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Bartlett Bay Consulting^{LLC}

**Contamination Control
And
Minienvironment Specialists**

September 2005

The Newsletter for the Contamination Control Community

We hope that you find these newsletters interesting & informative reading. Please feel free to [contact](#) me with any questions or comments. Past issues are available on the [Bartlett Bay Consulting](#) web site.

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**Steve Silverman, President
Bartlett Bay Consulting**

This newsletter contains two articles which the contamination control community will certainly find of interest:

1. An Interview with **Arnie Steinman**, CTO of Ion Systems and
2. The second installment of our Feature Article, “Meeting ISO 1” for clean environments”

In addition, the newsletter continues its on-going features of conferences and articles of interest.

**An Interview with Arnie Steinman:
“ESD and Ionizers: the Basics”**

Arnie Steinman is Chief Technology Officer of **Ion Systems** (Berkeley, CA) and Leader of the SEMI ESD Task Force (SEMI Standard SEMI E78 (latest revision due 11/05), SEMI E129-1103, and SEMI E43-0301)

(note: the intent of this newsletter has always been to provide an on-going and interactive relationship with its readers. In that vein , Arnie Steinman and I have agreed that this interview will be a “primer” on the subject of ESD/Ionizers, AND that the next newsletter will continue the interview by answering questions from our readers on this subject)

Bartlett Bay Consulting: First, let us start with some definitions: what are ESD and ionizers?

Arnie Steinman: ESD is ElectroStatic Discharge, the rapid transfer of charge between two objects, either of which can be damaged by this event. A related acronym is ESA, ElectroStatic Attraction, which causes contaminating particles to be attracted to charged surfaces, and unwanted/uncontrolled movement of charged objects both of which can result in equipment problems. One of the methods of removing static charge is to supply charges of the opposite polarity. An ionizer is a device that creates charged gas molecules, typically in the surrounding air. These charged gas molecules are attracted to, and neutralize, charged surfaces.

Bartlett Bay Consulting: How do ionizers work, what makes them effective, and how do they fit into a static control program?

Arnie Steinman: An ionizer works by moving electrons between gas molecules. A gas molecule containing extra electrons is a negative ion, while a gas molecule lacking electrons is a positive ion. Alpha ionizers use alpha particle emission from a polonium 210 radioactive source to move the electrons between gas molecules, while corona ionizers use electric fields to do this. Alpha ionizers are particularly suited to flammable or explosive environments because no power source is required. Unfortunately, even these safe, low level radiation sources must follow government regulations regarding their use and disposal. Corona ionizers have no regulatory issues and come in a wide variety of forms (ceiling ionizers, bar ionizers, point-of-use ionizers, blowers, and blow-off nozzles) for many cleanroom, minienvironment, and non-cleanroom applications.

Surfaces in any work area may have either positive or negative charge, depending on what contacts them. Conductive surfaces can be connected to ground, and the ground connection will assure that there is no static charge, but most work areas and products contain insulators or isolated conductors that cannot be connected to ground. Ionizers are the only practical means to neutralize charge on isolated conductors and insulators. The charge on the surface of an object will attract opposite polarity ions from the air until all the surface charge has been neutralized.

Bartlett Bay Consulting: What kind of ionizers are best and where do they work best?

Arnie Steinman: Every application of ionizers has its own requirements. Some require extreme cleanliness, some require precision balance of positive and negative ion levels, and some require auxiliary airflow sources. There are ionizers that can meet all of these requirements, but no one type of ionizer is “best” for all applications. For example,

semiconductor manufacturers use ceiling ionizers to cover large open areas in “front-end” (pre-metal/connection steps) manufacturing, in addition to using a variety of ionizer types which are built into the process equipment. Disk drive assemblies utilize cleanroom-compatible ionizing blowers to protect extremely ESD-sensitive disk drive components.

Bartlett Bay Consulting: Everyone is concerned with shrinking dimensions in electronics (semiconductors, disk drives, etc); how do ionizers help in cleanrooms to address this problem?

Arnie Steinman: As noted, in cleanrooms and other areas, ionizers are the only practical means of removing charge from insulators and isolated conductors. Cleanliness and process requirements (e.g., high temperature, chemical resistance) generally increase the use of insulating materials (glass, plastics, and Teflon). Once charged, all of these materials become particle “magnets”. As product feature sizes continue to shrink, more products are produced in cleanrooms, and the products themselves become more sensitive to ESD. To make matters worse,

- a. particle attraction increases as the particle size decreases, causing more defects, and
- b. cleanroom filtration efficiency decreases for smaller particles.

All of these problems have made removing static charge from insulators in many cleanrooms a key requirement for achieving high levels of product quality and yield.

