PLASMA POLYMERIZED FILM COATING ON PELLET TARGET

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ABSTRACT

Plasma polymerized film coating was studied in relation to fabrication of multishell structure in a pellet target for laser fusion experiments. plastic film, metal doped plastic film and low density plastic film were coated on substrates of glass micro sphere, glass fine rod and glass plate. The coating rate and the surface finish were improved using hexafluorobutylmethacrylate.

1. INTRODUCTION

Among numerous new energy developments, fusion reaction is an essentially inexhaustible energy source. Different conceptual approaches to producing controlled fusion reaction are being investigated. The two major approaches are magnetic and inertial confinement, both of which require heating a deuterium-tritium (D-T) mixture to an ignition temparature.

In the inertial confinement approach, the D-T fuel is compressed to required temperature and density by spherical implosion caused by rocket reaction forces. For the compression, powerful energy driver and specifically designed high performance targets must be developed. Because of recent progress in high power laser, it was made possible to fabricate multiterawatt lasers which were necessary to ignite the inertial confinement fusion of D-T fuel. For higher efficiency of power production, however, a parallel effort to that of developing more powerful laser must be devoted to design and fabrication of high performance laser targets[1,2].

Specific targets must be designed at each stage of development of the high power laser. Multishell targets are designed for the scientific breakeven, i. e. to a thermo nuclear yield equal to the energy deposited by the laser. The multishell structure will be made of plastic, metal, glass and D-T fuel. The principal constraints on pellet target fablication are the spherical symmetry, the surface smoothness and the low temperature coating. The processing of pellet fabrication must be also available for mass production and the cost of pellet is necessary to be cheap.

Low temperature plasma chemical process was proposed to be a possible method for a plastic coating on a glass micro baloon (GMB) [1-5]. The plastic coating is however replacing by a vapor phase pyrolysis (VPP) of di(p-xylene), because the growth rate is usually larger than that of plasma polymerization and a levitated pellet is coated by this method [6]. But, in this stage, the significant task is to prepare several technical processes in order to reply various demands on the pellet fabrication.

In this paper, the plasma polymerization coating of plastic film, metal doped plastic film and low density plastic film were studied. Especially, the uniform coating on glass micro sphere was discussed and a new monomer was proposed to be used in order to improve the growth rate of plasma polymerized film.

2. EXPERIMENTAL

The plasma polymerization coating was performed using a tubular type reactor which has parallel plate electrodes [7]. Glass micro sphere (250-300 μm diameter) supported by a glass rod, glass fine rod and glass plane were used as substrates which were placed on the discharge electrode as shown in Fig. 1. Selection of monomer for the pellet coating is important subject. In this experiment, ethane, styrene and hexafluorobuthylmethacrylate were used for plastic coating and low density coating. Tetramethyltin was selected as the monomer for metal doped plastic film coating.

3. RESULTS AND DISCUSSION

3.1. Uniform coating on glass micro sphere

As a coating object, the pellet is very small sphere and its diameter is ranged from 50 μm to 5000 μm. The spherical symmetry of coating is very important. The variation in concentricity is necessary to be 2 % or less. For surface smoothness, peak-to-valley value of coating surface must be smaller than 1000 A. Also, the necessary thickness is ranged from about 10 μm to 100 μm [1].

Usually, plasma polymerization is performed at a pressure of 0.1 -1.0 torr. A mean free path of coating particle becomes same order of the diameter of pellet sphere. If the mean free path is larger than the diameter of sphere and the coating particles are flowing to the specific direction in the reactor, the coating particles will deposit on the specific area of sphere. This will result in inhomogeneous coating on pellet sphere. If the critical pressure is defined as that the mean free path is equal to the diameter of sphere, a relation between the critical pressure and the diameter is calculated as a function of gas temperature in air as shown in Fig. 2.

