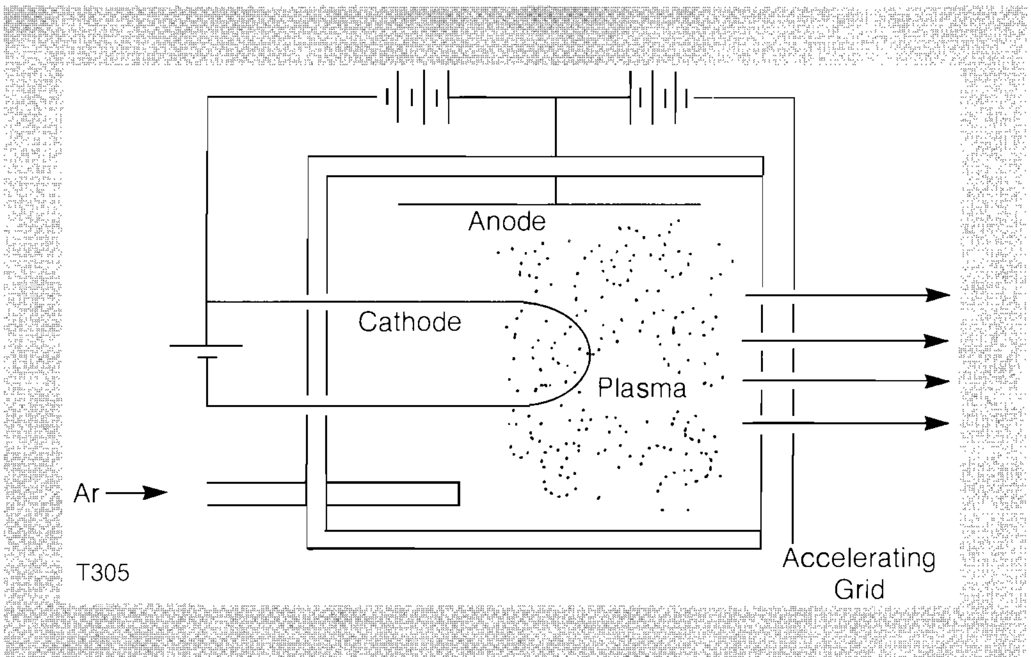
3.B Target Pusher Layer Fabrication Developments

The Target Group has recently begun to apply ion beam sputter deposition for target pusher layer fabrication. Metal deposition on both levitated and stalk-mounted fusion targets has been demonstrated. We believe this is the first application of this versatile deposition technique to IF target pusher layer fabrication. Our initial results indicate that ion beam sputtering is far more controllable than the more conventional magnetron sputtering, and its use should permit us to produce better coatings of a wide variety of materials than was previously possible.

In any sputter deposition process, a block of the deposition material (the sputter target) is bombarded by energetic ions, usually of argon. The ions physically eject atoms of the target material, which then deposit on the surrounding surfaces, including the substrate (fusion target core). In conventional plasma sputtering a glow discharge is struck between two electrodes, one of which is constructed from the material to be deposited. A substrate placed in this environment can be rapidly coated by atoms sputtered from the target, producing pusher layers of reasonably high quality. There are, however, several disadvantages to this technique. For example, the substrate is directly exposed to the discharge plasma and as a result is heated by radiation and by energetic electrons from the discharge. This adversely affects the deposited layer's surface quality. In addition, the flux of sputtered atoms, their energy, and the gas pressure all affect the quality of the deposited surface; in a glow discharge, these parameters cannot be independently varied to optimize the deposition process, but rather are coupled through the dynamics of the gas discharge.

Fig. 31
A schematic of an ion beam source. Ions are extracted from the plasma through a grid system and accelerated toward the sputtering target.



In contrast, ion beam sputter deposition allows much greater control of the deposition process parameters. Figure 31 illustrates an ion beam source. The plasma which produces the ions is confined within a small volume. Ions are extracted from this plasma through a grid and then accelerated through a second grid toward the sputtering target. This permits independent control of the ion flux and the ion energy. Furthermore, the pressure at the location of the sputter target and substrate can be varied over a wide range (~ .005 Pa to .02 Pa) while still maintaining the plasma discharge. Finally, the substrate is not directly exposed to the plasma, thereby reducing the heat load.

