Effect of Cleaning Parameters on Cleaning Effectiveness in an SEM Equipped with an Oxygen Plasma Etching Device

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PROCEEDINGS M&M2007 CD1732

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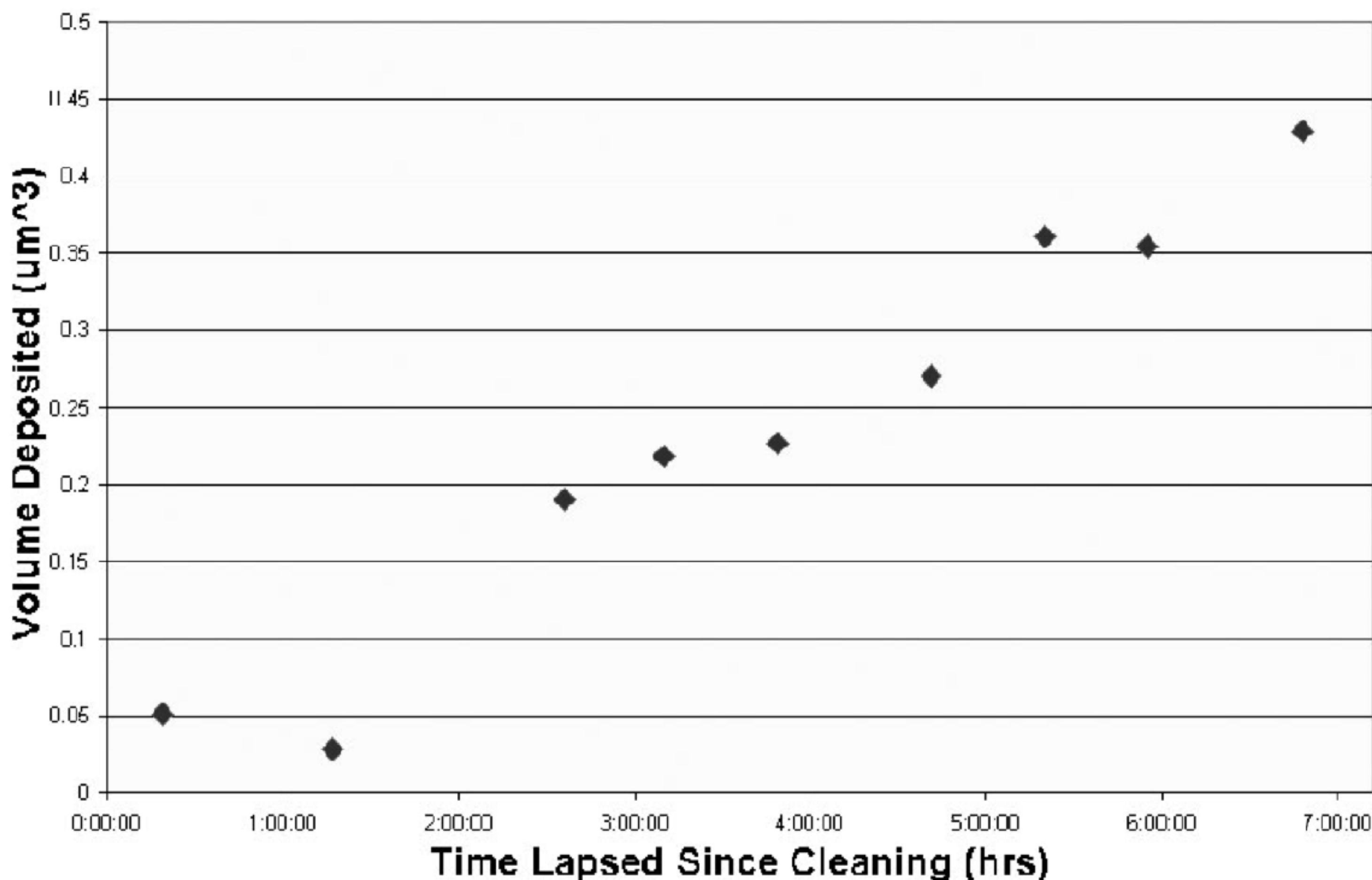
Previous studies have demonstrated that using an oxygen plasma etching device, in this case an Evactron® RF plasma system manufactured by XEI Scientific, to clean the chamber of a Scanning Electron Microscope (SEM) greatly decreases the deposition of hydrocarbon contamination during routine operation of the SEM **[1]**. It has also been shown previously that the contamination rate can be determined by observing the absorbed specimen current **[2]**. As hydrocarbon contamination accumulates on a specimen surface the absorbed current increases. The increase in absorbed current is thought to be due to the low secondary and backscattered electron yield of the deposited hydrocarbons. The change in absorbed current allows for routine monitoring of contamination buildup.

