Advantages of Using RGA as Part of Atomically Clean Surface (ACS™) for Sub-10 nm Parts Cleaning Process

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Introduction

The ability to detect and mitigate moisture, hydrocarbons and other types of contamination from cleaned parts is becoming more critical as semiconductor technology nodes progress to and beyond the 10 nm threshold. QuantumClean® incorporates residual gas analyzers (RGAs) for Atomically Cleaned Surface™ (ACS™) process development for critically cleaned chamber components. ACS™ processes provide solutions for critical parts cleaning and address critical defect concerns such as the detection and elimination of moisture, metallic, ionic, organic, particulate contamination. Component outgassing rate affects post-PM recovery time, which is important to end users. Decreasing recovery time increases product throughput and decreases production cost. Materials used during cleaning and packaging, including gloves and wipes, are also factors in cleaned part final cleanliness. The present work addresses some of the challenges, solutions, and learning afforded by RGA use at various stages of the parts cleaning development process.

Background / Process Analysis

RGAs are mass spectrometers that measure the chemical composition of gasses and are often used as leak detectors in various high vacuum systems operated at pressures less than 10^{-5} mbar. There are three main components of an RGA: an ion source, a quadrupole mass analyzer and a detector. The detector measures the mass-to-charge ratio (M/z) as ion current. Sweeping through a 1-200 amu (atomic mass unit) range of M/z ratios, one can determine molecular concentrations of individual gas mixture components in a vacuum environment. Equation 1 defines component outgassing rate $Q_x(t)$ of species x (H_2O or C_xH_y, volatile or C_xH_y, non-volatile). The output data is plotted as a bar graph and is referred to as a mass spectrum (Figure 1).

$$Q_x(t) = I_x(t) \times \text{Ratio}(t) \times S_{\text{eff}} \qquad \text{Eqn. 1}$$

Where,

$$I_{H_2O}(t) = I_{18}(t) \qquad I_{C_xH_y,\text{v}}(t) = \sum_{\text{amu}=45}^{100} I_{\text{amu}}(t) \qquad I_{C_xH_y,\text{nv}}(t) = \sum_{\text{amu}=101}^{200} I_{\text{amu}}(t)$$

$$Ratio(t) \equiv P_{\text{vac}}\left(\sum_{\text{amu}=1}^{200} I_{\text{amu}}(t)\right)^{-1}$$

and effective pumping speed $\boldsymbol{S_{\text{eff}}} = Q_{\text{leak}}/\Delta P$,
where Q_{leak} is the calibrated leak rate
and $\Delta P = P_{leak} - P_{no\ leak}$.