In the plasma, there are electrons, ions and activated monomers like as free radicals, which will contribute to plasma polymerization. The behaviors of active particles in plasma are evaluated. The displacement of charged particle in a half cycle of 13.56 MHz is calculated to be 0.1-1.0 mm at the discharge condition because the mean drift velocity of ion is about 10^6 cm/sec [8]. The flow velocity of particle is 8 x 10^4 cm/sec at 0.5 torr and 20 cm^3 STP

/min in our apparatus. The flow length of neutral gas molecule in a half cycle of discharge is calculated to be 60 μm. Whereas, the charged particle drifting in the electric field is supposed to affect on the coating, but the effect of gas flow may be small.

In order to study the uniform coating on the sphere, plasma polymerization coating with styrene and ethane was performed on a fine glass pipe at 0.3-1.0 torr, 20-40 cm^3STP/min and 20-50 watts. An example of sectional SEM picture was shown in Fig. 3, where plasma polymerized styrene was coated at 0.3 torr and 25 watts. The growth rate was 1.4 μm/hr. Mostly uniform coating was observed on the pipe in the range of discharge condition. One of reasons of uniform coating will be referred to the ion sheath formed around the glass pipe. The ion sheath will diminish the effect of directional ion bombardment to the substrate. The density of free radical is usually higher than that of ion [9] and the electrically neutral free radical will also contribute to the uniform coating without the affection of electrical field.

The value of growth rate is comparative to the values reported previously and is smaller than that of VPP of di(p-xylene) [3]. In order to improve the growth rate, 6FBMA was used as a new monomer. An excellent surface finish was obtained at a high growth rate of 6 μm/hr as shown in Fig. 4. But, when the substrate was set in the farther down stream of the reactor, hemispherical defects were observed on the coating surface as shown in Fig. 5. At a higher growth rate, the number of hemispherical defect increased. Usually, shape, size and number of hemispherical defects depended on polymerization condition and monomer. If the plasma polymerized film was coated on the surface which has defects like as scratches, hemispherical defects were also formed on the scratches [10]. Whereas, an origin of hemispherical defect will be refer to defects on a substrate. However, this is not enough for the explanation of hemispherical defect, because the number of defect depended on the polymerization condition. Therefore, another origin of defects will be referred to the relatively large particles polymerized in the gas phase and deposited on the coating surface [11].

3.2. Coating of metal doped plastic film

In order to dope metal into the plastic film, tetramethyltin was adopted for plasma polymerization. Actually, double layers of plasma polymerized tetramethyltin and styrene were formed on glass fine rods. The controll of discharge for a coating of double layers was very difficult because optimum conditions for each layer were different. When the discharge was not controlled correctly, cracks and deformation of thick film were observed. The facts suggests that the surface tention is serious problem for thicker film coating. However, it is belived that the uniform coating will be obtained by controlling the discharge carefully.

3.3. Low density coating

At a certain condition of plasma polymerization that gas flow rate is small and discharge power level is high, it is well known that powder like polymer is obtained [9]. The powder like polymer was aimed to use as a low density layer in the pellet target. As shown in Fig. 6, the powder like polymer was coated on a glass fine rod sucessfully. The density of powder was about 50 mg/cm^3. The serious problem of powder coating is how an uniform film coating can be performed on the powder as an outer shell.

REFERENCES

1) The commettee for pellet target developing (Chairman C. Yamanaka),"Report of the situation in pellet target development", April (1980).
2) D. M. Stupin and R. J. Fries,"Advanced Laser Fusion Target Fabrication Research and Development Proposal", LA-UR, 78-2762 (1978).
3) R. Liepins, M. Cambell and R. J. Fries,"Plastic Coatings for Laser Fusion Targets", LA-UR, 78-2438 (1978).
4) W. L. Johnson, S. A. Letts, C. W. Hatcher, L. E. Lorensen and C. D. Hendricks, ACS Polymer Preprints, 14, 544 (1978).
5) R. Liepins, M. Campbell and R. J. Fries, ACS Organic Coatings and Plastic Chemistry, 40, 175 (1979).
6) W. E. Anderson, J. M. Bunch, R. Liepins and A. T. Love, Conf. on Laser & Electro-Optic Systems, Sym. on Inertial Confinement Fusion, San Diego, Feb. (1980).
7) S. Morita, A. T. Bell and M. Shen, J. Polym. Sci., Polym. Chem., 17, 2775 (1979).
8) S. Morita, S. Ishibashi, M. Shen and A. T. Bell,"Modification of Polymers" ACS Sym. Ser., 121, (ACS, Washington 1980).
9) H. Kobayashi, A. T. Bell and M. Shen, Macromolecules, 7, 277 (1974).
10) M. Niinomi, H. Kobayashi, A. T. Bell and M. Shen, J. Appl. Phys., 44, 4317 (1973).
11) S. A. Letts, W. L. Johnson, D. W. Myers, J. D. Illige, L. E. Lorensen and C. W. Hatcher, UC-ID, 18324 (1979).

