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Principles of Sheath Technology and Low Maintenance Ionizers

The Operation of Corona Ionizers

Corona ionizers operate by disassembling air atoms into ions through the use of an intense, localized electric field. This electric field accelerates electrons to a high speed, resulting in the electrons striking nearby atoms, which gain or loose an electron to become ions. The electric field also drives away the ions of the same polarity to the applied potential. This is referred to as harvesting and delivering.

The process of generating the ions requires very little energy, but the energy required must be highly concentrated. The electric fields are intense only for a distance of a 50-100 μm from the emitter point. This volume is called the plasma zone. The power dissipation within the plasma zone (ion current* applied voltage) is typically represented by the following formula:

$$P = iV = 2\ \mu A * 1\ kV = 3\ mW$$

The voltage of 1 kV used for this estimation is only about 10% of the total voltage applied to the emitter due to the fact that the remainder of the voltage drop is beyond the plasma zone and represents a much lower energy density. Although this power is low, its high density results in an air temperature of hundreds of degrees Centigrade immediately adjacent to the emitter point.

The Creation of White "Fuzzballs"

While corona ionizers have the desirable feature of dissipating static surface charge, they also have the undesirable feature of also serving as a chemical reactor inside of the plasma zone as a result of the elevated temperature. A cleanroom is by definition a place with clean air (low particle count) but owing to the nature of the manufacturing processes, a cleanroom also has a exceptionally high density of airborne molecular contaminants (AMCs). As an example, there is often a high concentration of HMDS (hexamethyl disilazane) in the atmosphere of a flat panel or semiconductor cleanroom. It is these contaminants that undergo chemical reactions when they enter the plasma zone. The action of the plasma is to disassemble the complex organic chemicals into smaller radicals and then allow them to reform into crystalline structures on the emitter points. The resulting precipitated material appears as a white "fuzzball," shown on the tip of an emitter point in Figure 1.

Figure 1. A White "Fuzzball" Appears On Emitter Tips As A Result Of Precipitated Materials

While the material that is drawn from the room air acts as a kind of electrostatic precipitator, it still affects the ionizer's performance and as such, must be removed regularly. This represents a maintenance burden for the product.

The cleaning frequency depends upon several factors. The concentration of AMCs in the air varies widely from location to location. Photo areas generally have the highest levels. As such, these areas require the most maintenance. The other factor in controlling the rate of fuzz growth is the output level of the ionizer. By setting the ionizer to the most efficient parameters for the configuration (frequency, off time, etc.), the ionizer output amplitude can be decreased, thus decreasing the amount of power which is dissipated in the corona surrounding the point. This decreases the rate of fuzz buildup.

Eliminating Buildup

Fuzzballs need to be removed from the ionizer to maintain proper operation. While this is a simple operation, it often involves thousands or tens of thousands of cleaning operations to clean 10-30 points on several thousand emitters. In addition, the ionizers may not be easily accessible in certain applications. If this is the case, it is highly desirable to eliminate the need for cleaning of ionizers.

Ion initiated a design project to explore an emitter point nozzle that would protect emitter points from the air and eliminate fuzzballs.

Because of the difficulty of ionizer maintenance in some applications, Ion initiated a design project for an ionizer that is virtually free of the white fuzz buildup was undertaken. The principle of operation involved separating the emitter points from the room air. Only ultra pure air with no AMCs (airborne molecular contaminants) was allowed to contact the points. See Figure 2. This technique is called an air sheath.

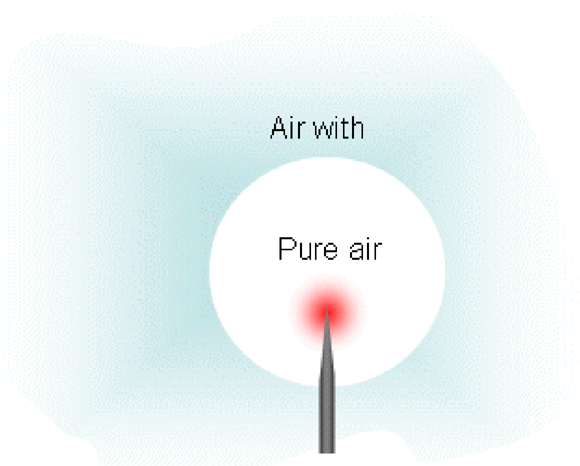

Figure 2. Air Sheath Design

The implementation of a sheath design requires excellent attention to detail. For example, any amount of eddy in the pure air will allow AMCs from the room atmosphere to contact the emitter point and as a result generate fuzzballs. This is an easy trap for a design to fall into because the pure air container must have an open end so that the ionization can escape into the space it is to protect. See Figure 3.

