



## Technical Note

# Titanium and Silicon Emitter Point Erosion Analysis

The damage mechanism for emitter points is mainly due to chemical reactions, leading to an oxidative corrosion process. The evidence for chemical oxidative damage to the emitters from these molecules is reasonably good, and comes from accelerated aging studies of point-to-plane emitter geometries at currents 10 to 50 times higher than Ion Systems emitter units. The reaction rates and temperature at the emitter point scale with the current, so expect the damage to accumulate more slowly over time.

The corona discharge produces a “soup” of very reactive gas molecules, including oxygen free radicals,  $O_2^-$ , OH,  $O_3$ , etc. These reactive chemical species also can participate in reactions that can lead to gas-to-particle conversion processes from trace molecules in the air. These reactions are now documented in the literature, including production of ammonium nitrate,  $NH_4NO_3$ , from water and silicates from dimethyl siloxane, produced by off-gassing from silicone sealing materials used extensively in HEPA filters. This is the dominate process that leads to the formation of “fuzz balls” on the emitters. If these products accumulate over time they can slough off and lead to particle generation, often in bursts.

The evidence for particle production from ion emitters universally shows the formation of ultra fine aerosols, typically about 0.05 microns in diameter. All papers show diameters much less than 0.2 microns and in some cases particles as small as 0.01 microns are found. Our own observations confirmed this pattern, and found a typical size of about 20 nm from Ion Systems emitters. All emitter points produce some particles as a result: of (a) gas-to-particle conversion chemical reactions; and (b) damage to the points from corrosion.

Titanium (Ti) and silicon (Si) points both combat this process in a similar way. Both titanium and silicon are very resistant to sputtering damage (Ref Wolf and Tauber, 343) at the low ion bombardment energies (<100 eV) present at emitter points. Also, both of these materials are strong oxygen “scavengers” that quickly grab any free oxygen and convert the surface layers to  $TiO_2$  or  $SiO_2$ . This has the initial effect of quenching the chemical reactions at the surface, and over time forms a passivation layer that significantly limits the particle production. However, it is not sufficient just to quench the reaction, since the material must also resist ion bombardment.

Naturally, any particles dislodged from the surface would be in oxidized form, not in the form of the base emitter material. So, the other important feature of these emitter materials is that they form a very tenacious oxidized layer on the surface. This layer strongly adheres to the emitter and resists further corrosion damage, but slowly wears off and leads to emitter point wear.

In conclusion, ionizers can produce ultrafine aerosols by several mechanisms, and this leads to erosion of the points. But we have not observed release of micron-sized chunks of the base material from emitters. This is not consistent with what is known about emitter damage or particle production mechanisms.

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