

The Use of Oxygen in SEM Plasma Cleaning Equipment

Thomas O. Mueller , J. Cowan , and E. Swanson

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ON Semiconductor, Gresham Failure Analysis Laboratory, 23400 NE Glisan St, Gresham, OR 97030

Getting the most out of your SEM has in the past meant baking out your column and being vigilant about wearing gloves when handling samples. As feature sizes decrease this may not be enough. Hydrocarbon buildup in SEM vacuum chambers can lead to less than ideal resolution. The electron beam reacts with contamination and deposits carbon on the sample which can cause charging and degrade image contrast. Oxygen plasma has long been used for cleaning surfaces in a vacuum. O₂ is split into oxygen ions and radicals which are effective at removing organic contaminants. Manufacturers have produced low energy plasma cleaners that pull oxygen ions and radicals out of “thin air.” While this may seem like “snake oil”, it actually does work. This approach works, is easy to use, and has very little setup, but it is very slow. If you have a “dirty” system you may spend days or weeks on an initial cleaning. We modified our Evactron® De-Contaminator to use welding grade oxygen. The investigation that we have performed indicates that there is a night and day comparison for effectiveness and speed. One or two four hour sessions with oxygen was shown to be more effective than using ambient air for weeks.

Plasma works by converting gas atoms into ions and radicals. High frequency magnetic fields oscillate gas atoms into a frenzy, both breaking bonds and producing a luminescent glow. The ions and radicals then do all the work. Oxygen ions and radicals are very effective cleaning agents. The cleaning process involves the oxygen gas ions and radicals reacting with the hydrocarbons inside the SEM. These reactions yield H₂O, CO, and CO₂ that are then removed from the system by the vacuum pumps.

When air is used as the process gas oxygen ions and radicals are produced but so are nitrogen ions. Nitrogen ions, not only do not contribute to the cleaning process, they also recombine with oxygen ions and radicals. Since air is 70 % nitrogen the probability of long lived oxygen reactive species is slim. As their lifetime is reduced so is their mean free path, making cleaning farther away from the plasma less likely.

When oxygen is used as the process gas there is no predatory nitrogen to get in the way. Oxygen ions and radicals have less restrictions, can move farther and clean better.

But how can a low energy plasma system be converted to work with oxygen? A trip to a welding supply store produced a bottle of O₂ and a regulator. With a bit of tubing and some fittings we were ready to begin. With the regulator in place the bottle is opened and the regulator is just barely opened to produce a constant wisp of oxygen flow. The tubing is attached to the leak port of the plasma system and it is ready to go.

References

- [1] Neal Sullivan, et al., *Microscopy and Microanalysis 2002*
- [2] T.C. Isabell AND P.E. Fischione, *Plasma Science, 1998.*
- [3] http://en.wikipedia.org/wiki/Plasma_cleaning

