Section 3
DEVELOPMENTS IN MICROFABRICATION

3.A Biased Sputtering of Target Pusher Layers

Many laser fusion target designs call for metal pusher layers which have surface roughnesses of less than 50 nm and thickness uniformities of a few percent. Applying coatings which meet these requirements to spherical glass microballoons is a unique challenge. One reason for this is the problem which arises when the coating material is deposited on a surface at oblique angles of incidence, as it must for a spherical substrate. In this situation, small defects in the surface tend to shadow the surrounding area, and therefore grow preferentially with respect to the background.[1,2] The rapid growth of these defects can lead to unacceptably rough surfaces.

Another variable in the coating process is the mobility of the atoms which arrive at the surface. This mobility is a function of the substrate temperature, energy of the incident atoms, and the reactivity of the metal with impurities such as oxygen and nitrogen which always exist in a coating environment. If the mobility is too low, the coating grows in columns, aggravated by the oblique incidence problem discussed above. This produces an underdense layer with a rough surface. If the mobility is too high, macrocrystallites grow, which also leads to a rough surface.[3]

An approach which we have been exploring, in order to gain greater control over the growth of defects and surface mobility, is the use of a bias voltage applied to the microballoon during sputter coating. Biased sputtering, as this is called, is a common practice in many coating applications,[4,5,6] but this is the first time, to our knowledge, that it has been used in pusher layer fabrication. The principle is quite simple. A film being grown by sputtering is bombarded by ions and neutral atoms of both the depositing metal and the background sputter gas (usually Ar). By applying an accelerating (negative) voltage to the substrate, the ions can be made to arrive more nearly normal to the surface, and they will impart energy to the growing film, thereby increasing the adatom mobility. There is considerable evidence[4,5] that bias sputtering can dramatically alter the quality of deposited films. This led us to examine its effect in pusher layer fabrication.

The apparatus used for our experiments is illustrated in Fig. 17. The vacuum system consists of a cylindrical stainless steel chamber, 40 cm in diameter by 30 cm high, pumped by a cryo-baffeled 15 cm diffusion pump. The sputtering source is a Sloan model S-310 magnetron, operated at a dc power of 340 watts. The system is pumped to a base pressure of 2 x 10^{-4} Pa or below prior to each run. The system is operated at a pressure of 1.0 Pa using purified Ar. The stalk-mounted microballoons are located 7.5 cm directly below the center of the S-310, and are rotated as shown in Fig. 17. A sliding contact allows the microballoon to be biased during coating. No precoating of the microballoon or stalk was done; therefore biasing does not occur until a continuous conducting film, tens of nm thick, has been deposited on both the stalk and microballoon.

