What kind of maintenance needs to be done ?

All corona ionizers require maintenance – there are no "maintenance free" corona ionizers . Basically the emitter points of the ionizer needs to be cleaned with electronic grade IPA and foam/polyester swabs or available small emitter point cleaning capsules that fit snugly into the emitter point holders to clean effectively . The *frequency of cleaning* can range from 1 week to 3 months interval depending on the type of ionizer, the working environment (cleanroom, non-cleanroom, presence of chemicals or solvents in working environment etc) and the type of manufacturing process being carried out within the facility (eg wafer fab, disk drive etc) . Over time, all corona ionizers will begin to collect dirt and particles around the emitter points due to the gas to particle chemical reactions that occur at the tips, and if not properly maintained and cleaned, these "fuzzballs" might dislodge and fall onto your workstation thereby creating process contamination issues. *Maintenance is therefore not an option but a must* . Typically, the emitter points (eg : Tungsten, Titanium, Silicon) should be replaced every 2 to 3 yrs depending on level of erosion or degradation .

Nuclear or the commonly used Po 210 alpha ionizers are, off course, maintenance free and the sources need to be replaced at a predetermined frequency, normally yearly but not limited to this frequency . Extension of the usage of the source depends on the half life (138 days in the case of Po210), the deterioration of the performance (ie, balance voltage and decay time) and governmental requirements which state that these sources need to be wipe or leak tested annually in most countries .

There are feedback sensors cum controllers currently available that can help monitor the swing / balance and decay time parameters for AC, Steady State DC or Pulsed DC ionizers located within tools . Especially in Semiconductor Equipment Front End Modules (or EFEMs) the performance of the ionizer is normally not monitored due to a lack of available downtime and this results in an infrequent maintenance of the ionizer . In most instances, the ionizer could not be performing optimally due a lack of preventive maintenance cum re-calibration. So having a sensor located within the worksurface of the tool to monitor the necessary ionization parameters helps to ascertain when the ionizer needs to be re-calibrated or maintained . These sensors come with necessary LEDs or a separate display module that can be mounted outside the tool for easy observation by the technician or operator . Once any of the set alarm thresholds are exceeded, the display module will show an alarm and in this way necessary remedial action can then be taken.

Ionizer Control for Critical Applications

For critical applications where the balance voltage needs to be tightly controlled (say for eg to ±1V), ionizer feedback sensors or controllers are available that can continuously monitor the ionization level at the critical location and then feedback to the ionizer via a necessary cable connection to adjust accordingly . This kind of ionizer feedback controllers can actually help to reduce the re-calibration frequency for the ionizer by continuously providing a closed loop feedback and maintaining the balance to the desired level . The ionizer emitter points still need to be cleaned but generally the cleaning frequency could also be reduced depending upon the environment and process. The feedback sensor or controller is normally small enough to be located within the working environment and can come complete with the necessary monitoring LEDs and alarms . When selecting such a controller cum sensor it is important to select one that does not react to static voltages or fields inadvertently introduced within the environment but solely to ionization levels . If the sensor reacts to static voltages, then this will send false signals to the ionizer causing the ionizer to always re-adjust and balance itself unnecessarily, possibly resulting in the ionizer going out of balance rather than keeping it's balance – this situation could have a drastic effect on the product . Therefore selection of the right feedback controller is of paramount importance .

Conclusion

Though ionization is not an exact science, it helps solve your basic problems caused by static charge build up. Selection of the correct ionizer is vital and currently available ionization sensors cum feedback controllers for corona ionizers, ensure not only continuous optimal performance but also alerts the user when maintenance (including re-calibration) needs to be affected .

Editor's Note :

Inderjit Singh is presently a Director with Cesstech (S) Pte Ltd which is a provider of microcontamination and ESD solutions for ultra clean environments and processes including third party cleanroom and contamination control testing and ESDC surveys, audits & testing .

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Ionization in Clean Environments :

Fundamentals, Selection, Applications, Maintenance & Monitoring

by Mr Inderjit Singh
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Abstract

This article serves to provide an insight into the fundamentals, selection and applications of ionization, including the recommended maintenance frequency, types of ionization technologies available and the checking and monitoring of the performance of ionizers, especially with respect to applications within the semiconductor and data storage industries.

What is Air Ionization ?

Air Ionization is the process by which a neutral atom or molecule acquires a positive or negative charge – ie, it is a process of making the air more conductive *(refer to Figure 1)* so as to eliminate static charges that already exist in the environment via triboelectric (frictional) charging or induction charging . Charged atoms or molecules are called Ions . The formation of air ions starts with an electron being knocked off a neutral air molecule, which rapidly attracts a number of polar molecules (10 to 15) - mostly water and this cluster is called a positive air ion . The lost electron probably attaches itself to an oxygen molecule and this negative molecule in turn attracts a number of water molecules (maybe 8 to 10) and forms a cluster of negative air ions . This happens rapidly and as such positive and negative air ions are produced – either naturally by radioactive materials or artificially via field or corona ionization.

