## New SMC Tests required by ITRS 2003

At the end of 2003, the ITRS (International Technology Roadmap for Semiconductors) added recommendations for SMC (Surface Molecular Contamination) on witness wafers exposed to the clean room, mini-environments, wafers shippers and other environments. Being an active contributor to the roadmap, Balazs offers the tests required by the 2003 release for performing baselines, routine monitoring, or troubleshooting in clean room environments.

New SMC limits were added to the 2003 roadmap since many AMC (Airborne Molecular Contamination) compounds can be in air, but not necessarily affect the process unless they stick to the wafers. This was discussed in an article titled, “Investigating Yield Loss Caused by Airborne Organophosphates. By Dr. Anurag Kumar, Dr. Latif Ahmed and Dr. Mark J. Camenzind. Micro, January 2001” (see www.balazs.com for this article. For maximum protection of your processes, and to align it with the roadmap, baselining your facility and processes for these new tests and trending over time are recommended for all semiconductor fabs. Balazs has been offering SMC testing of organics, dopants and metals testing for several years, and provides detection limits below the recommended values in the roadmap.

The new ITRS limits for SMC are given below, and can be found in Table 114a of the 2003 roadmap (page 20 of yield enhancement section, see http://public.itrs.net/).

*Table 114a Technology Requirements for Wafer Environmental Contamination Control—Near-term*

| *Year of Production* | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|
| *Technology Node* | | hp90 | | | hp65 | | |
| *DRAM ½ Pitch (nm)* | 100 | 90 | 80 | 70 | 65 | 57 | 50 |
| *MPU/ASIC ½ Pitch (nm)* | 107 | 90 | 80 | 70 | 65 | 57 | 50 |
| *MPU Printed Gate Length (nm)* | 65 | 53 | 45 | 40 | 35 | 32 | 28 |
| *MPU Physical Gate Length (nm)* | 45 | 37 | 32 | 28 | 25 | 22 | 20 |
| *Wafer Environment Control* | | | | | | | |
| Critical particle size (nm) [A] | 50 | 45 | 40 | 35 | 33 | 29 | 25 |
| Number of particles > critical size (/m$^3$) [B] | ISO CL 2 | ISO CL 2 | ISO CL 2 | ISO CL 2 | ISO CL 2 | ISO CL 2 | ISO CL 2 |
| *Airborne Molecular Contaminants, Surface Deposition Limits (for Si Witness Wafer, 24-hour Exposure to Closed FOUP, Pod, Mini-environment or Air)* | | | | | | | |
| SMC organics on wafers, ASTM 1982-99, ng/cm$^2$ [0] | 4 | 2 | 2 | 2 | 2 | 2 | 2 |
| Front-end processes, bare Si, total dopants added to 24-hour witness wafer, atoms/cm$^2$ [E] [P] | <2E12 | <2E12 | <2E12 | 1.E+12 | 1.E+12 | 1.E+12 | 1.E+12 |
| Front-end processes, bare Si, total metals added to witness wafer, atoms/cm$^2$ [G] [Q] | <2E10 | <2E10 | <2E10 | <2E10 | <2E10 | <2E10 | <1E10 |

The method in the Table was ASTM 1982-99, but this is now referred to as SEMI MF1982-1103.



BALAZS nanoanalysis

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For SMC organics on wafers, Balazs bakes out wafers to be organic free, and ship worldwide without contamination or loss of compounds. Our 300mm full wafer desorption system allows us to do analyses per SEMI MF 1982-1103, one side of the wafer at a time, so fabs can decide if they want to do the top side (most common) or bottom side of the wafer. Detection limit for individual semivolatile organics is currently at 0.1 $ng/cm^2$, well below the ITRS needs for the upcoming years. This test is especially valuable for both FEOL and BEOL wafers, since organics can cause delamination of metals or resists, contact resistance, electrical defects, lithography problems, and hazing of optics, steppers, etc. We also have seen multiple cases of organics adsorbing onto wafers, affecting ellipsometer thin film measurements, especially for thin gate oxides, and have seen organophosphates on wafers that caused doping problems.

For Surface Molecular Dopants on wafer (SMD),testing in the FEOL process areas is critical since dopants can cause resistivity drops, threshold voltage shifts, leakage currents and other electrical problems. Boron has been a significant concern since even ppb levels of HF in air can attack the borosilicate glass of ULPA filters to put BF3 into air, which can then re-absorb onto wafers, and affect especially the lightly doped FEOL Si wafer steps.

The regulatory limits for HF in air are at ppm levels, yet ppb can affect the processes both due to corrosion and the Boron problem mentioned above.

"new SMC limits were added to the 2003 roadmap to provide the fab with recommended levels to monitor and track on the wafer surface"

Since incoming wafers often have E12 B/cm2 range or higher, we provide precleaned and validated wafers for exposure experiments. The wafers are sent in a shipper box, and all you need to do is open the box, expose the wafers for 24 hours, then return the box with wafers for analysis.

Overall, most metallic contaminants have historically been particulates, so if particles are well controlled, few metal contributors are to be expected. However, this may change as more volatile organometallics or halides come into use, such as Zr, Hf and many other new compounds, in addition to the more common Ti, Ta and W species.

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Using witness wafers has also been very effective for assessing the efficiency of Carbon filters or other molecular phase filters for cleanroom air or mini-environments. Wafers should be concurrently exposed both upstream and downstream of the filters. Special methods can be used, if needed, to sample in high velocity air ducts.

In summary, new SMC limits were added to the 2003 roadmap to provide the fab with recommended levels to monitor and track on the wafer surface. These compounds can directly affect the yield of the product. Balazs provides detection limits below the recommended values in the roadmap on all 3 tests (Organics, Dopants and Metals). These tests are valuable since organics can cause delamination of metals or resists, contact resistance, electrical defects, lithography problems, and hazing of optics and steppers. Dopants and Metals can cause resistivity drops, threshold voltage shifts, leakage currents and other problems. You should also remember to take into consideration the AMC guidelines which are still crucial and an important aspect of a complete fab baseline. Acid and base compounds in air may not stick to some wafers, yet may affect processes such as lithography resist t-topping, hazing of optics or masks, or corrosion of metals including fab equipment. Please contact us for more information on determining where your facility rates against the 2003 ITRS roadmap!