Bartlett Bay Consulting: are ionizers useful in minienvironments, as well?

Arnie Steinman: Specialized ionizers have been designed for use in minienvironments. In addition to needing to be small enough to fit in the limited confines of the minienvironment, even more attention must be paid to cleanroom compatibility. Today, and in the future, in minienvironments we will be looking for ionizers that meet ISO Class 1 or 2 requirements; much more stringent than the older Federal Standard 209E Class 1 requirements common

in cleanrooms. Since there is much less air dilution, material compatibility, particularly corona ionizer emitter point materials, need to be considered when installing ionizers in a minienvironment or production tool.

Nobody doing silicon semiconductor production should be using ionizer emitter points made of anything but the industry standard, single crystal silicon, the same material as the semiconductor wafer. Germanium, silicon carbide, and metallic emitter points all produce unacceptable contamination of the silicon surface. Ionizers must prove their cleanroom compatibility using appropriate testing. If your killer particle size is less than 50 nm, your test equipment must be able to detect particles at least 25 nm in size, or smaller. There are both pulsed DC room ionizers and pulsed DC or steady state DC equipment ionizers available that have been tested and shown to meet ISO Class 2 specifications, as well as manufacturers' process requirements.

Bartlett Bay Consulting how does one know if ionizers are needed?

Arnie Steinman: The short answer is, anywhere the laws of physics apply. Static charge generation is a certainty when materials are placed in contact with each other and subsequently separated. Grounding solves the static problem for conductive materials, so the first question to ask is, are there any insulators in the product or process? If the answer is yes, the next questions to ask are whether the product or process is sensitive to ESD or to small particle contamination? If the answers to any of these questions is yes, then the production processes can be improved with ionizers. One more question, do we care about product quality and production yield? It is surprising that many times this question is not asked until after there is a major production loss that is traced to static charge. The laws of physics apply everywhere.

Bartlett Bay Consulting: Give us some insight into the future: will ionizers change? Why? How?

Arnie Steinman: All of our high-tech industries follow their own technology roadmaps. But one thing is consistent: as products change, the static problems become worse and there is a need to control static charge to lower levels. In semiconductors, for example, electric fields from charged surfaces anywhere in the factory are recommended to be controlled below 100 volt/cm for 90 nm technology in 2004 (refs., International Technology Roadmap for Semiconductors 2005, SEMI E78 [equipment], SEMI E129 [factory]). The level drops to 50 volt/cm for 45 nm technology in 2010. Anyone designing a minienvironment or production tool today must take into account static control that will be required 5 to 10 years from now. Ionizers will need to change as well. They will need to improve their discharge rate, balance and stability, they will need to fit in smaller spaces, and they must prove their compatibility with products and use environments, particularly cleanrooms, in which they will be used. For ionizer manufacturers, this challenge is not new. The state-of-the-art in ionizers has been evolving rapidly in the last decade to meet these new technology requirements.

Bartlett Bay Consulting: Thank you very much, Arnie.

So, dear readers.... It is your turn. What questions do you have? Arnie has agreed to answer them in the next newsletter, so make your questions as detailed as you wish. As this article was meant to explore the basics, would you like some more advanced discussion on this topic? We await your questions!

Feature Article
Meeting ISO 1 for Clean Environments: Cleanrooms and minienvironments:
Part 2

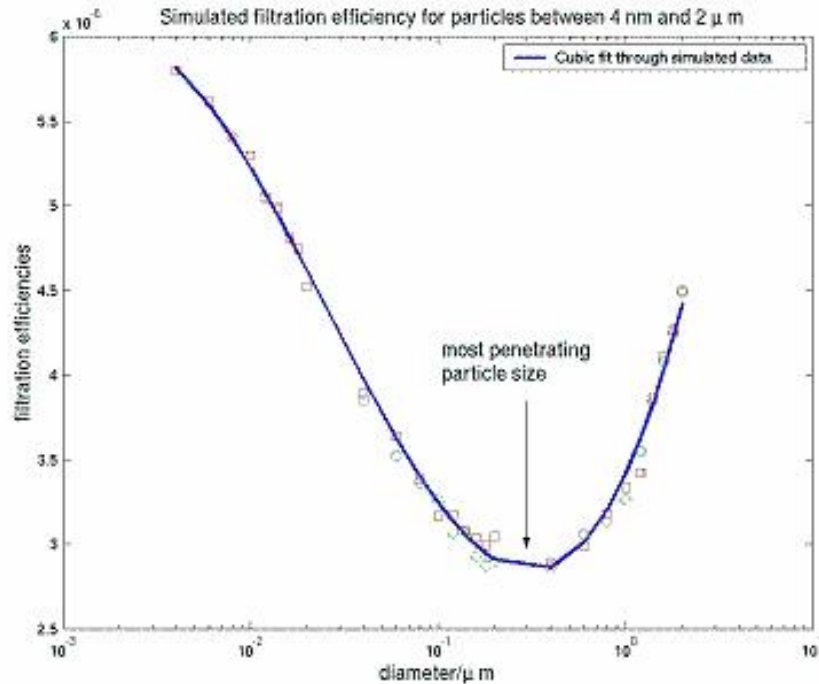
As we learned in the last article, filters are a key element in the control of contamination of cleanrooms and minienvironments. In this article we will learn about some of the problems with filters as well as the details of the other elements of a clean air system, namely air exhaust and pressurization.

