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The UVB-100 and UV Enhanced Deposition: Part 2

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Note that all references to The Phototron have been replaced with The UVB-100. Otherwise this article is unchanged.

by Phil Danielson

Part 1 discussed how the quality of most thin films formed by physical vapor deposition would be improved by total or partial desorption of water vapor from the substrate.

Residual Water Vapor Effects During Deposition

The amount of water vapor in the residual gases during deposition is likely to have an effect upon the quality of the film being deposited. Figure 7 shows the number of molecules per liter of system volume present at various pressures. Since all and any of these molecules are in constant motion within the vacuum chamber, it becomes statistically possible to determine the number of collisions between molecules and a surface. In this case, we can narrow the focus to the number of molecules that will come in contact with a substrate surface per unit time. Figure 8 shows the number of collisions between molecules and one (1) square centimeter of substrate surface during a single second's duration. If we assume a water vapor partial pressure of 10^{-6} torr, we can see that 10^{15} molecules are hitting each square centimeter of substrate per second. Under normal conditions, this translates to the formation of a monolayer of water sorption per second, as shown in Figure 9.

The actual specific effects of water molecules sticking to the forming film will depend upon a number of variables such as deposition rate, substrate temperature, type of film being deposited, and the deposition process being carried out. There are, however, obvious effects that must at least be considered. If we use the mental picture shown schematically in Figure 10 as occurring all during the deposition process, we can then focus on the growing film.

Although each and every impacting water molecule will not stick to a surface through the weak physical bonding that usually occurs, a number will do so. Additionally, some of these water molecules will react with such chemically active films as aluminum. Impacting water molecules that would probably neither stick nor react will be plastered over and trapped by the forming film so they cannot escape. They then become inclusions of impurities within the film and have their own resultant effect on film structure and performance.

UVB-100 Effects on the Forming Film

Even though a UVB-100 has been used during the pumpdown to reduce the amount of water vapor present in the residual gases, whatever is left will have a very good statistical chance of impacting with the forming film as deposition occurs. The detrimental effects discussed above can be negated or at least reduced by flooding the film with UVB-100 radiation during the entire deposition process. This will make the surface of the film a relatively hostile surface for water vapor sorption. Impacting water vapor molecules will be either UV energized in flight or as they strike the surface so their probability of sticking to the film or becoming trapped will be much lower.

Practical Considerations

Obviously, the more UV power directed onto either the substrate or the forming film, the more desorption effect can be expected. Additionally, the lower the water vapor concentration in the residual gases, the lower the possibility of impact. In a practical system, some care in installation and application must be taken to make sure that a self defeating situation does not arise. Since the whole point in using a UVB-100 during pumpdown is to reduce the desorption rate of water to effect a lower concentration of water vapor in the residual gases prior to processing, you don’t want to maintain an elevated desorption rate during processing. Turning the UVB-100 OFF when the desired desorption rate is achieved is the usual technique, but then you can’t use the UVB-100 during deposition or desorption from the rest of the systems inner surfaces will result.

This apparent dilemma can be avoided by realizing that we are looking at two different jobs for the UVB-100 technique and that they must be approached differently. You want to use a UVB-100 that spreads as much UV power as possible throughout the chamber for pumpdown desorption, and you want to put as much power as possible on the substrate for deposition. During deposition, you want all the UV power on the substrate, but you don’t want much to hit the other surfaces where it will cause desorption during deposition. One way of solving the dilemma is to use two different UVB-100 configurations as is shown schematically in Figure 11. The open or nude UVB-100 is used during pumpdown and the Substrate Desorber is used to concentrate almost all the UV power on the substrate during deposition so further chamber surface desorption is kept to a minimum during deposition.

Film Effects Not Related to Water Vapor

A number of additional effects on thin film deposition processes have been reported relating to the use of UVB-100 radiation that do not appear to be connected totally with water desorption. Although none of these effects are, as yet, totally understood; the results are real enough that further work is definitely required. It is unlikely that effects will be seen in every process, system, or material; but it is important that further work be done and reported.