The apparatus we have used for the ion beam sputter deposition of pusher layers on stalk mounted microballoons is illustrated in Fig. 32. The sputtering target's conical geometry with the microballoon located in the center of the cone maximizes the deposition rate and improves the deposition uniformity. The microballoon is rotated about an axis perpendicular to the axis of the ion beam and is protected from direct ion beam bombardment by a small masking shield. With this configuration, both copper and iron

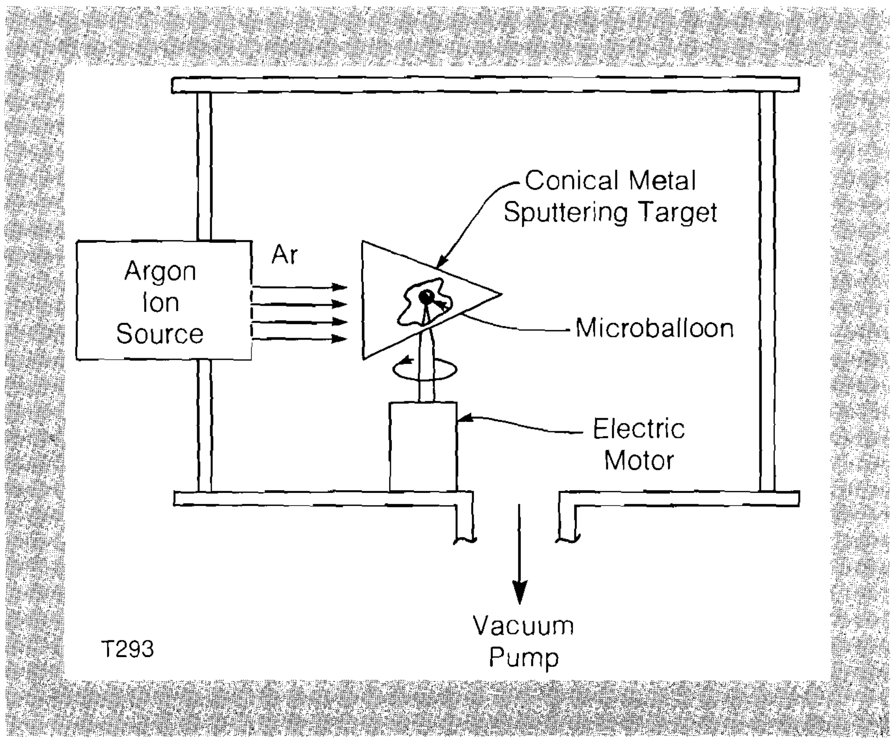


Fig. 32
The apparatus used to ion beam sputter deposit metals onto stalk mounted microballoons. The sputtering target is conical, and the microballoon is rotated in the center of the target.

depositions at rates in excess of 1 μm/hr have been achieved. Pusher layer thickness uniformity, determined by cross sectional measurements of fractured microballoons is typically within 10%. Figure 33 is a scanning electron micrograph of a 1.2 μm thick iron coating produced by ion beam sputter deposition which clearly shows that 1 000 Å surface smoothness is achievable.

Figure 34 illustrates the experimental configuration used for ion beam sputter deposition onto levitated target cores. The ions are directed at a planar target which is positioned above the

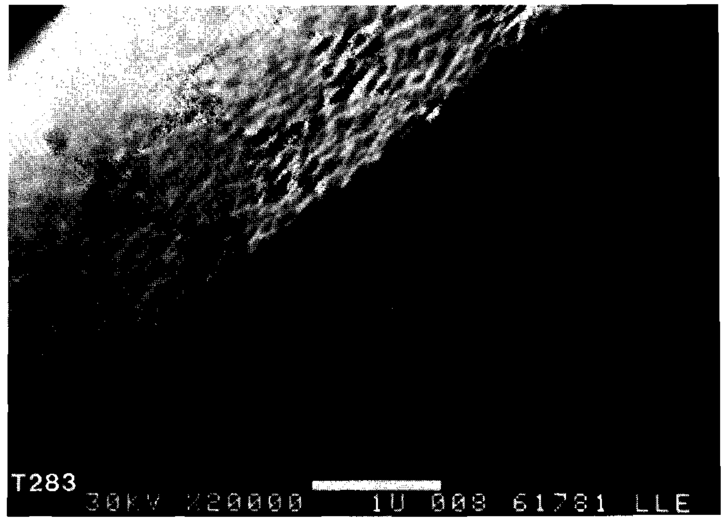


Fig. 33
An iron coating deposited on a stalk mounted microballoon using ion beam sputtering. The thickness is 1.2 μm, and the surface roughness is less than 1000 Å.

levitated balloon. The levitation system consists of a converging array of 25 μm diameter capillaries through which argon gas flows at approximately 1 scc/min[1]. A beveled washer produces an additional radial component to the gas stream flow which provides lateral stability to the levitation. This molecular beam levitation technique has been used with conventional sputtering at LLE,[2] and elsewhere.[3]

