Contamination Removal Rates Improved by New Impedance Matching Network for the Evactron® De-Contaminator

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INTRODUCTION

Hydrocarbon contamination causes the image darkening or "Black Square" in the image in Figure 1a. The Evactron® De-Contaminator (D-C) removes hydrocarbon contamination from electron microscopes, as seen on the image in Figure 1b. A radio frequency (RF) generated plasma is attached to the microscope chamber. Room air or other oxygen containing gas passes through the plasma. This process creates oxygen radicals which ash the hydrocarbons within the electron microscope chamber. An impedance matching network (match) is used to maximize the power delivered to the plasma. Improving the efficiency of the match can increase the cleaning efficiency of the Evactron D-C.

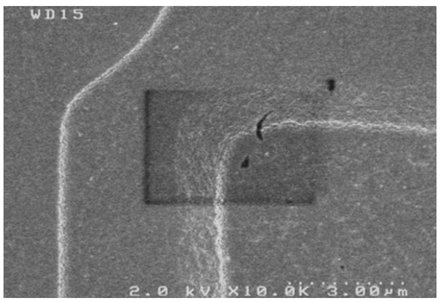

Figure 1a: SEM image with Black Square before Evactron cleaning (image c/o Rick Passey, HP)

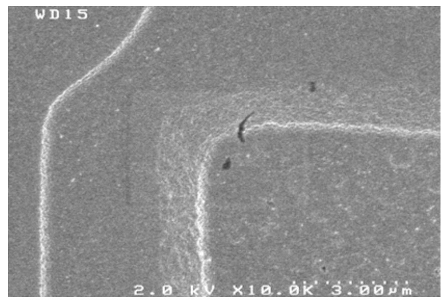

Figure 1b: SEM image with Black Square after Evactron cleaning (image c/o Rick Passey, HP)

OLD AND NEW IMPEDANCE MATCHES

The old match shown in Figure 2a is not ventilated, and it requires user adjustment via a trimmer capacitor (see white arrow). The reflected RF power has values between 10-20% of the forward RF power.

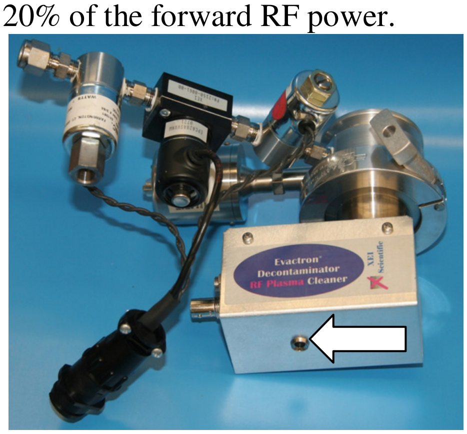

Figure 2a: Old impedance match is silver box.

Figure 2b: New impedance match is silver box in figure.

The design of the new match (shown in the Figure 2b) has improved circuit topology for increased efficiency. A second tunable element is added to allow for improved matching on both the input and output. The new design operates at higher power levels with concomitant reduction in power component stresses. Rather than using commonly available parts, special components are used to reduce losses. In addition, all components in the signal path are derated significantly. Ventilation is added to the case to help reduce power component temperatures. With these improvements, the reflected power now has values typically between 0-10% of the forward power.

OPTICAL EMISSION DATA

Optical emission spectra were taken for both old and new matches (Figures 3a and 3b, respectively). Room air was used as the plasma gas. Details of how spectra were obtained are discussed in accompanying poster. Most of the emission comes from excited states of N_2; these excited states can be considered a proxy for atomic oxygen production.