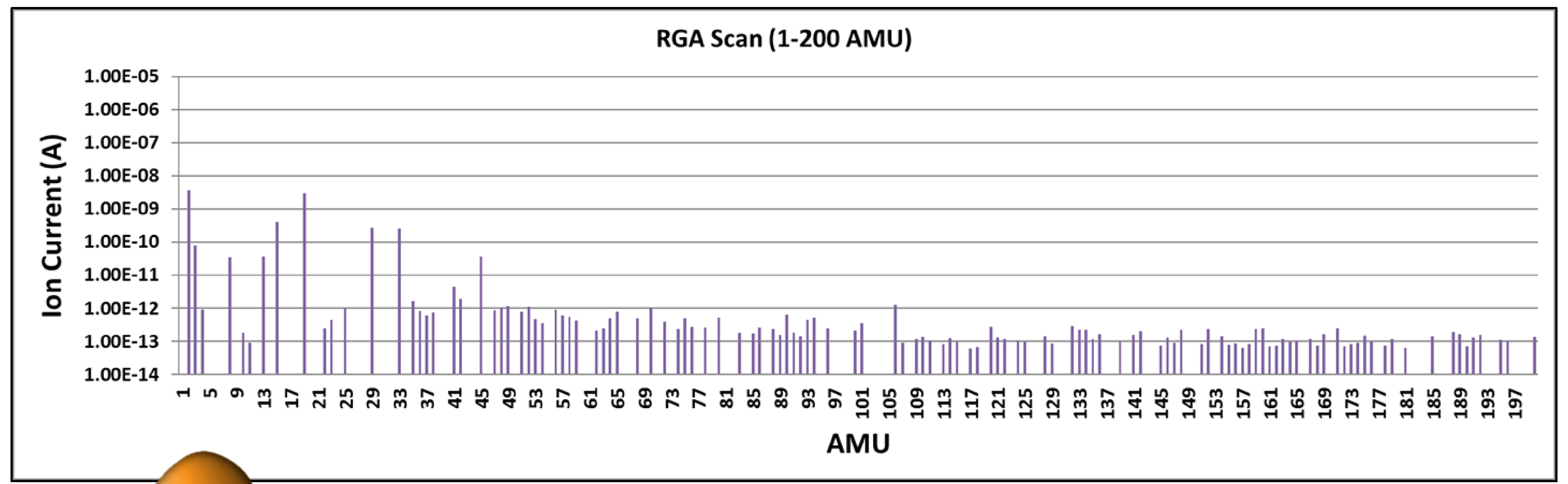

Figure 1: RGA Mass Spectrum

Kit Part Analysis and Comparison

Figure 2 shows an outgassing summary of six different ACS™ cleaned kit parts from a single PVD shield set and one new buy supplier part for comparison.

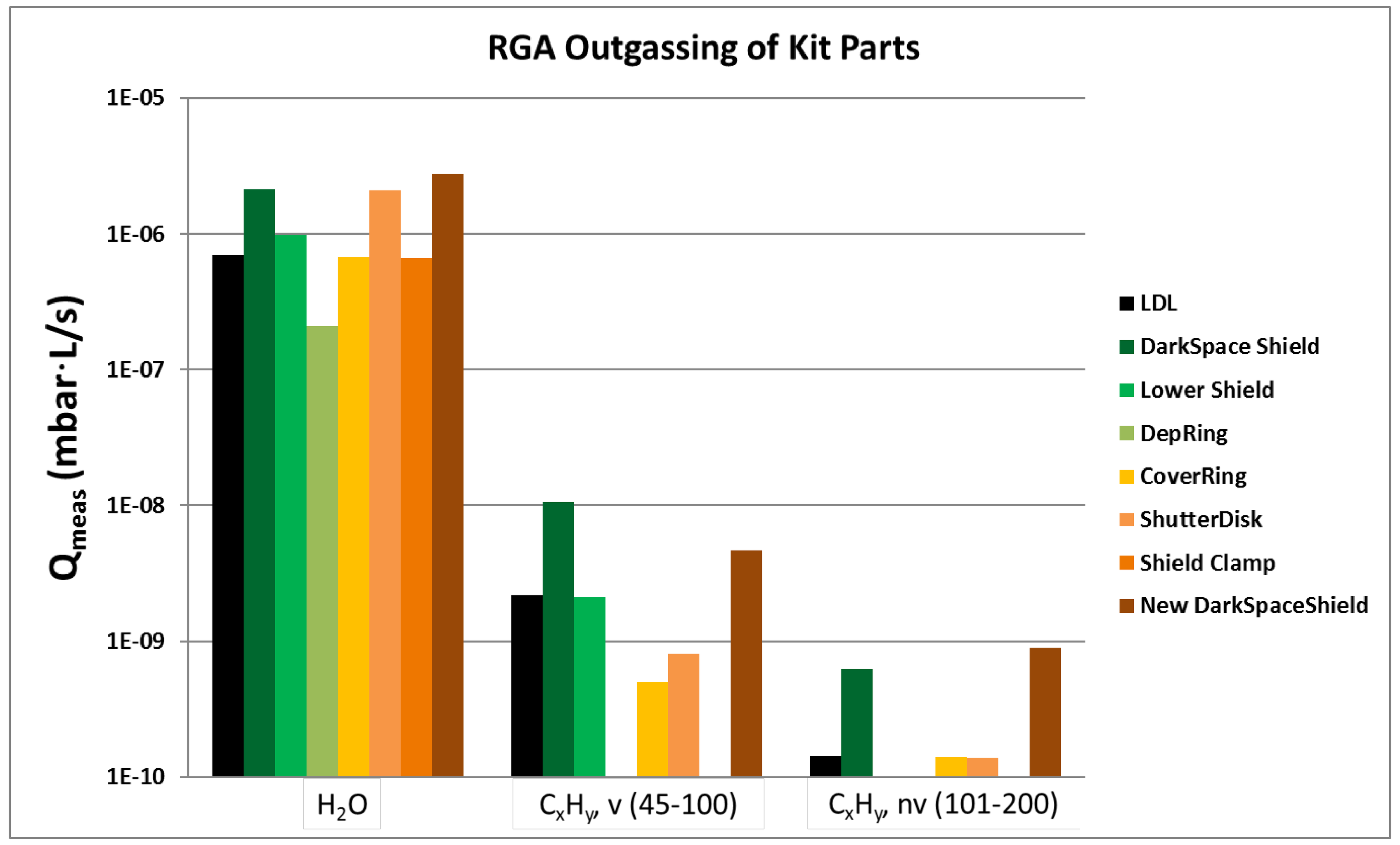

Figure 2: Cleaned Part Outgassing Comparison

Bagging Material Comparison

Figure 3 illustrates RGA testing results of polyethylene packaging from six different suppliers and compares results for residual moisture, volatile hydrocarbons and non-volatile hydrocarbons.