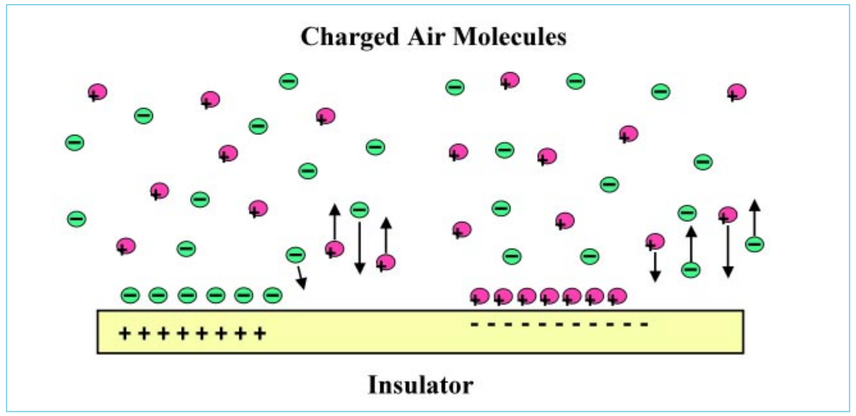

Figure 1: Air Ionization

Ionization Technologies

Basically there are two different forms of ionization technologies currently available – ie, field (or corona) ionization and natural (or nuclear) ionization.

- **Natural (or Nuclear Ionization)**

Here radioactive isotopes (eg : Polonium 210) are used to produce ionization where alpha particles emitted as a result of the radioactive decay of the source, collide with air molecules and hence ionize them. Both polarities of ions are therefore produced . In some applications soft X-rays (or photon ionizers) have been used to provide complete ionization, basically within tools – however, these tools need to be completely enclosed to prevent exposure to the X-rays from such ionizers . As such there are only minimal applications for such ionizers.

- **Field Ionization**

In this form of artificial ionization, a high electric field is applied to a sharp conductive needle or wire point via a high voltage power source . Depending on the polarity of the high voltage source, positive or negative ions are therefore produced *(refer to Figure 2)*.

This is the most common form of ionization technology currently used when designing bipolar (implies both positive and negative ions are produced) ionizers and are available in the following forms :

<u>AC Technology</u> – High voltage is applied to a number of closely spaced emitter points that cycle alternately between negative and positive at the incoming line frequency of the voltage source, ie, 50/60Hz . Due to this very fast cycling and resultant ion recombination, AC systems must have high airflow to blow the ions away from the emitter points.

<u>Steady State DC Technology</u> – here dedicated emitter points are provided for each polarity and as such one half of the emitter points continuously produce negative ions and the other half continuously produce positive ions . Steady state DC ionizers work with low as well as high airflow , providing the emitter points are spaced far enough apart to reduce ion recombination, without creating hot spots.

Pulsed DC Technology – similar to steady state DC ionizers, where dedicated emitter points are used to provide positive and negative ions . The difference here is that the high voltage to the emitter points is alternately turned on and off thereby creating clouds of positive and negative ions . Pulsed DC ionizers can perform fairly well even in low airflow cleanrooms because of the reduction in recombination due to the turning on and off of the high voltage to the emitter points. In very low airflow cleanrooms the "off" timing can be increased to reduce recombination and improve efficiency.

There are other technologies available like Pulsed AC - where emitter points are alternately turned on and off by tuning to different frequencies. These other technologies are in one way or another, just an extension of the three technologies stated above.

What can Ionizers Do ?

Basically, bipolar Ionizers can be used to eliminate the following :

- Electrostatic attraction (ESA) which causes particles to be attracted to surfaces and thus creates contamination
- ESD events which can cause damage to circuits/dies on wafers, read/write heads etc
- Microprocessor / Robotic lockup which can result in the lost of yield and high downtime Ionizers should be used to *complement* other ESD control measures like grounding of flooring material, worksurfaces and tools etc and not to replace such measures .

Selection of Ionizer :

Before a suitable ionizer can be selected the following needs to be established :

- Effective coverage area required (the type of ionizer selected will depend on the area to be effectively covered by ionization)
- Purpose of having ionization (Contamination control , ESD control or for microprocessor lock up)
- Specification of ionizers in terms of balance/swing voltage, decay times (1000V to 100V or 1000V to 50V or 1000V to 10V decay) - This depends a little on the damage threshold of the part or component based on the human body model, machine model or charged device model – used to ascertain the ESD damage threshold)
- Environmental conditions like Temperature, RH (the lower the RH, the higher the probability of producing static) and airflow velocity in cleanrooms .
- Cleanliness of emitter points – there are various materials of emitter points available ranging from Stainless steel to Tungsten to Titanium to Single crystal Silicon. Due to the application of high voltage at the emitter points and due to gas to particle chemical reactions that occur at the tips, proper emitter points need to be selected which are compatible with the cleanliness class of the cleanroom and process. Ensure also that the emitter point material doesn't result in process contamination issues as a result of poor maintenance.
- Ceiling height of facility where general room ionization, is required. This will impact the distance of the ceiling ionizer (or the length of the rods of ceiling ionizer) from the worksurface and affect the spacing between ionizers, depending off course on the specifications as well.

