A New Solution For Reticle Haze Prevention

Offers a significant increase in the life of 193 nm phase shift masks

Like most of the technology leaders in 193 nm photolithography, Inotera, Taiwan, has experienced problems with reticle haze growth. Despite significant research and cooperative work with vendors, only marginal improvements in reticle life have been achieved.

Entegris approached Inotera with a new solution to prevent reticle haze called the Clarilite system. A joint evaluation was agreed upon with the objective of extending initial reticle life up to 20,000 equivalent wafers printed and to compare it with current solutions under investigation at Inotera's photo bay.

It was determined that reaching the 20,000 target would improve the operating profitability of the photo department and solve many problems associated with reticle logistics due to frequent mask cleaning and inspection time. Each cleaning reduces the life of the mask and, in some instances, Inotera has no other option but to invest in duplicate mask sets in order to meet production demands.

The formation of haze is a multifaceted and complex phenomenon. The crystal growth mechanism can involve several types of contaminants, some existing on the mask itself from quartz manufacturing and some created in the fab environment. Refer to the Toppan and DNP presentation in past SPIE/Bacus conferences for discussion on reduction of contamination from the mask manufacturing process.

Contaminants causing crystal growth can be classified in four categories: humidity, acids (as sulfates), bases (as ammoniums) and organics. The contaminants causing crystal growth are not harmful except when activated by an important source of energy, the DUV laser. DUV breaks some chemical bonds and initiates crystal growth reaction.

The situation would not pose a problem if the reaction stopped once the source of energy is removed, i.e., once the mask is returned to its reticle pod and to the stocker. But, this is not the case. The reaction continues and is fed by the contaminants close to the mask environment, i.e., outgassing from pellicle materials and adhesives, pod materials, as well as AMC (airborne molecular contamination) in the fab environment. The reaction is further enabled by humidity present in the fab and mask environment, actually speeding up the reaction.

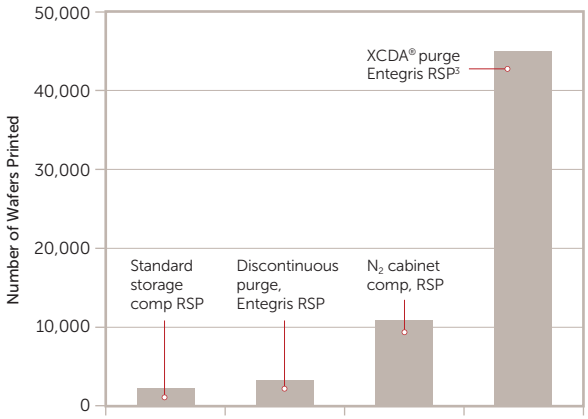
Entegris' Clarilite system introduces a new reticle pod, the RSP^3, which enables purging in order to maintain extremely dry and clean conditions in the environment surrounding the reticle once it is in the stocker. One of the most important features of this solution is a built-in AMC purifier to maintain extremely clean conditions during travel in the fab and before reaching the scanner. The Clarilite system offers an integrated approach to eliminate those contaminants and extend the life of the mask.

The objective of this evaluation was intended to prove, with a minimum of production disturbance, that an extremely clean and dry environment could be maintained while the reticle pod is in the stocker and also while the reticle is in the photo bay (during transport, waiting to be loaded in the scanner library, or during storage in the scanner library).

Two tests were conducted in parallel; one maintained a constant purge while the reticle was in an idle situation and one used an intermittent purge. However, intermittent purge proved to be impractical in an industrial environment because it requires too much of the stocker robot resource and adversely affects throughput.

The test results demonstrate the effectiveness of the Clarilite solution in the removal of contamination generated inside the reticle pod. While other solutions like N_2 enriched cabinet

Mean Time Between Reticle Cleans



storage, simple N_2 or CDA purge provide significant improvement to the original situation, the Clarilite solution to date offers more than four times the performance (see chart). (The new objective set by Inotera for this evaluation is now 70,000 equivalent wafers printed.)

The choice of purge gas is also an important component for this solution. Drawing from experience with leading exposure tool OEMs to protect scanner optics, Entegris has tested and identified a proven purge gas source to minimize and eliminate risk to the litho process. The purge gas system is approved for and used with lens assemblies in these same exposure tools. Further, the high grade of optical purity has no effect on the numerical aperture of the reticle. This purge gas source is also safer for operators and offers the lowest operating cost. Entegris' Extreme Clean Dry Air (XCDA®) is the gas used by the Clarilite system.

XCDA is safe, while N_2 is hazardous to humans. An N_2 line from the fab facility needs to be purified, just like CDA, to achieve the optical purity requirement. The use of Entegris' gas purification system (GPS) XCDA technology enables the use of virtually any kind of CDA grade used in process tools, while N_2 requires tight control to maintain incoming purity. Finally, the cost difference generally observed in fabs favors the use of CDA. N_2 costs four to 10 times more than CDA, depending on the method and capacity of the N_2 supply facility.

Conclusion

The implementation of the Clarilite solution is not difficult and provides an immediate reduction in production costs and other benefits. The return on investment is estimated to be less than two months.

The Clarilite solution does not necessarily solve all haze problems, but it does offer a practical way to reduce and prevent haze formation at the end user's site. It is a novel, comprehensive approach based on the research done by the community at large and by Entegris scientists. Clarilite offers a process solution for one of today's critical photolithography challenges.

As a result of this evaluation, Inotera has decided to implement the Clarilite solution and utilize it for all of their phase shift masks for their new fab in June 2007.

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