YES-1224
Silane Vapor Deposition System

Yield Engineering Systems, Inc.

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The History

Yield Engineering System (YES) has been manufacturing production equipment for the semiconductor industry since 1980. The first systems engineered by YES for the semiconductor industry introduced a process known as Vacuum Bake/Vapor Prime.

Vacuum Bake/Vapor Prime is an improvement on the use of HMDS (hexamethyldisilizane) as a surface priming treatment to enhance the adhesion of photoresist on a wafer surface. Early application of HMDS used immersion or spraying of liquid chemical onto the surface of the wafer in a room atmosphere.

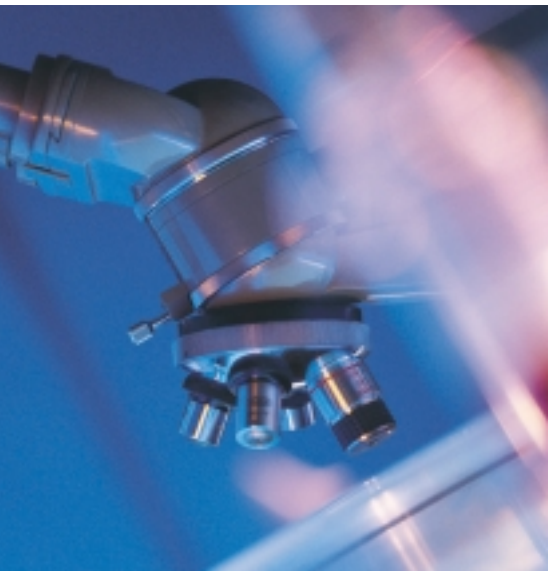
Although effective in dramatically reducing photoresist adhesion problems, the wet HMDS application processes had limited surface longevity. Photoresist had to be applied within a few hours of HMDS treatment or the surface modification affects of the HMDS were degraded or lost.

Investigation of the HMDS surface treatment degradation discovered that the problem was caused by incomplete removal of the water vapor that is always entrained on surfaces exposed to atmosphere. Effectively, the HMDS was bonding to a microscopic water layer rather than to the wafer surface.

The YES Vacuum Bake/Vapor Prime process solved this problem by using a vacuum/nitrogen cycle purge at elevated temperature to completely remove the surface layer of water vapor. Wafers are then exposed to HMDS vapor at low pressure (approximately 14 torr) to create a thin monolayer of HMDS bonded directly to the wafer surface.

The Vacuum Bake/Vapor Prime process offers several process advantages over liquid HMDS application:

- The process leaves a superior HMDS/wafer bond so that weeks after processing, there is no change to the surface adhesion.
- Chemical usage for the vapor process is less than 1% of the amount required for wet application processes. Customers have reported that pay back period for the YES tool was less than two months based on reduction in chemical costs alone.
- The Vacuum Bake/Vapor Prime process provides contact angle uniformity of ±1° for an entire chamber full of product wafers
- Contact angle can be controlled within process limits by varying vapor temperature, vapor pressure and exposure time
- This process and our equipment have been saving money for chip manufacturers for many years, and are considered a standard protocol for the semiconductor industry. It is here that we began the development of a process that is now becoming the answer for the microarray world.



The Problems

Like silicon wafers, the glass slides often used for microarrays require surface modification with silane chemistry to improve the adhesion of DNA and oligonucleotides. Current industry practice uses immersion in liquid chemical or exposure to vapor at atmospheric pressure to apply the silane coating to the slides.

Both methods of producing slides with dehydration then silane modification often do not completely remove entrained water molecules on the slide or allow water monolayers to reform if the slide is exposed to air in between dehydration and silane application. The silane bonding reaction can then take place with entrained water molecules as well as with the surface of the slide, creating an apparent bond that is actually on *top* of moisture.

Over time, additional moisture can combine with partially reacted water molecules on the slide, liberating the oligo bond from the slide and causing adhesion failure of the DNA or oligonucleotide coating. The water oligo bonds also produce variations in the molecular length of the oligos.

Loss of adhesion can take place over a few hours of exposure to room air. It can also occur during washing to put down a blood sample or washing to remove possible false positives.

The Challenge

Production of reliable, accurate microarray slides requires a process that will provide dependable, controllable surface modification of glass substrates with silane chemistry for stable, long term oligonucleotide and DNA adhesion. The ideal for this process is to modify the slide surface tension by application of the specific silane chemistry required for optimum oligonucleotide and DNA adhesion.

