SIMCO ION™
An ITW Company

APPLICATION NOTE

Why Silicon Points?

Corona type air ionizers apply high voltage to sharp points in order to make ions. The sharp points have the effect of creating an intense electrical field at their tips. Close in, where the field is most intense, ions are created as a result of the high level of kinetic energy of the electrons involved in the current flowing to or from each point. Simco-Ion has selected silicon points for most cleanroom applications owing to the physical properties of silicon. This allows the emitters to be safely used in most cleanrooms while providing a minimum of maintenance and a long operating life. The rationale for the choice of silicon is given below.

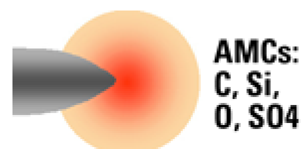
Non-Invasive

Silicon is the basis for most semiconductor manufacturing. Also, for flat panel manufacturing where glass (SiO_2) and amorphous silicon are used, silicon is not a potential contaminant even in ultra-trace quantities. It is important to design an air ionizer emitter point that avoids the introduction of a material that is potentially harmful to the manufacturing process. Since silicon is already employed in these factories, it is a good choice for use in emitter points.

Thermal Conductivity

A typical ion emitter employs up to approximately 10 kV potential and draws a current of nominally 20 uA. This represents a power dissipation of 200 mW. This power is dissipated as heat within 50 mm of the emitter tip and will result in an elevated air temperature at the emitter tips.

One of the principal mechanisms for dissipation of this energy is by conduction up the sleeve of the emitter. Thus, the thermal conductivity of the emitter material plays an important role in the temperature of the tip and of the air in the plasma region at the tip. See the following figure. A higher temperature means greater erosion of the emitter point and can affect its lifetime for the worse.



Charge at emitter tip attracts AMCs, which include corrosive chemicals that can seriously alter the geometries of an emitter point

The high voltage found at the tip of corona ionizer emitter points produces a charge that attracts chemicals known as airborne molecular contaminants (AMCs) already present in the cleanroom air. AMCs include such corrosive chemicals as acids and bases which can seriously alter the geometries of an emitter point.

As AMCs corrode the structure of a point, the points become jagged and each serrated edge starts emitting ions itself. Once the emitter points' geometry erodes, ions are produced from the jagged edges and the inherent balance of AC ionizers begins to fade. AMCs eat away at the emitter point structure.

A heat transfer calculation can be used to estimate the temperature at the tip. All ionizers have a current (>5 uA) and voltage which results in at least 25 mW of power dissipated in just the tiny volume of a sphere 25mm in diameter. This leads to amazingly high temperature in such a small body.

The discoloration of the tips reflects the high temperature quoted above. The calculation we performed reveals that the amount that the temperature is elevated above room temperature in the range of 100s of degrees K.

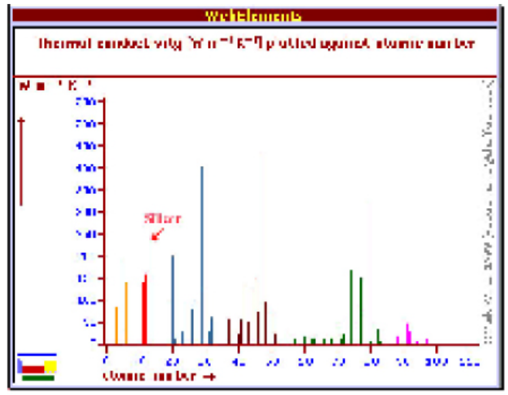
A temperature of 750°C (1000°K) is high enough to drive many chemical reactions of AMCs. If the temperature is not controlled through the correct choice of emitter materials, more chemical reactions will take place resulting in particle production and producing material deposition on the points. This deposition is the source of the white powder that builds up on the emitter points with time and represents a maintenance issue since it must be removed manually. Because of the importance of the cooling of the emitter tip, it is important to choose a material that has a high thermal conductivity. Silicon rates extremely well in this category.

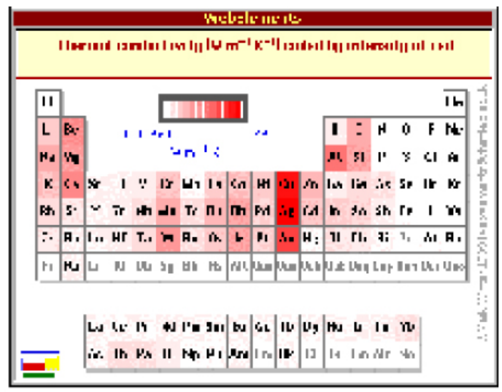
The table below lists a variety of candidates for emitter tips. It can be seen that silicon rates favorably compared to most metals and it stands out compared to other semiconductor materials. Since the temperature elevation at the tip will vary inversely with the thermal conductivity of the tip, the use of any of the materials below will result in a temperature at the tip which is 100's of degrees higher.

Material	Thermal Conductivity (w/m °K)
Silicon	149
Silicon Carbide	115
Germanium	60
Selenium	0.52
Iron	80
Steel	16-47
Aluminum	121-233
Tin	67
Ni	92
Gold	297
Platinum	69

For this reason, silicon lasts for a long time in ionizers and it also is particularly clean when measured with a Condensation Nucleus Counter (CNC) which can detect the very small (~0.01 micron) particles that are the result of AMCs.

The thermal conductivity of the elements is shown in the figures below. As can be seen from the figures, there are very few elements which have a thermal conductivity higher than that of Si.





The thermal conductivity of the elements. Images courtesy of Universtiy of Sheffield

Conclusion

Silicon is a good choice for emitter point material as it is the same material already present in great quantities in semiconductor and flat panel factories. Silicon also has the property that it will provide a long operating life for emitter points and require minimum maintenance while also representing the smallest risk of particle generation of any material studied.

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