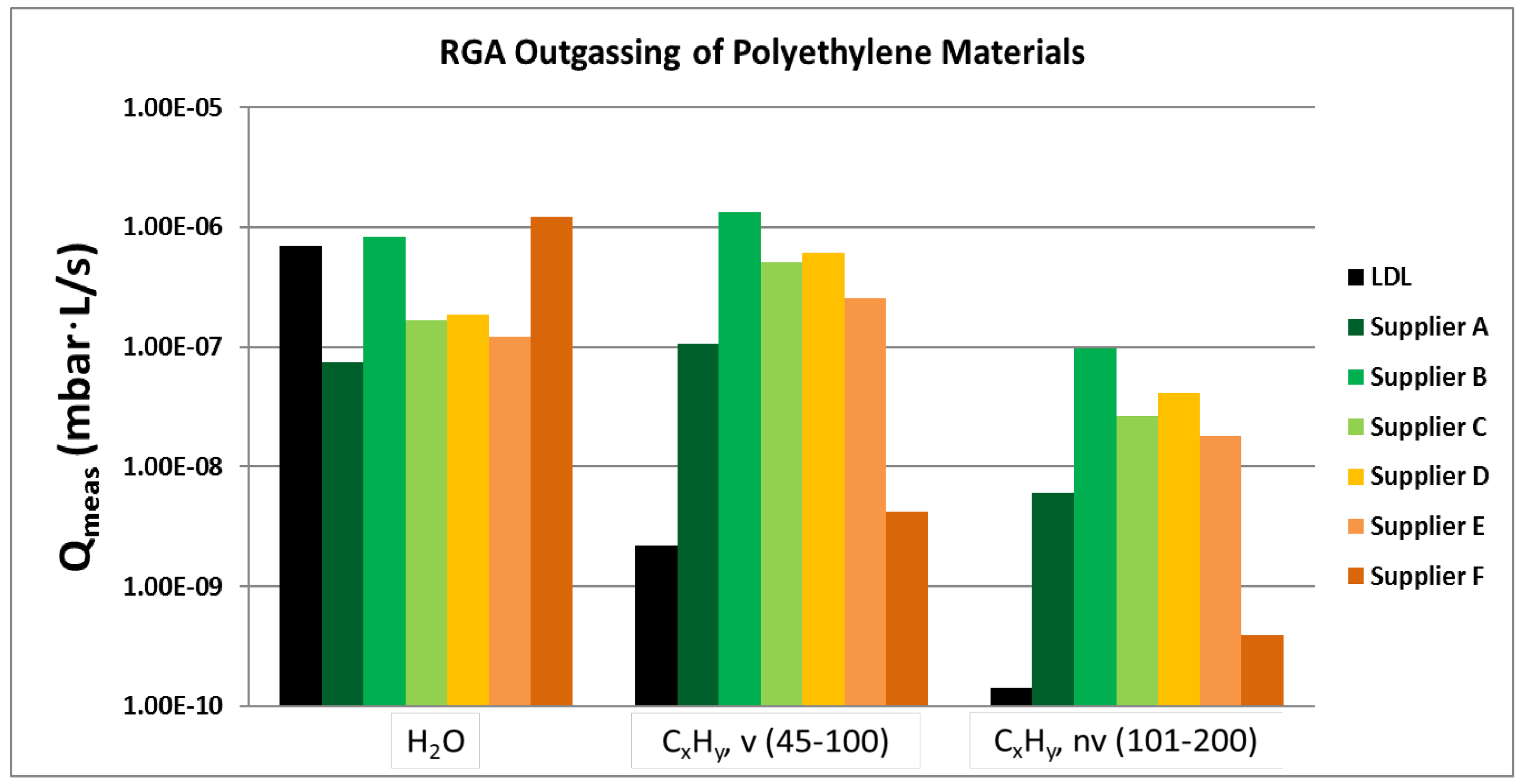

Figure 3: Polyethylene Bag Material Outgassing Comparison

Glove Comparison

Figure 4 shows RGA results of cleanroom gloves from four different suppliers and is used to recommend supplier and product preferences for ACS™ processing.

