PRIMING SUBSTRATES PRIOR TO ORGANIC COATING

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The following compounds are commonly used form priming:

1) Hexamethyldisilazane (H.M.D.S.) $C_6H_{19}Si_2N$ is used in over 99% of photoresist priming applications.

2) Trimethylsilyldiethylamine (T.M.S.D.A, T.M.S.D.E.A., or D.E.A.T.S.) $C_7H_{19}SiN$ has a faster reaction time than H.M.D.S. but is not in common use for silicon layers. It is commonly used for metal layers.

3) A.P.T.S. $C_9H_{23}NSiO$ or A.E.P.T.S. $C_6H_{12}N_2Si$ are both used for priming (for polyimides). These are low vapor pressure chemicals and difficult to deal with in practical use.

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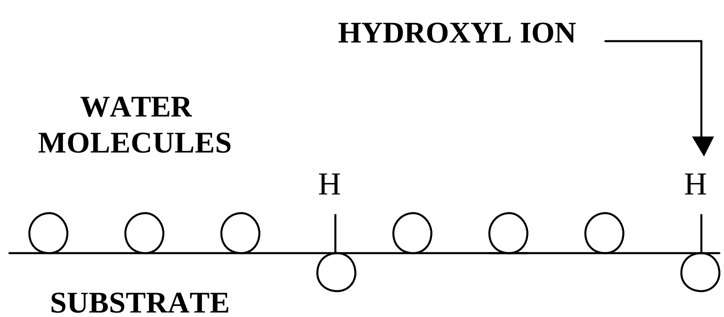
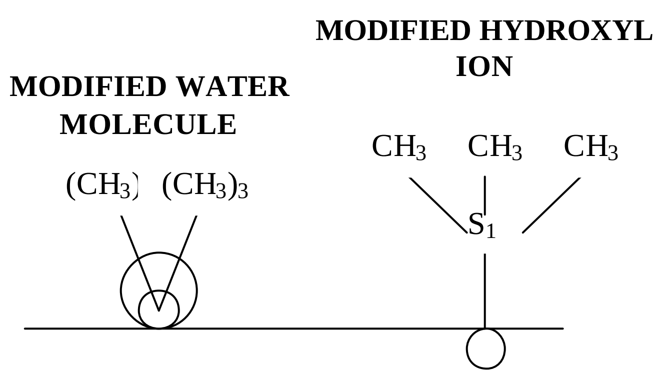
To effectively prime a surface for photoresist adhesion it is imperative to dehydrate the wafer surface as completely as possible. If water vapor remains, it will affect the priming in two ways.

a) H.M.D.S. will react with hydrogen and any water on the wafer surface. As the water molecules can be (and usually are) many molecules deep, it can react with the top layers of water leaving an unreacted layer of water beneath. This causes a weak spot for etching agents to attack and the very common appearance of a slightly ragged line (a very likely site for electromigration) at etch when compared to a totally dehydrated primed wafer.

b) If only one molecule of water is left on the surface, H.M.D.S. will react with it. As the water molecule is not ionically bonded to the surface, the molecule created by the addition of the H.M.D.S. is similarly not bonded to the surface and will lift at etch.

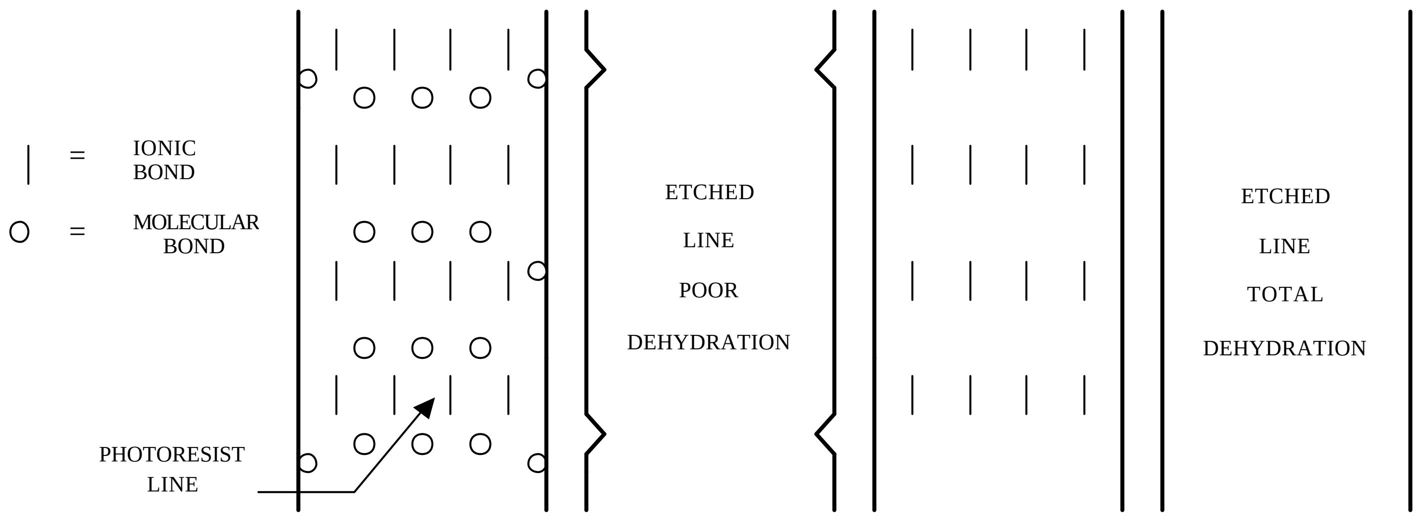
Note: Hydroxyl ions are ionically bonded to the wafer surface and the modified ion will also be bonded to the surface and difficult to remove at etch.