What filters do: a very good job (but certainly not perfect. See below) of preventing particles from penetrating; by using a “honeycomb” fiber construction, particles are trapped in the filter structure as the air is pushed through by a fan. Additionally, there are also electrostatic filters available which use charged fibers to increase collection efficiency. Modern filters can *help* maintain exceptionally clean air especially in minienvironments, where ISO class 1 has been shown to be achievable.

What filters do not do:

1. They don't prevent all particles from entering the clean area. Consider a top of the line ULPA filter with a 99.9995% efficiency; this may seem pretty darn good (and it is!), but consider also that, while it only allows 0.0005% of the particles through, dirty air contains MILLIONS of particles, so that minute percentage can translate into many particles going through the filter (you can see why pre-filters, good air flow management, and good minienvironment design are needed!).
2. They don't trap virus': Because virus' are usually much smaller (0.005- 0.05um) than modern day filter media, other methods must be used to kill them such as UV lighting.
3. They don't produce laminar flow air directly out of the filter face: because of the twisting path the air takes in going through the filter fibers, the air actually emerges with some turbulence. It requires about 300mm (12”) below the filter face before the air “smooths out” and approaches laminarity.
4. They don't get more efficient as the particles get smaller: it is a common misconception that the *best* efficiency for a 0.12um filter is *at* 0.12um. In fact, the exact opposite is true as 0.12um is

(as was described in the last article) the “Most Penetrating Particle Size”: the filter reaches its lowest efficiency at 0.12 μ m and then, as shown in the figure below, the filter becomes more efficient BELOW 0.12 μ m (yes, it sounds strange, but the physics of this are beyond the scope of this article).



As stated above, the filter is only a part of the picture, and while it is an important part, the other 2 elements, exhaust and pressure are of equal importance. Probably the least understood is the issue of the exhaust of the cleanroom or minienvironment.. There are 2 parts to the exhaust “picture”, the first being the volume of air that comes into the cleanroom/minienvironment and the second being the heat load of the room:

1. **Volume of air:** in order to have a properly working clean environment, the volume of air entering, must equal the volume of air exiting (yes, I know that sounds rather obvious, but some designers just think of getting the air in, and forget that it has to come out; in fact, I have had many a discussion with OEM companies who want to design minienvironments **with no air exit!**)

For an ISO 5 or better cleanroom, the amount of air entering and leaving is VERY high and can result in between 400 and 700 air changes per hour: a tremendous volume of air.*

The difficulty is *managing* this volume of air without having turbulence, and, for this, proper placement of air exhaust ducts are critical. Additionally, for the cleanest cleanroom (ISO 1,2,3), a raised floor is needed.

2. **Heat Load:** this is an important, though often forgotten, piece of this complex puzzle: obviously, this heat has to be removed/maintained not only for the overall processing requirements of the product, but also for the comfort of the operators inside the room. Managing this air is not for the in-experienced, as it is a very complicated business composed of complex air movement, mixing, heating/cooling (when necessary), cleanroom pressurization, heat load and dissipation in the cleanroom, tool placement, number of operators/personnel in room, etc.

*Note: for minienvironments, this number is far less, generally in the order of 20-30 air changes/hour. Too high a number in this small volume will result in severe turbulence

The second major piece is pressurization. In order to insure that the clean area (cleanroom/minienvironment) is kept clean (e.g. the dirty air from outside the cleanroom must not be allowed to enter), the pressure inside these areas must be maintained at a higher level than the surrounding non-clean areas, e.g. the cleanroom/minienvironment is kept at a positive pressure relative to surrounding room(s) (more on this later). The whole concept of pressurization is also usually misunderstood as well, but there are 2 key points to remember:

1. that the pressure of a given area is directly related to the velocity of the air through Bernoulli's equation (see [this link](#) for a good discussion) which says that the pressure is proportional to the square of velocity.