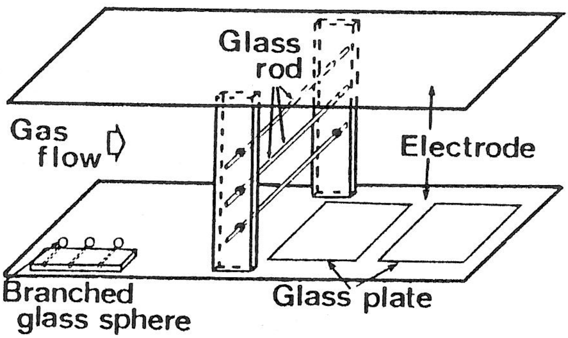

Fig. 1. Disposition of substrates

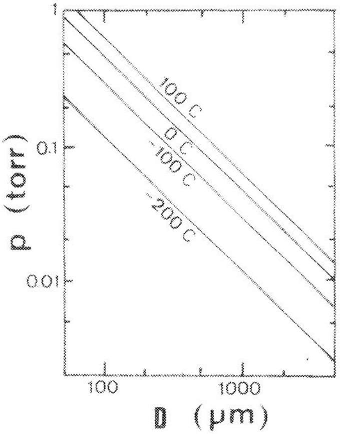

Fig. 2. Relation between the critical pressure of coating and the diameter of pellet at each gas temperature.

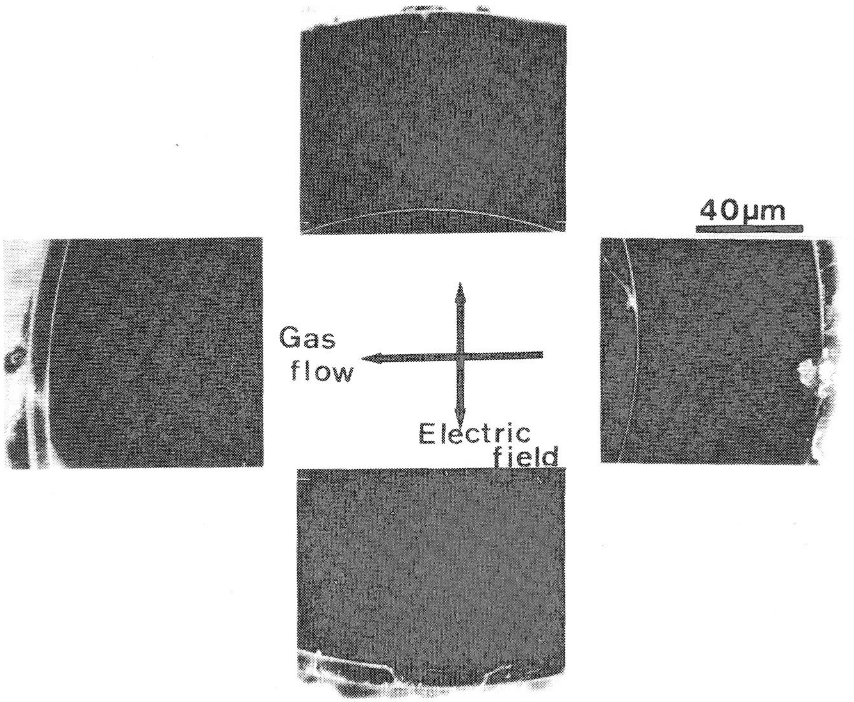

Fig. 3. Cross sections of glass pipe coated by plasma polymerized styrene film at each direction of electric field and gas flow.