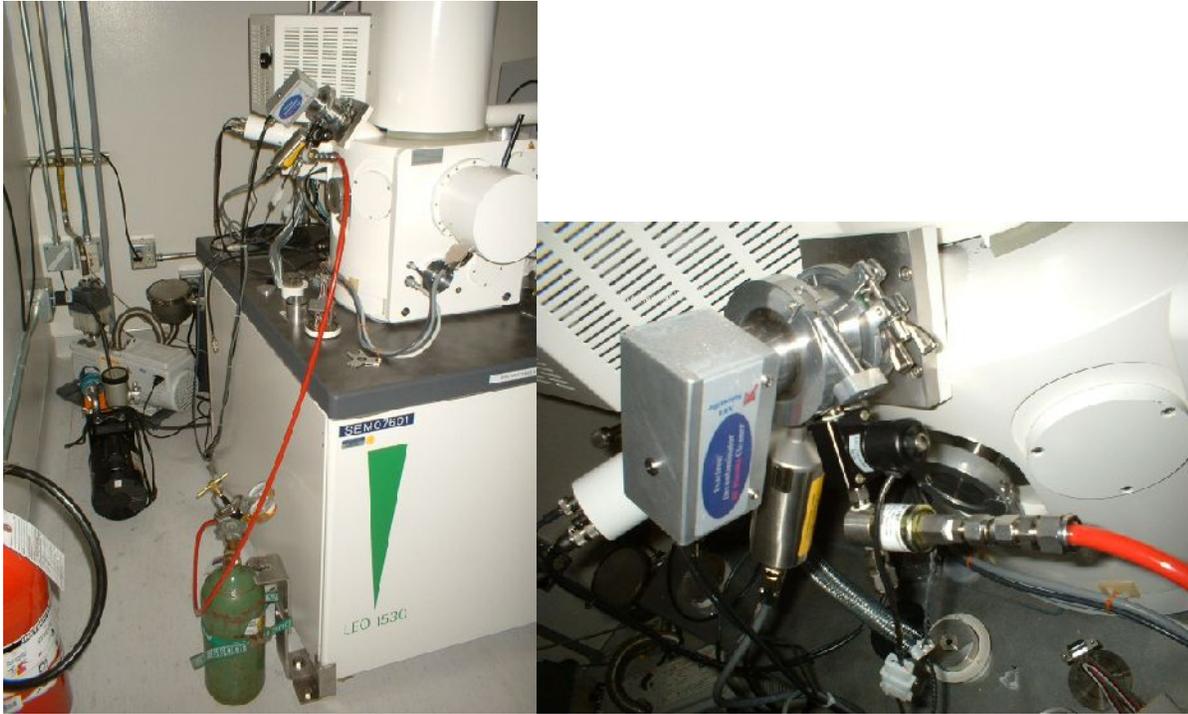


FIG. 1. Oxygen tank attached to Evactron Decontaminator low energy plasma cleaner. Red tubing connects the bottle/regulator to the intake port of the Evactron.

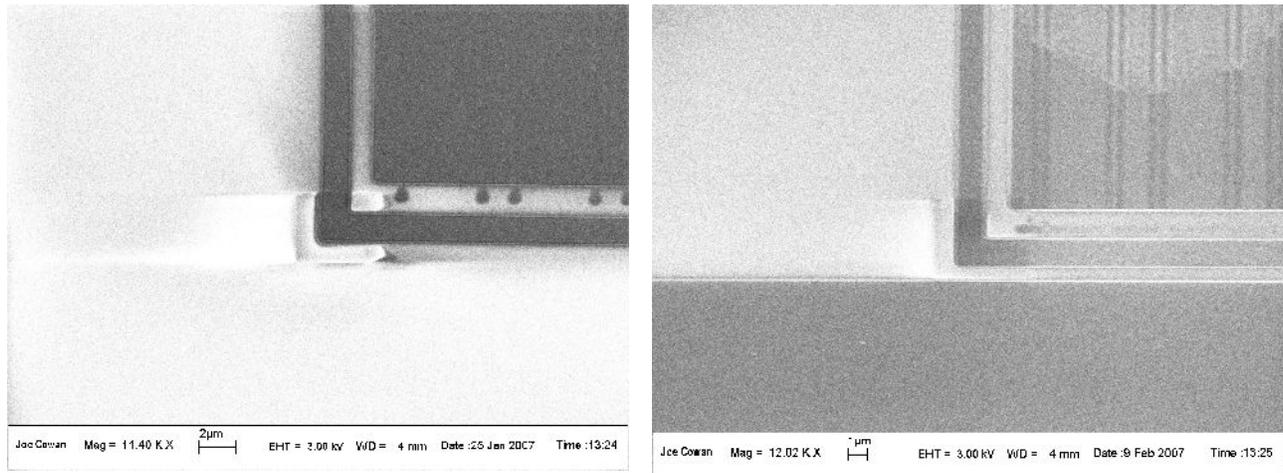


FIG. 2. Before (left) and after (right) 4 hours of chamber cleaning with oxygen plasma.