(Without a relationship between pressure and velocity, airplanes couldn't fly and, even worse, your favorite baseball pitcher would not be able to throw a curve ball!). What this means is that given a clean area with a given filter coverage and exhaust, the pressure increases as the velocity is raised; consequently, the balance between the velocity and the pressure is a delicate one in which one has to make careful adjustments to the entire cleanroom system to achieve this balance.

2. The pressure differential must be very small. A common misconception regarding the pressure differential is "the higher the better", and this is simply not true. Let us take the "simple" case of a minienvironment where the pressure relationship is easier than a cleanroom as a minienvironment has a small volume and is generally always closed. For a standard minienvironment, the differential pressure (relative to the cleanroom) is typically 1.5 -5.0 Pascal*. This is a very small difference (1 Pascal =0.004" of H₂O=.00001 atmospheres), but numerous experiments (see, for example, *Airflow Parameters for Control of Molecular Contaminants* by Richard Wang, Stephen Silverman, and Michael Robinette, Proceedings – [Institute of Environmental Sciences](#), 1966) have shown that a only very small pressure difference is required to keep dirt/non-wanted species out of the minienvironment. Another
*Cleanrooms typically run from 5-10 Pa differential pressure relative to the surrounding areas, but there are a lot of exceptions to this range.

misconception is the upper value (~5Pa): I have often been asked “if a small pressure differential is good, why isn’t a large pressure better?”. The answer lies in the pressure velocity relationship: the higher the pressure, generally, the higher the velocity, and high velocities inside the minienvironment translate to turbulence. A well-designed minienvironment is one in which turbulence is minimized based on the velocities at various locations inside the minienvironment. Air velocities of 0.3-0.4m/s (60-80 ft/min) are typical.

At this point, you probably have a lot of questions: how is the pressure and velocity measured? How is a minienvironment designed to minimize the turbulence? How does one insure meeting ISO 1? How is the exhaust designed to insure good air flow? Etc etc. However, for these questions, I’m afraid you will have to wait until the next issue of this newsletter.

Upcoming Conferences:

November 1-3, 2005, [NanoCommerce/SEMI NanoForum](#), Chicago, IL

November 6-10, 2005: [ISPE](#) Annual Meeting, Phoenix, AZ

March 21-23, 2006: [Interphex](#) (Pharmaceutical Conference) New York, NY

February 13-15 2006, 25th Annual [SPWCC](#) Conference, Santa Clara, CA

March 15-16, 2006, [Cleanrooms and Contamination Control Technology Conference and Exhibition](#), Boston, MA

Upcoming Conferences (cont.)

May 7-10 2006: [ESTECH](#) (IEST Spring conference); Phoenix, AZ

June 19-21, 2006 [10th International Symposium on Particles on Surfaces: Detection Adhesion and Removal](#), Toronto, Canada

Interesting Articles

Effects of Moisture on the Purification of Compressed Air, John Rotter et al, [A2C2 Magazine](#), February 2005

Interview with TSMC's Burn Lin, [Micro Magazine](#), June 2005

Meeting Manufacturing Metrology Challenges at 90nm and Beyond, Benjamin Bunday et al, [Micro Magazine](#), August/September 2005

Hazards of Molecular Contamination Grow over Space and Time, Carolyn Mathas, [Cleanrooms Magazine](#), July 2005

Bartlett Bay Consulting WEBINARS

Webinars are online PowerPoint presentations delivered via [WebEx](#)®, providers of web-based conferencing & presentation technologies. The Webinars are very in-expensive training method, as no travel is involved and a company's participants can all be in an internet-ready conference room or at their work station. Video is delivered to your monitor directly, and Audio is delivered through VOIP or standard POTS line (telephone). Additionally, "instant messaging" is active, keeping each member of the audience in direct communication with the Moderator throughout the presentation. Essentially, it is the same as any moderated presentation, only we are not all in the same room! Communication is limited to Moderator/Audience Member. The links are secure, and there is no connection between each member of the audience.

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Notes of Interest

ITRS: Steve Silverman, President of Bartlett Bay Consulting continues to lead the ITRS Surface Preparation Focus Team on Backside Particles. This committee is charged with updating the "Backside Particle" section of the ITRS Roadmap. *[If you are interested in being a participant in this committee, please contact [Steve](#)*

It has always been the intention of this newsletter to provide valuable and timely information to the contamination control community, and, with the growing success of this newsletter comes that opportunity. To that end, Bartlett Bay Consulting has instituted 2 new features:

1. **bbcForum™: Get Credit for your work!** If you would like to contribute a short article or feature that would be of interest to our readership, [contact me](#)
2. **bbcLink™: Promote your company!** if your company would like to be promoted as a link on the Bartlett Bay Consulting web site, click [here](#) and fill out the form on that page

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