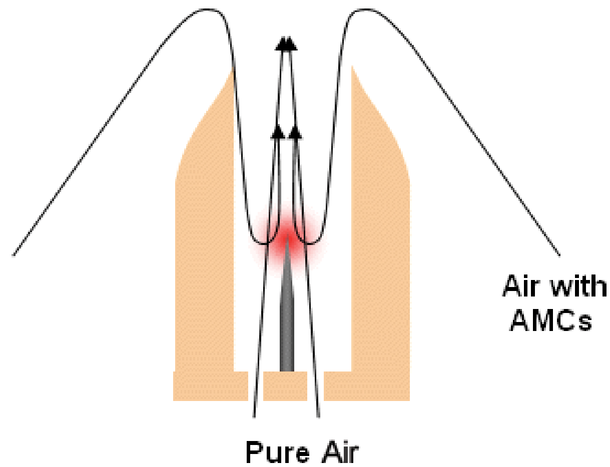

Figure 3. Design Trap Of A Sheath Nozzle Design

Any sheath design must have air injected around the emitter point with extremely laminar flow so that entrainment of room air does not occur.

Another issue to overcome is the corona process that involves high energy electrons and ions, which are accelerated by the emitter point bias voltage. In Figure 4, a high energy Argon ion is shown moving through a photographic material sensitive to charged particles. The argon strikes a nucleus and a shower of secondary particles results. In addition, many electrons can be seen on the left side of the picture as they are knocked off of atoms by collisions of the Argon ion with the local atmosphere.

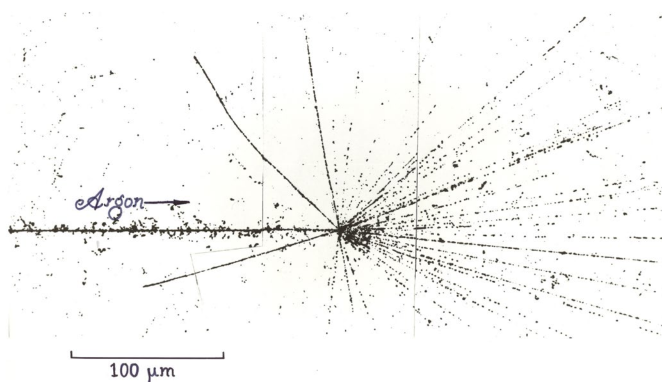

Figure 4. High Energy Argon Ion Moving Through Photographic Material
Photograph courtesy of Lawrence Berkeley National Laboratory.

These electrons travel a distance of approximately 10 μm in the photographic material which corresponds to less than 100 μm in less dense air. It is there that secondary electrons reside, which represent a contamination hazard to the sheath design. Placing the emitter tip too close to the nozzle of an ionizer represents a potential source of damage to the plastic nozzle and a source of contaminating particles. This problem eliminates many potential nozzle/emitter point configurations, which are sure to avoid backdrafts. Two examples of nozzle erosion are shown in Figures 5 and 6. Figure 5 shows a piece of emitter nozzle, polycarbonate plastic, which was placed approximately 200 μm from an emitter point operated at a bias voltage of 10 kV for 12 months. The pitting in the emitter is evident. In Figure 6, the polycarbonate plastic nozzle was cracked through by the action of corona.

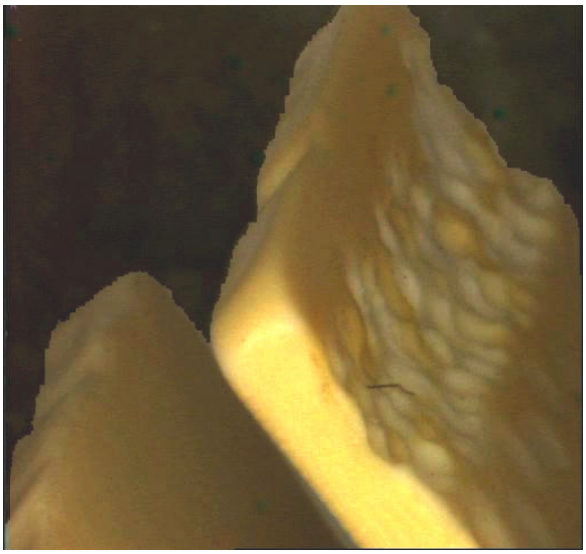

Figure 5. Pitting In Emitter Nozzle

Figure 6. Cracked Nozzle From Corona

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