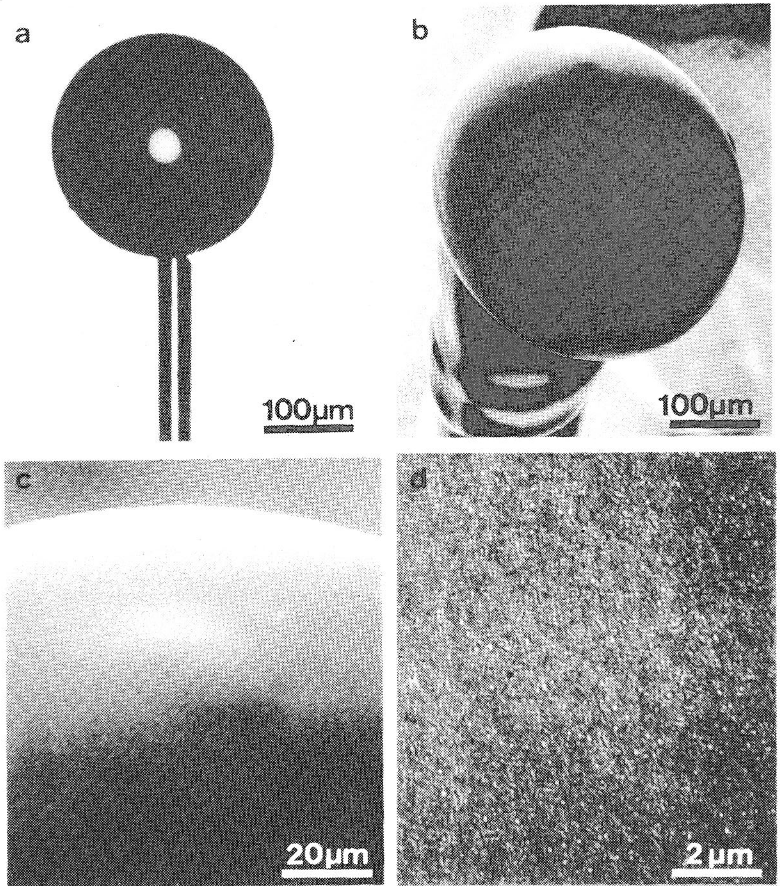

Fig. 4. PP6FBMA coating;(a) Glass sphere, (b)-(d) Coated sphere.

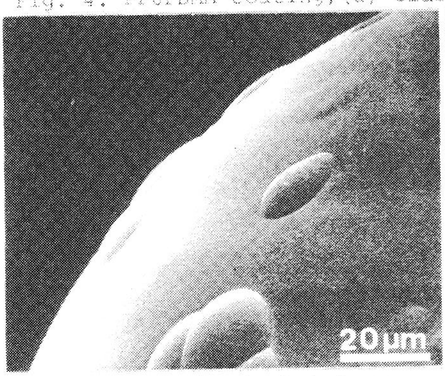

Fig. 5. Hemispherical defects on PP6FBMA coated sphere

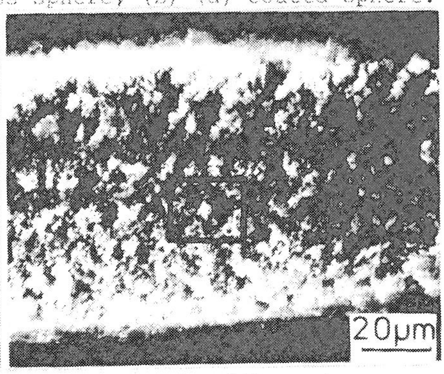

Fig. 6. Powder like polymer coating of PPStyrene.