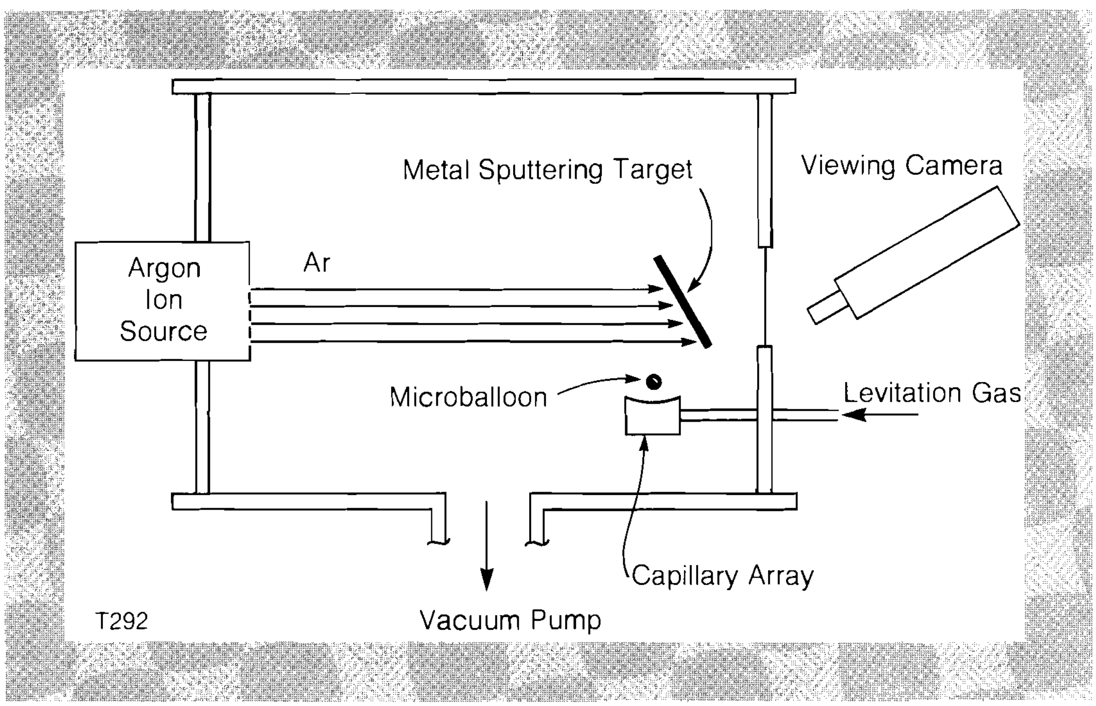


Fig. 34
The apparatus used for ion beam sputter deposition onto levitated microballoons. A focused hole structure produced the Ar molecular beam which was used for levitation.

One serious difficulty usually encountered with glow discharge sputtering onto molecular beam levitated target cores is electrostatic charging due to the proximity of the plasma; the resulting time varying electrostatic force on the balloon makes levitation difficult. We find no evidence of this difficulty for ion beam sputter deposition. However, the low pressures used in ion beam sputtering reduce damping of the target core's motion which creates other problems. We believe that the target becomes gyroscopically stable about a preferred axis, perhaps due to an undetectable defect in the balloon, and thereafter coats nonuniformly. At some point the target core begins to precess, and soon goes into uncontrollable oscillation. We are studying the possiblility of incorporating magnetic damping to alleviate this problem. Figure 5 is a scanning electron micrograph of a copper surface which has been ion beam sputtered onto a glass microballoon target. Although pusher layer fabrication on levitated target cores is not yet routine, Fig. 35 illustrates that good pusher surface finishes are possible with the ion beam sputter deposition technique.

In summary, the versatility of ion beam sputtering, the availability of a wide variety of sputter target materials, and the encouraging preliminary results demonstrate an important extension of our metal coating capabilities.

REFERENCES

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3. J. K. Crane, *Technical Digest of the Topical Meeting on Inertial Confinement Fusion, San Diego, CA,* 1980.

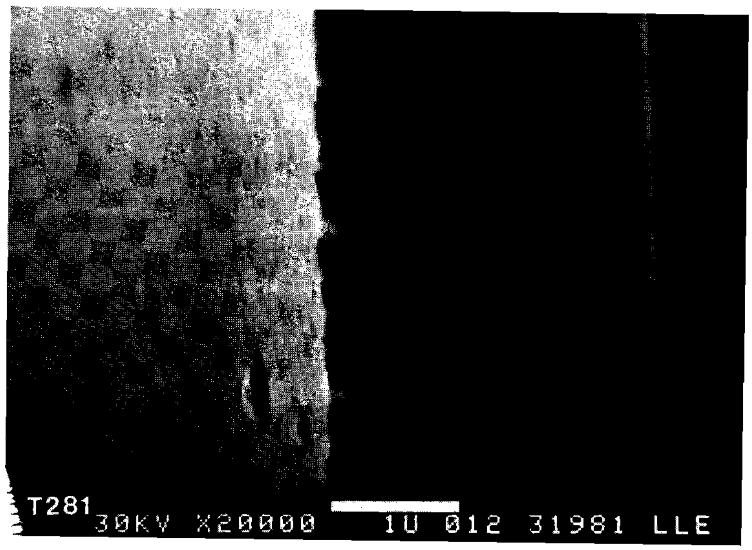

Fig. 35
A copper coating which was deposited on a levitated microballoon using ion beam sputtering. The dense structure and smooth surface of the coating can be seen in this electron micrograph.