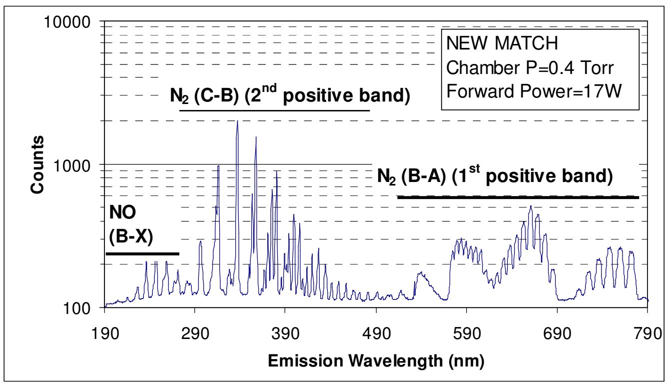

Figure 3a: Optical emissions taken from room air plasma using new impedance match. Vibronic transitions seen in plasma are labeled. Y-axis is a log scale.

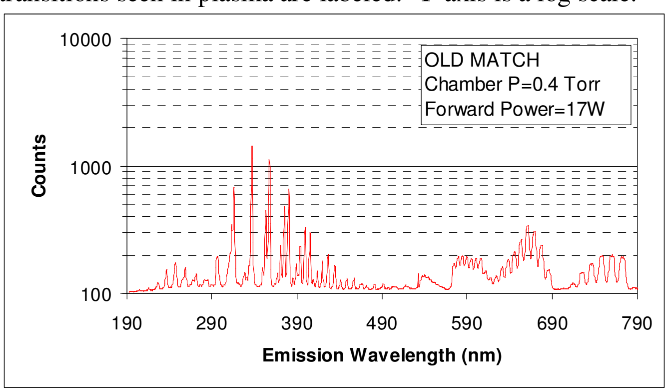

Figure 3b: Optical emissions taken from room air plasma using old impedance match. Y-axis is a log scale.

The total optical emission signal can be obtained by integrating the signal, as shown in Figure 4. We see that more emissions are produced by the new match. More signal means more oxygen radicals are produced in the plasma.

QUARTZ CRYSTAL MICROBALANCE (QCM) DATA

Data in Figure 5 were taken using Ag-coated QCM. The oxygen radicals create Ag_2O and increase the thickness. Traces can be modeled to determine the oxygen radical concentration; results are shown in the graph in Figure 6. Using Au-coated QCM contaminated with pump oil, cleaning rates of the different matches can also be measured. These results are shown in the graph in Figure 7.

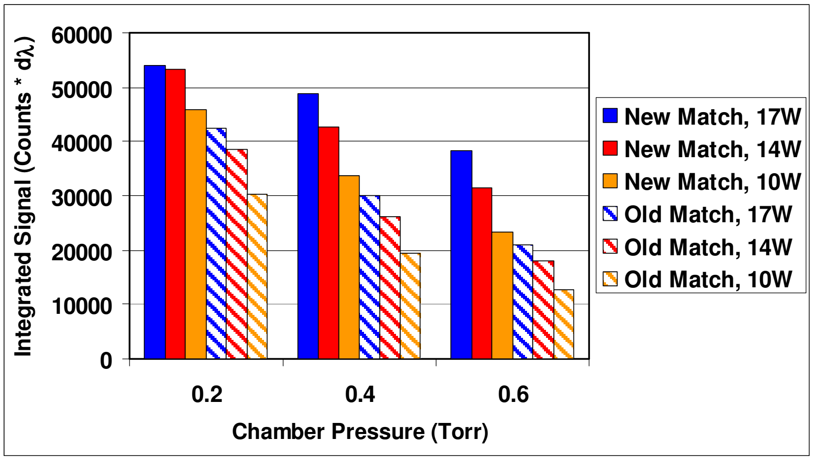

Figure 4: Total integrated optical emission signal as a function of type of match, forward RF power, and chamber pressure. Room air was used as plasma gas.

