Air Ionizer Tip Deposit Analysis

New AMC Monitoring Method Can Also Protect UV Optics and Reduce Particle Formation Risks

Air ionizers are used in cleanrooms, glove boxes, mini environments, or equipment to neutralize surface charge, reducing the risk of:

- Electrostatic Discharge, that can ruin circuits, photomasks, or cause electromagnetic interference (EMI) and electrical faults
- Reduce electrostatic attraction of particles to surfaces, or surfaces to each other

Corona discharge ionizers are the most commonly used type of air ionizer and can come in many form factors. For rooms, two or more ceiling emitter rods can be hung down from the HEPA/ULPA grid ceiling in pairs with one positively charged and one negatively charged, often at voltages of +/- 5-20 kV. These form positive and negative ions that are injected in the laminar airflow, either continuously or alternately. These ceiling emitters may be used throughout an entire fab or where they are most needed. Other areas or specific tools may use built-in ionizers with two, four (e.g. “Quadbars”), or more tips (Aerobars), or may use blowers/fans or purge gases to move the ions toward the location where charge neutralization is needed.

Some trace white deposits on Si emitter tips is normal, and recommended cleaning may be every 3 months, or more often if needed. Occasionally, air ionizers can react with excessive amounts of volatile Airborne Molecular Contamination (AMC) to form non-volatile SMC (Surface Molecular Contamination), which can collect over time on hot emitter points to form deposits that range from µm to several mm in length. These deposits are often dielectric insulators such as SiO_2, formed from Si compounds in air that can lead to faults in ionizer circuits or imbalances. Ammonia may form ammonium salts like ammonium nitrate or sulfate. These deposits grow as a result from AMC reacting thermally with the tip and air or by other mechanisms. The ionizer tips form oxygen, the superoxide ion (O_2^-), the hydroxyl radical (OH), ozone (O_3), nitrogen oxides, and $H_3O^+\cdot(H_2O)_x$ clusters. HEPA and ULPA filters are used to remove particles in the air, however AMC molecules are volatile and hit the fibers in the filters, but then revolatilize and eventually are not retained for long. Then, AMC can pass into the particle-free cleanroom to possibly interact negatively with the air ionizers or other critical surfaces and form particles.

Ceiling Emitter Tip Sampling Kits

Sampling kits provide a way to remove ionizer tips from ceiling emitters and ship them with deposits remaining intact. Included in these kits are custom-made tweezers as well as universal sample holders that can securely hold ionizer tips with diameters ranging from 0.18 cm to 0.25 cm and up to 2.5 cm in length. Special customized tweezers, only available from Balazs^{TM} NanoAnalysis, are needed since standard tweezers can typically knock off the deposits or lose/break the tip. Sampling instructions are provided with the kit to demonstrate the optimal technique for using the provided tweezers to extract tips, insert tips into the sample holders, and replace a broken tip if necessary (rare occurrence). Training is also available.

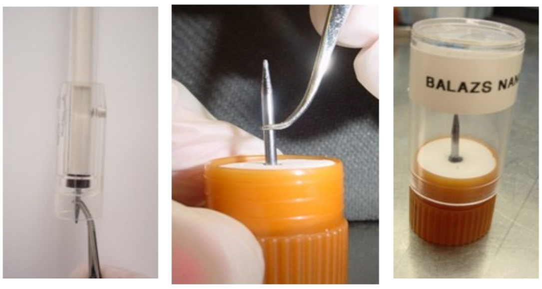

Figure 1. Tweezers used to remove ionizer tip from ceiling emitter and place into sample holder

In addition to tip removal sampling kits, crush tube sampling kits are also offered. Crush tube kits are designed to provide a convenient way to collect and ship tip deposits for analysis using Texwipe TX726 Crush Tube Swabs, which are commonly used for cleaning the tips for many space-constrained applications.

Figure 2. Crush tube used to collect tip deposits

Tip Deposit Identification Methods

When a tip arrives for analysis, it is optically photographed and weighed to 1 µg. Scanning Electron Microscopy with Energy Dispersive X-Ray Spectroscopy (SEM-EDS) is used to make an elemental map of the intact tip residues using electron imaging as well as determine the elemental composition of the sample (except H, Boron). If the deposits are inhomogeneous, further analysis is needed since EDS detects to a few microns depth, and does not detect deeper, or far side elements in deposits that can be thousands of microns long. If the deposits are mainly SiO_2, our trained chemist can safely use HF to etch and completely dissolve the SiO_2 from the Si tip. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) can be used to identify 20 elements including Si, Sn and dopants like B, P, which may not be detected or accurately quantitated at low levels by one SEM-EDS analysis. By identifying and quantifying elements present in the deposits, it becomes possible to assess AMC-to-SMC risks quantitatively for trending. Higher refractory AMC levels are likely in areas with the largest deposits on the ionizer tips, and these compounds may also put UV optics at risk of photo deposition. SEM-EDS and ICP-MS can similarly be used to perform an elemental analysis for crush tubes used to collect tip deposits.

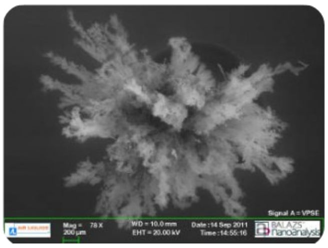

Figure 3. Electron image

New problems with higher ionizer deposition rates that were not present before suggest a chemical leak, air handler failure, or other issues. Knowing the elements present greatly simplifies assessing what sampling method may be used next to help find and eliminate the source to reduce risks to wafers, UV optics, masks, scanners and air ionizers. Balazs can provide separate methods for analysis when needed, such as GC-MS, Ion Chromatography, and FTIR for air or witness wafers to further diagnose AMC, SMC and ionizer issues.

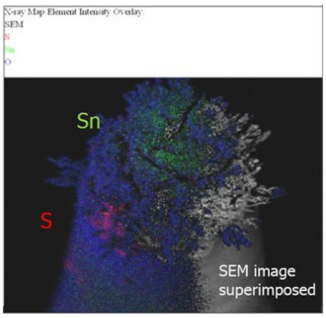

Figure 4. Elemental map of tip deposits

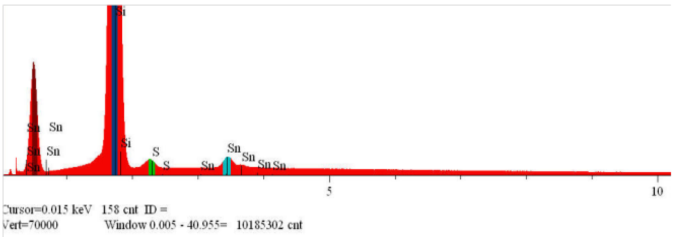

Figure 5. EDS elemental analysis: Elemental selection for maps

If you have deposits on your ionizer tips, especially if >1 mm white deposits in one month, or green or blue deposits that might indicate a corrosion issue, please contact Balazs. Fabs with 193 nm ArF scanners might require better control, and longer wavelengths might be more tolerant of deposits. EUV pellicle–free masks might have new requirements.

Balazs^{TM} NanoAnalysis operates ISO 17025 certified laboratories that identify, analyze and resolve contamination issues for high-tech industries around the world. The Microcontamination Experts^{TM} at Balazs provide rapid and accurate analyses and expertise for water, air, chemicals, process gases, components, wafers, consumables and any other contamination sources.