The YES-1224 Vapor Deposition System was developed specifically to adapt the long-established, successful Vacuum Bake/Vapor Prime process to the requirements of the microarray industry for silane surface modification of glass slide substrates.

The YES-1224 process completely dehydrates the substrate surface and then exposes the substrate to silane vapor. With control of the substrate temperature, vapor temperature, vapor pressure, and the time of exposure, all process parameters can be manipulated to give optimum surface reaction.

The YES-1224 process provides the same advantages for microarray substrates as Vacuum Bake/Vapor Prime does for semiconductor wafers:

- A superior silane/substrate bond that is stable after exposure to atmospheric moisture. With the YES-1224 process, the slides can be guaranteed to be totally dry.
- Chemical usage for the vapor process is less than 1% of the amount required for wet chemical application processes. The raw material cost savings alone can pay for the equipment in a very short amount of time.
- Contact angle uniformity of ±1° for an entire batch of up to 1600+ slides. The YES-1224 process saves money by greatly reducing rejects due to contact angle variation. In fact, with a correctly run process we would expect to see zero defects.
- Contact angle can be controlled within process limits by varying substrate temperature, vapor temperature, vapor pressure and exposure time. The length of the silane bond is totally

controllable. Surface tension of a slide produced with a vacuum vapor approach is totally controllable. The quality of the finished product can be engineered and controlled at all times.

- The YES-1224 can be used to apply Amino Silanes, Epoxy Silanes, and Mercapto Silanes even though some of these silanes react unfavorably to air at higher temperatures and some can decay with prolonged exposure to high temperatures.

The Answer - The 1224 Process

The process begins with vacuum chamber cycle purges to prepare the product. The chamber is evacuated to low pressure (about 10 torr) and refilled with pure nitrogen several times to completely remove water vapor. This is the same process as our standard Vacuum Bake/Vapor Prime systems. This process replaces all room air with preheated nitrogen, which also helps to heat the product.

After the cycle purges are complete, there is a programmable stabilization period at low pressure (about 1 torr) to complete substrate dehydration and to ensure that the product substrates are brought to temperature (longer stabilization periods are recommended for larger/thicker substrates).

The YES-1224 system then pumps the silane chemical directly from the source bottle to vaporization chamber without exposing the chemical to heat or air. A nitrogen purge in the source bottles helps to ensure that chemicals are not degraded by exposure to atmospheric oxygen. The chemical remains at room temperature until it is needed.

The YES-1224 accommodates two chemical source bottles; the two chemicals may be either the same or different. The system may be programmed to mix multiple chemicals or to automatically draw from the second source bottle while the first bottle is being replaced. All of this is easily programmable through the touch screen operator interface.

The chemical is sent in metered amounts to the vaporization chamber where it is flash vaporized. The vapor flows into the process vacuum chamber and into contact with the preheated and fully dehydrated substrates.

The process engineer has control of the amount of liquid, the speed of liquid injection, vaporization chamber temperature, vapor line temperature, process vacuum chamber temperature, process starting pressure, and exposure time. This allows the system to accommodate the wide variation of vapor pressures among the different silanes.

After exposure to the silane vapor, the vacuum chamber is again cycle purged several times with nitrogen to remove all vapor from the chamber before the door is opened for unloading. The YES-1224 includes a vapor trap on the vacuum exhaust line to prevent silane chemical from entering the vacuum pump.

Wetted materials for the YES-1224 are 300 series stainless steel, Teflon, and a chemically resistant Vespel.

The Proof

Please call our sales department at (408) 954-8353 or (888) YES-3637 for further information on these systems or to arrange a demonstration of the system with your chemical and samples. We are certain you will be pleased with the results!

SYSTEM SPECIFICATIONS	
Cleanliness for Surface modification:	Dependent on chemical grade
Cleanliness for Image reversal/process gas:	Less than 5 x 1 micron particles per sample
Capacity:	1600+ microscope slides with YES boats.
Throughput:	Surface modification - 1 load/hr (typical)
Chemical Usage:	10 mL/run (typical)
Ammonia Usage:	2 ft^3/run (typical)
Nitrogen Usage:	30 ft^3/run (typical)
Maximum chamber temperature:	205°C
Dimensions:	Chamber - 16" (406mm) H x 16" (406mm) W x 18" (460mm) D System - 40-23/32" (1034mm) H x 38-3/4" (984mm) W x 36" (914mm) D (Not including light tower)
Weight:	Approx. 350 lb (159 kg)
Power:	Domestic - 208V, 60 Hz, 1 Phase, 20A European - 230V, 50 Hz, 1 Phase, 20A

Patents Pending

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