A quantitative method of relating to the effects of partial v's complete dehydration was reported by one semiconductor manufacturer with a 1.2 micron silicon gate structure. After quite some time optimizing their Track system, they were able to achieve a resolution of +/-0.1 micron CD disparity.

This was reduced to +/- 0.06 with a YES Batch Prime simply because of superior dehydration.



Another problem caused by water is that, in combination with wafer dopants, it can have a catalytic effect on the priming agent. Silanols are acid catalyzed and on phosphorous doped surfaces phosphoric acid is created. (It is not uncommon to have a phosphorous doped surface primed for a time of 3 to 4% of a normal prime time).

To further complicate the matter, the molecular weight of the photoresist used causes variations. Most of the industry standard positive photoresists are of large molecular weight.

Shipley 1350, Kodak 820, and Hunts L.S.I. have a molecular weight of 80,000 and a water contact angle of 75 degrees is close to perfect with these heavy molecules. (This contact angle is achieved with a 300 second prime in a Y.E.S. Vacuum Bake/ Vapor Prime System).

With smaller molecular weight photoresist, a lower contact angle is achieved and a correspondingly shorter prime time is required.

Shipley A.Z. 111 has a molecular weight of 13,000 and requires a prime time of 60 seconds.

Kodak 809, a high resolution photoresist, has a molecular weight of 5,000 and requires 10 seconds.

One manufacturer with an internally manufactured photoresist for ultimate resolution, (molecular weight of 1700) used a prime time of 1 second which required a modification of his YES vapor prime unit to achieve controllable times.

The last complication is the number of available hydroxyl sites for silylation. Ceramics and silicons have lots of free hydroxyl sites and are easily primed. Metallics have less available sites and thus take longer to react to the same level as a silicon surface. For optimum priming on an aluminum surface, up to 20 minutes in a batch prime is common.

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With these factors in mind, one manufacturer did a detailed analysis of what was required to provide an optimum prime and how it related to Track and Batch priming.

First, they performed a Track type single wafer dehydration cycle using a hot plate in a vacuum with a downstream humidity detector.

Using a variety of different substrates they found that with a hot place set a 150°C it could take up to 210 seconds to dehydrate a single wafer completely.

To prime the surface with HMDS took a further 10 to 300 seconds for a water contact angle of 75°.

Using DEATS or TMSDEA, the priming time for silicon dioxide surfaces was 10 seconds.

Unfortunately, for faster reacting surfaces, the optimum time was 0.3 seconds; - in their opinion an uncontrollable period.

The next part of their study looked at particle generation. Since they already had multiple YES System, they were able to characterize the particle generation at less than 0.04 particles, 0.3 micron in size, per square centimeter. (A specification that none of the Track companies could meet).

The last part of their study looked at reliability and in this they referred to published Sematech figures of 99.8% uptime on 200 mm YES System at Sematech. (Again, not approachable with a Track system)

As may be gathered from the above, the analysis came out overwhelmingly in favor of continuing with the Batch approach for their new fab area.

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The most recent addition to the YES range of Vacuum Bake/Vapor Prime Ovens incorporates a patented laminar flow system which actually cleans the wafers (and cassettes) during the process cycle, so that the wafers are cleaner after process than before process.

In addition to photoresist adhesion system, YES also offers complete systems for Image Reversal, Silylation, Polyimide Bake, Plasma Strip and Plasma Clean.