Improved Pumpdown Times and Productivity in SEM/FIBs by means of Evactron Turbo Plasma Cleaning

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Vacuum-based processes exhibit decreased performance in the presence of adventitious hydrocarbons that are volatilized from various sources such as lubricants and solvents. For example, in electron microscopy the presence of hydrocarbons causes unwelcome effects such as image blur, unexpected signals during microanalysis, astigmatism as well as "black square" formation during lengthy beam exposure times. These and related issues have given rise to the use of RF-driven plasmas to decontaminate vacuum chambers via the generation of excited-state species (typically oxygen radicals) that gently remove contamination. It is important to note that these systems generate neutral cleaning species that flow from the plasma into the chamber so the decontamination is removed remotely by chemical reactions, not sputtering or kinetic reactions.

To demonstrate the effect of Evactron Turbo Plasma Cleaning on pumpdown time and hydrocarbon contamination removal, experiments were conducted using an Evactron model E50 Plasma De-Contaminator on a large, highly oil-contaminated 50 L vacuum chamber. We also used a commercial quartz crystal microbalance (QCM) coated with a hydrocarbon using a proprietary process to monitor chamber cleanliness. Residual gas analysis (RGA) spectra identified adventitious hydrocarbons and confirmed their removal after plasma cleaning. Remote plasma cleaning can be performed on SEMs and FIBs at pressures below 100 mTorr (13.3 Pa) during direct pumping with a TMP (Turbo Molecular Pump). Previous studies showed that low chamber pressures increase the rate of cleaning and the distances at which cleaning was observed. Low pressures increase cleaning speeds by increasing mean free paths and reducing the recombination rates of oxygen radicals by three body collisions. Instant plasma ignition at low pressure also allows the plasma to be turned off after short cleaning times of 1-5 minutes. Systems quickly return to base pressure as the turbo pump removes reaction products. Fast removal obviates the need for overnight cleaning, which is discouraged because of extended exposure of the instrument interior to oxygen radicals.

The length of pumpdown time shows dependence on hydrocarbon contamination levels in SEMs and FIBs. Therefore this time could be used as an indicator of the cleanliness of the vacuum system. The data show that Evactron plasma cleaners significantly reduce both the pumpdown time of SEMs and FIBs as well as hydrocarbon contamination, and thus help increase sample processing throughput and productivity without compromising the quality of analysis. In summary, vacuum chambers can be cleaned to maintain pristine conditions with the Turbo Plasma Cleaning process at turbo molecular pressures of 10^{-2} to 10^{-3} Torr with typical cleaning times of 2 - 10 minutes. SEM/FIBs return to typical operating pressures in less than 20 minutes. Current users of Evactron Plasma Cleaners report significant reduction in pumpdown time as well as easier maintenance of the pristine state of cleanliness of their SEMs and FIBs after using Evactron De-Contaminators.