Surface Molecular Contamination Can Cause Yield Loss

While AMC monitoring remains a vital part of ensuring cleanroom quality and process yield, another classification of contamination, Surface Molecular Contamination (SMC) is now receiving increased attention and definition within the industry.

SMC refers to molecular compounds or particles that adhere to surfaces, sometimes at less than monolayer levels. Key problems that can be caused by SMC and can promote yield loss include corrosion of metal layers, pitting of wafers, hazing of surfaces, unwanted doping and delamination between layers.

Due to these concerns, the 2003 ITRS Roadmap defined three new SMC contaminant classes in Table 114a under the heading, WECC for Wafer Environmental Contamination Control:

1. Surface Molecular Condensables – Organics (SMORG),
2. Surface Molecular Dopants (SMD),
3. Surface Molecular Metals (SMM).

Witness Wafers can be used to measure SMC contributed by environment or processes.

SMC may adhere to wafers, causing corrosion, hazing, delamination, and unwanted doping.

The ITRS roadmap also established appropriate levels for present and future technology nodes.

Reasons for SMC Analysis

There are two main reasons for the emergence of SMC as an important class of contamination. Contamination that adheres to the wafer surface can play an immediate role in affecting process yield. Secondly, because effects from contamination in closed environments such as FOUPs, pods, and mini-environments can cause potential yield problems, it is important to extend cleanroom air AMC limits to SMC limits for the wafer environment.

A major advantage of SMC monitoring is that SMC tests can be used for both witness wafers exposed to the environment, monitor wafers run through an individual process or sequence. For witness wafers, a clean wafer is exposed to typical cleanroom air or a FOUP, POD, or mini-environment, for a set period of time, ex. 24 hrs, and then analyzed for contamination by the appropriate methods.

Balazs methods meet all current and future ITRS-defined requirements for SMC on wafers within the fab.

Comparing wafer contamination levels can help assess which process step contributes the most contamination, allowing the fab to focus on improving the most detrimental processes first.

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Surface Molecular Organics (SMORG)

Balazs has extensive historical data for organics that commonly stick to wafers and affect process yield. Common sources of organic compounds such as DBP, DOP, TXIB, silicones and organophosphates include plasticizers, sealants and flame retardants. See Balazs data showing the percentage of sites we have analyzed for organics with contaminant levels in each range in figure 1.

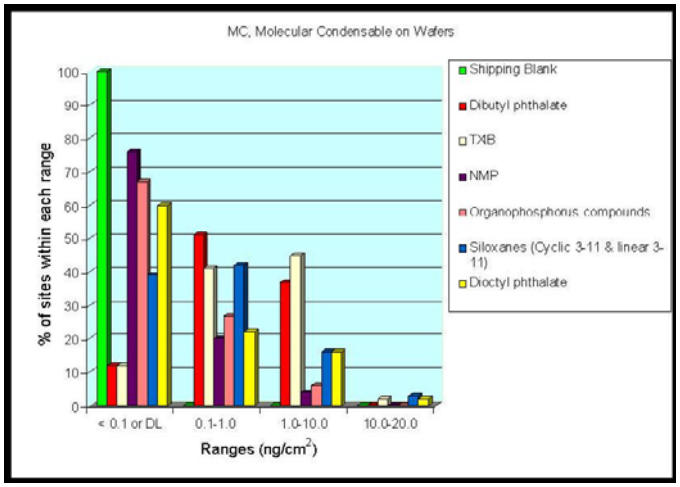

Fig. 1 Organic Contamination on Wafers

The new 2003 roadmap recommends 2 ng/cm2 limits for total organics on the wafers for 2004 - 2009. Balazs can routinely report to 0.1 ng/cm2 using an organic method defined in ASTM 1982-99 and has developed methods to ship samples without contamination or loss of compounds.

Surface Molecular Dopants (SMD)

SMD involves an analysis for dopants B, P, As, and Sb. This analysis is especially important for environmental boron contamination that result in unwanted p-doping of process wafers. P and other dopants can also cause sporadic doping problems. The process sensitivity to dopants can vary dramatically, and front end lightly doped processses tend to be the most susceptible. Balazs has worked through numerous studies of dopant contamination from air and from processes.

Surface Molecular Metals (SMM)

As more volatile organo-metallic compounds are used for new gates and high k dielectrics, the concern for surface molecular metal contamination from volatile metals will certainly increase. Otherwise, SMM is typically not observed at detectable levels unless particulate sources are present. Metals, if present however, can cause defects on process wafers.

Balazs Analytical Services offers the complete suite of analyses for SMORG, SMD, and SMM with current capabilities lower than the ITRS-defined limits through 2016. Shipping blanks for wafers are provided for each analysis, and analyzed with each returned sample set to ensure quality control.

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Our experience involves not only the analysis and typical contamination levels found in fabs but also the problem solving expertise to help fab customers identify compounds and SMC sources, and to control them to help reduce potential impacts on processes. See trouble shooting table below.

SMC TROUBLE SHOOTING	
Problem or Effect	**SMC Test Recommended**
Hazing of wafers	SMORG
Delamination (PVD, CVD, photoresist, ARC layers)	SMORG (at process step just before step that causes delamination)
Gate Oxide Thickness Measurement Variation or Ellipsometer Errors	SMORG
Unwanted Doping	SMD, SMORG
High Particle Count on Wafers	SMM

For more information about SMC and how Balazs can help you resolve your SMC problem, contact your local Sales Manager.