The next step is to determine the effects of varying operating parameters on the effectiveness of the oxygen plasma etcher in controlling contamination buildup. While the manufacturer makes recommendations for pressure, power level, and precursor gases for controlling contamination buildup, there have been no quantitative studies to show their relationships with respect to cleaning effectiveness. In this study, an Evactron® RF plasma anti-contamination system was mounted on an auxiliary port of a Hitachi S-3200N SEM equipped with a GW specimen current amplifier connected



to a National Instruments USB data logger. InP was used as a substrate due to its flatness, conductivity, and repeatable absorbed current signal decrease as a function of contamination buildup. Contamination was deposited over a 1000 sec interval at 10,000 times magnification with the standard sample at 15mm working distance and a beam current of 2nA and a beam voltage of 5kV resulting in a 16.5 m13.2 m deposited rectangle (Fig. 2a) with a dose of 1056 C/cm2.

Two experiments were used to understand the relationship between pressure and power level with cleaning effectiveness and a third experiment varied the precursor gas using the optimum conditions found in the first two experiments. XEI Scientific recommends a 20 minute cleaning time at 10 watts with 500mT of ambient lab air as the precursor gas. First, the pressure was varied from 400 to 600 mTorr in 100 mTorr increments with all other parameters being held constant. The second set of experiments maintains a constant pressure while the power is varied from 10 to 14 watts in one watt increments. The third set of experiments varies the atmosphere introduced into the chamber while all other parameters remain constant. In this case the atmospheres will be air, oxygen and water vapor. Through this set of experiments the operating parameters for the Evactron® can be optimized.

[1] R. Garcia et al., 'A Quantitative Study of the Cleaning Effectiveness of the Evactron® RF Plasma System on an Environmental Scanning Electron Microscope', Microscopy and Microanalysis 2005, (Honolulu, HI).
[2] R. Garcia et al., 'Monitoring Contamination Rate in an SEM Equiped with an Evactron® RF Plasma Anti-Contamination Device', Microscopy and Microanalysis 2006, (Chicago, IL).

Fig. 1.Measured contamination in m^3 as a function of time since Evactron® cleaning was performed.

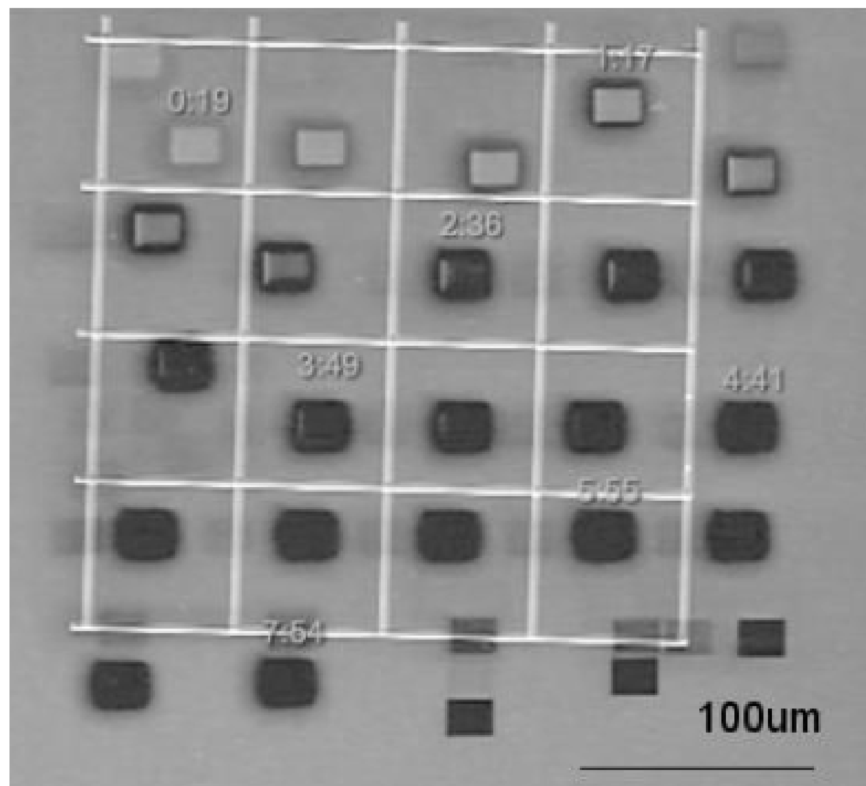


Fig. 2. Secondary electron image of contamination boxes (1000 sec exposure) deposited at approximately 20 min intervals since Evactron® cleaning. (number indicate time since cleaning when box was started in hours and minutes).