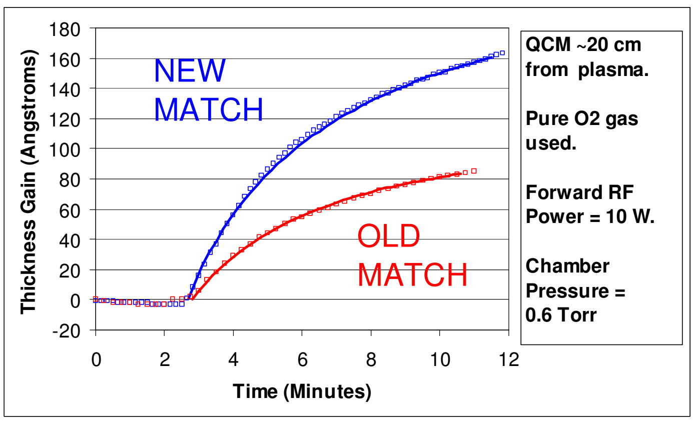

Figure 5: Traces of QCM thickness gain obtained when running the oxygen gas plasma at 10 W forward power at 0.6 Torr chamber pressure with different impedance matches. Red squares are experimental data for the old impedance match; Blue squares are experimental data for the new impedance match. Correspondingly colored lines are theoretical fits to the data. The QCM is ~20 cm from plasma.

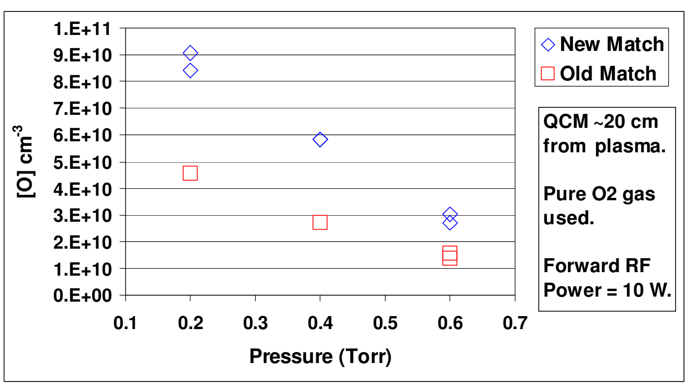

Figure 6: Results of Ag coated QCM experiment using old (red squares) and new (blue diamonds) impedance matches graphed as a function of chamber pressure. The QCM is ~20 cm from plasma. Pure oxygen gas was used in the experiment, and the forward power was set to 10 W.

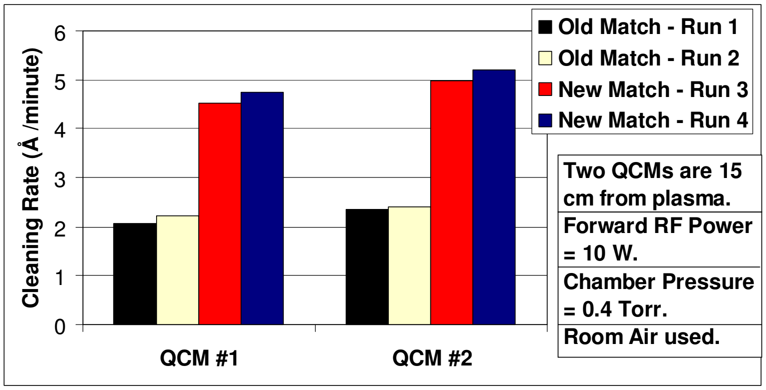

Figure 7: Results of Au coated QCM experiments with old and new impedance matches. For the experiment, two QCM were coated with >1000 Å pump oil, and then both QCMs were placed in a chamber 15 cm away from the plasma. The plasma was run at 10 W forward power with room air and chamber pressure at 0.4 Torr. The oxygen radicals from the plasma ash the pump oil, resulting in a measured thickness loss on the QCM. Once a steady cleaning rate was observed in terms of thickness loss per minute, four experimental runs were performed. The first two runs were with the old impedance match, and the final two runs were with the new impedance match.

CONCLUSION

Data from various experiments have shown that the new design of the impedance match creates more oxygen radicals and increases cleaning efficiency.