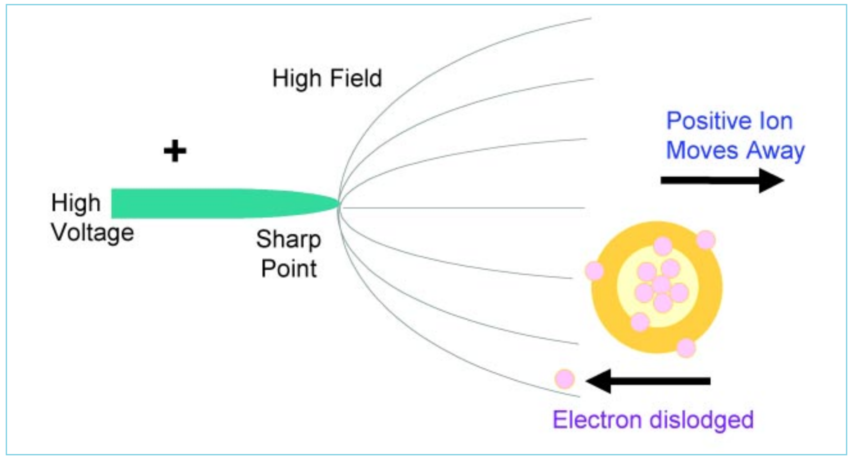

Figure 2: Corona Ionization

Once you have all the answers, you will probably be able to decide whether an AC, a Pulsed DC or a Steady State DC ionizer is required . Where for example room ionization is required in a cleanroom with say a 4m ceiling height, a Pulsed DC ionizer with adjustable on and off timings should be used because of the inherently low airflow in cleanrooms . From experience, the effective distance between the emitter point of the ceiling ionizer and the worksurface should technically be between 1.5 to 2.5 m to achieve good neutralization . At longer distances, the neutralization will be much longer. For minienvironment or tools ionization where the airflow is higher and more uniform a steady state DC ionizing bar for example can be used for the purpose of providing ionization as the proximity to the worksurface is much closer now (between 450 to 915mm in most cases) . Off course a Pulsed DC ionizer can be used as well. In instances where close to zero balance is required, either nuclear ionizers can be used or steady state DC ionizing blowers with feedback sensors /controllers be used to provide close to zero balance with fast neutralization times (eg : 1000V to 10V < 5 secs at distances of between 400 to 610mm) .

Types of Ionizers / Applications

There is a whole range of ionizers available depending on the application – *refer to figure 3*. To summarise, the ionizers can be broken down into the following few categories :

Figure 3: Type of Ionizers

a. Room Ionization

These ionizers offer general room ionization coverage and are installed from the ceilings in most cases . The ionizers can be spaced anything from 1.2m to 2.4m between ionizers and typically about 2.4m between adjacent rows .

b. Workstation / Tools / Minienvironment Ionization

In such applications where ionizers need to be installed above work-stations or within minienvironments or tools for instance, ionizing blowers and/or ionizing bars can be used - eg: within load/unload/process areas of semiconductor or disk drive tools. For some critical applications where a very good near zero balance is required, alpha ionizers need to be used to achieve the desired level of ionization . The alpha ionizers are available in bars, blowers and very small spot configurations .

c. Speciality applications

Such applications involve the use of customized or gas ionizers . In very packed environments where bars or ionizing blowers cannot be used, gas in line ionizers can be used to introduce a stream of ionized clean dry air or nitrogen within the environment . Other applications involve the usage of an ionized blow off gun to clean small parts before packaging.

How to measure the performance of ionizers ?

Basically a charged plate monitor (CPM) is used to measure the balance/

Figure 4: Calibration / Adjustment of Ionizer

swing voltage and decay time of the ionizer. Typically, the decay time is measured from an initial voltage of 1000V to a final or stop voltage of 100V, ie a 90% decay, though a stop voltage of 10V or 99% decay is called for in certain applications, eg : in the data storage applications . Typically the CPM is located at the working height *(see figure 4)*, during calibration or adjustment of the ionizer . It is also good practice to record the calibration height, the airflow at point of calibration and the adjusted settings of the ionizer (which will vary from ionizer to ionizer – eg : Ionizer cycle timings, Ionizer output etc)

All ionizers need to be measured in the field (at site) upon installation. Subsequently these ionizers should be adjusted (or calibrated) by measuring the above parameters at least on an annual basis, though a semi annual frequency is much better in terms of ionization control . In critical applications, the ionizer should be measured and/or adjusted on a monthly basis.

What affects the performance of ionizers ?

The following factors affect the performance of ionizers in most instances :

- Large grounded objects in the vicinity of the ionizer (this absorbs the ions produced by the ionizer)
- Airflow velocity (for ionizers without built in fans) and the type of cleanroom design, ie, unidirectional or non-unidirectional airflow cleanroom . Generally the airflow velocity should be within 0.45m/s ±20%, at point of measurement, if the velocity is lower the decay time will increase substantially
- Build up of dirt and particles on emitter point of ionizers (this is a normal phenemenon because of the process of corona ionization)
- Obstruction of airflow in cleanrooms
- Ceiling height, especially for room or ceiling ionizers.