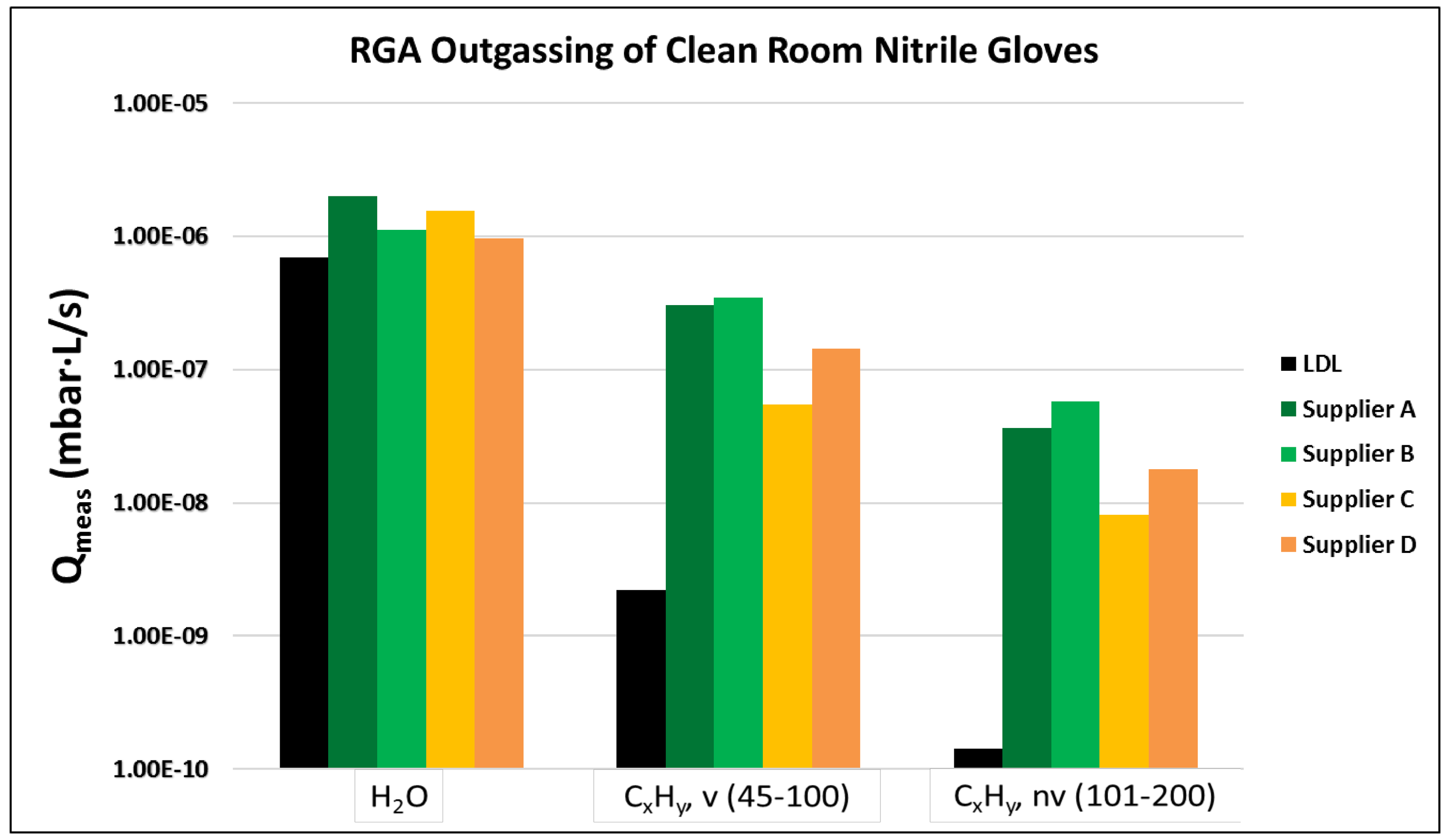

Figure 4: Glove Outgassing Results

Conclusion

QuantumClean® uses RGA to measure moisture and hydrocarbons while developing ACS™ critical cleaning processes for semiconductor equipment chamber components. Outgassing data is used specifically to recommend final bake processes based on substrate material and surface coatings. RGA analysis is used in conjunction other analysis methods to establish critical part cleaning protocols and specify packaging and handling supplies.

References

Generic Standards of ASML (11/25/2008) Ver.1 GSA 07 2211

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