular metal crystalites. Irregularities cut into the surface of the substrate were also replicated by the coating as can be seen in Figures 3 and 4. We have often observed conical defect structures in cross sections of fluorocarbon films. The growth of these cones originating at surface irregularities, is dependent on process variables. The conical morphology implies that the physical shadowing effect known in sputtering techniques is responsible for the defect shape. Continuing experiments should improve our understanding of the deposition mechanisms that are responsible for these surface irregularities. Presently we know that substrate irregularities as small as one tenth micron high produce defects that make the coating unacceptable for use in a laser fusion target. Our aim is to develop an analytical technique that quantifies the coating system's ability to resist defect growth.

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FIGURE 1. An SEM micrograph of the surface of a glass microsphere coated with 20 μm of fluorocarbon.

FIGURE 2. An SEM micrograph of the surface of a glass microsphere coated to a thickness of 20 μm using hexafluoroethane pulsing.

FIGURE 3. An SEM micrograph of a fluorocarbon coating grown over 2 scratches in the glass substrate.

FIGURE 4: A cylindrical sector defect in a fluorocarbon film grown over a scratched glass surface.