Surface Mobility

Changes in film characteristics where the film has been bombarded by UVB-100 radiation during formation have been noted that would normally be attributed to increased surface mobility of arriving depositant atoms. This would be an effect that would probably not be traced to the absence of water molecules in the film alone. Some mechanism of energy transfer from the UV to the depositant is the present hypothesis for this effect. Some form of photoionization or a related phenomena has been put forth as a possible explanation, but further work will likely be needed to clear up the actual mechanism and quantify the resultant film effects.

Plasma Density and Sputtering Rates

Changes in the performance of sputtering cathodes have been noted in terms of increased light emission and increased sputtering rates with changes in sputtered film properties. Some new effect on plasma density is likely if photoionization is also occurring within the plasma. Although this process is also not completely understood, it is expected that changes in sputtering processes could be brought about by further work in this area.

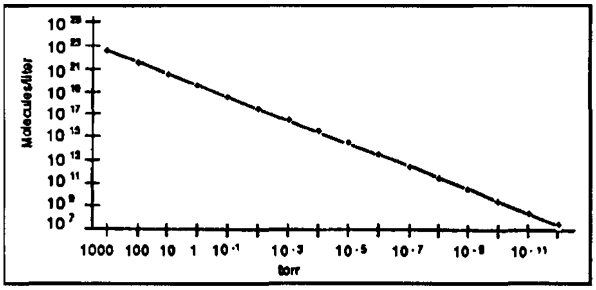

Figure 7. Number of molecules per liter of system volume at various pressures.

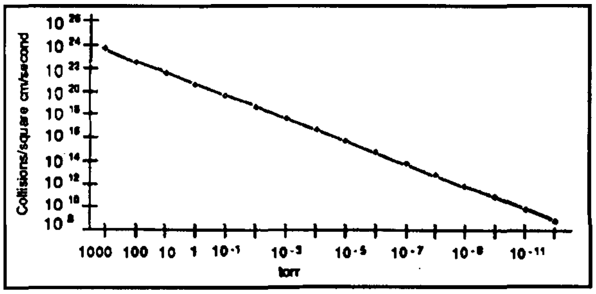

Figure 8. Number of collisions between molecules and one square centimeter of substrate surface per second.

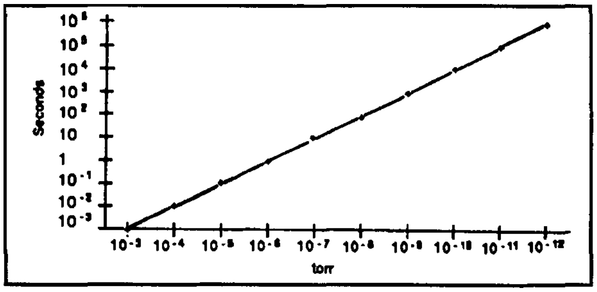

Figure 9. Time for water monolayer formation.

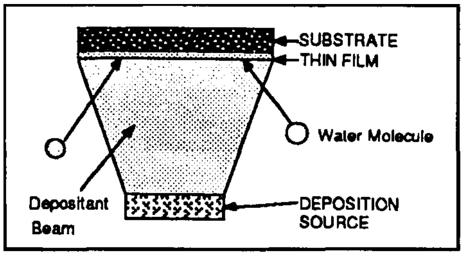

Figure 10. Water molecules impacting the growing film.

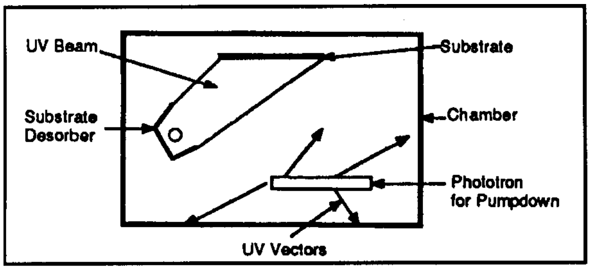

Figure 11. Schematic view of two UVB-100 devices in single system for specific applications.