WAFER PRIMING
Batch v's Track

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A general review of wafer priming is probably best accomplished by going back to the beginning.

In the early 60's photoresist was spun directly onto the wafer surface without an intermediary layer of photoresist prime. This was fine for the very large geometry circuits being designed at the time which were in the mil' range.

It was when geometries "shrunk" to the 20-micron vicinity that it became clear that the single factor most limiting further decreases in circuit geometries was the quality of photoresist adhesion. In order to faithfully reproduce the CD's of the circuit design a better method of photoresist contact had to be devised.

It was at this time an IBM scientist formulated and patented a material called hexamethyldisilazane (abbreviated to HMDS). This material had the unique quality of acting as a very strong inorganic (SiO) / organic (photoresist) bridge.
It is HMDS that is used to "prime" wafers to this day.

In the late 70's to early 80's two general methods were in use to deposit this material onto wafers prior to photoresist deposition:

(1) One mechanism involved baking the wafers to de-hydrate and then removing them from the oven and transporting them to a spinner where HMDS was sprayed onto the surface. Any excess was then spun off. A serious problem with this approach was that when the wafers were removed from the bake ovens their surface became re-hydrolized by atmospheric humidity.

Further shortcomings of this approach were a real propensity to generate and deposit particles, not to mention the substantial expense incurred in wastage of HMDS.

(2) Another method was to submit the previously baked wafers to HMDS vapor generated by equipment similar to a vapor degreaser. This method also suffered from re-hydrolization of the wafers on removal from the oven. Also, a further problem occurred in the early days due to the flammable nature of HMDS. Several fires were reported in fab areas using this process.

In 1980 YES came out with the first process that combined bake and prime in the same vacuum. This remedied several problems at the same time.

(a) No re-hydrolization occurred since the unprimed wafers were not exposed to atmosphere.

(b) The same vacuum that was used during the bake cycle was subsequently used to draw in a prime monolayer of HMDS.

(c) The interior of the chamber was evacuated several times (with intermediary nitrogen backfills) prior to exposure to HMDS. Thus at the time of HMDS exposure, the percentage of oxygen present in the chamber (and hence the chance of a flammable mix forming) approached zero. No fire has ever been associated with Yield Engineering equipment in ten years of business and well over a thousand units in worldwide usage.

By way of response, the TRAC people decided that they had better duplicate the Yield process. A very real problem existed however, and this was that the TRAC System was tied to a very expensive piece of equipment called a stepper and this stepper needed a wafer a minute to "earn its keep". Thus the TRAC manufactures were forced to try to bend the laws of physics to duplicate a 25-minute process in one-minute.

With no time restraints, Yield Engineering (and others) had found that it take around 20 minutes to fully vacuum de-hydrate a wafer. - TRAC gets 40-seconds.

With no time restraints, Yield Engineering found that it takes anywhere from 2 to 5-minutes to fully prime a completely dehydrated wafer. - TRAC gets 20-seconds.

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The difference in Quality of Prime becomes increasingly dependant on "time of dehydration" and "time of prime" when a surface layer of silicon nitride is used in place of silicon dioxide. Here, due to the comparitive density of the nitride layer, it is virtually impossible to obtain quality photoresist adhesion (and hence acceptable CD tolerance conformity) with the "one minute drill" imposed by TRAC.

A complete and thorough prime (that has been deposited with optimum adherence to the laws of physics governing both the dehydration and priming cycle) can be deposited on almost any surface such that a deposited drop of DI water will exhibit a 70 degree contact angle deposited to these criterea will remain fully primed (and hydrophobic) for weeks after deposition.

Further, with the concept of TRAC, a procession of wafers are hurried through to a hot chuck where they are subjected to vacuum, heat, nitrogen purge, vacuum and HMDS deposition, all in one minute. The speed with which all this occurs and the necessary purge speeds involved cause the particles that are transported into the priming area to be scattered within the chamber confines; causing particulate counts on wafer surfaces to be many time that experienced on the YES batch system where great pains are taken to avoid any surges of any kind within the chamber.

A general specification would be that with the YES Systems, users report 0 X 1-micron particles and less than 5 X 1/2 micron particles per 6-inch wafer.

TRAC users report 5-10 X 1-micron particles and > 30 X 1/2 micron particles per 6-inch wafer.

Last, but not least, let us address reliability.

People like John Nistler (ex AMD; now at Semetek) have given papers comparing the performances of various Trac Systems to the Batch approach. He points up the myriad of moving parts required for transport assemblies and the like in the TRAC process. As expected, the service needs go up drastically with increasing complexity.

The YES Batch System, on the other hand, has no moving parts and is supremely reliable..

Places like IBM (who have over 100 YES Systems) have selected the YES approach. The latest systems incorporating robotic load/unload of four cassettes of 8-inch wafers from a rotating door assembly. The process (using SECS II communications) is computer controlled.
So in summation, the laws of physics say that it takes up to 20-minutes to fully dehydrate a wafer. Yield Engineering takes the full 20-minutes, but elects to process 200 wafers at a time (enough for 6 TRAC Systems).

Similarly it takes anything from 2 to 6-minutes to fully prime a completely dehydrated wafer. We take the necessary time, but again, elect to process 200 wafers a time.

The TRAC people are faced with the dilemma of either producing 3 correctly dried and primed wafers an hour or facing the consequences of the alternative…