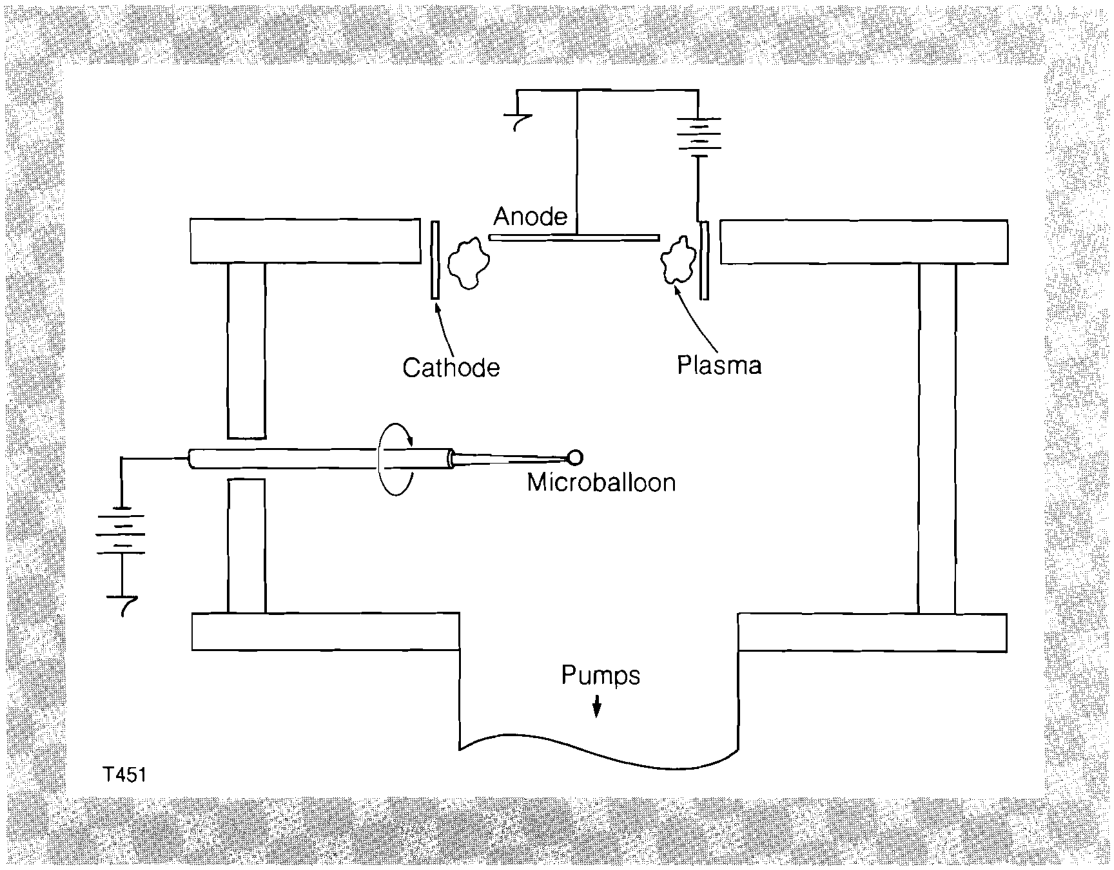
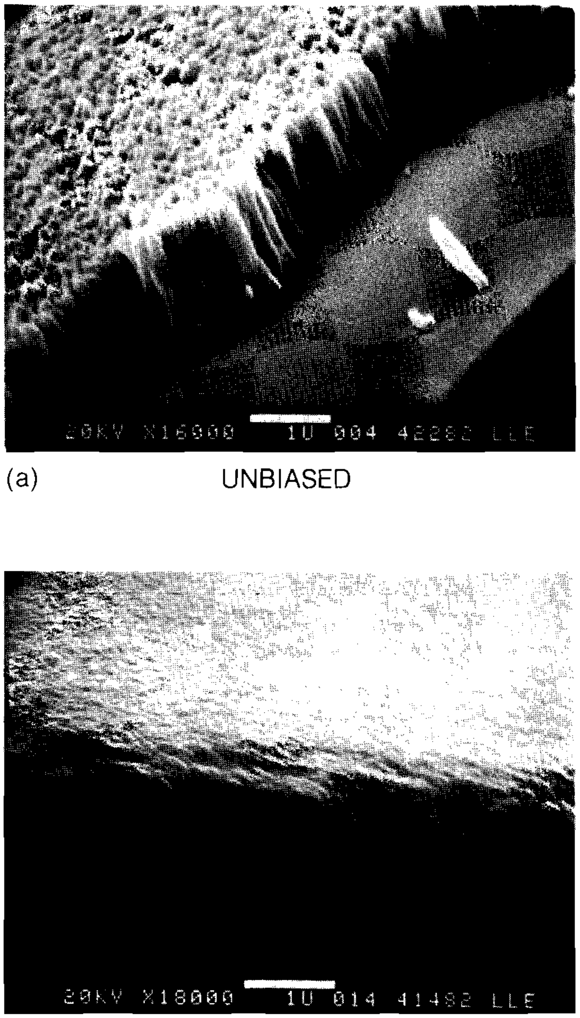


Fig. 17
Illustration of the apparatus used to sputter coat-biased microballoons. The stalk-mounted microballoon is located 7.5 cm below the magnetron sputter source and is rotated about a horizontal axis as shown. Negative biases of up to 100 V can be applied to the microballoon during coating.

Figure 18 shows scanning electron micrographs of Ni coatings applied under otherwise identical conditions, without bias (a) and biased at – 100 V (b). Figure 18a illustrates the columnar growth and resulting rough surface which is evidence of limited surface mobility. In Fig. 18b, the biased case, we see a much denser microstructure and smoother surface.

There appears to be an effect due to the stalk in the bias coatings. The hemisphere opposite the stalk, where Fig. 18b was taken, appears to be relatively more smooth than the area immediately surrounding the stalk. This is not surprising since the stalk is part of the charging circuit, and the symmetry of the electric field lines near the stalk will be different from that opposite the stalk. Nevertheless, the effect of a bias voltage is to improve the coating smoothness at all locations. We have found similar results for Cu deposited on biased microballoons.



(a) UNBIASED

(b) BIASED AT -100 V

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Fig. 18
Comparison of Ni coatings applied to a) unbiased and b) biased microballoons under otherwise identical conditions. The applied bias of – 100V clearly results in a denser microstructure and smoother surface than that found in the unbiased coating.