Short Term Vacuum Outgassing Measurements by the Pressure Rise Method

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1 Introduction

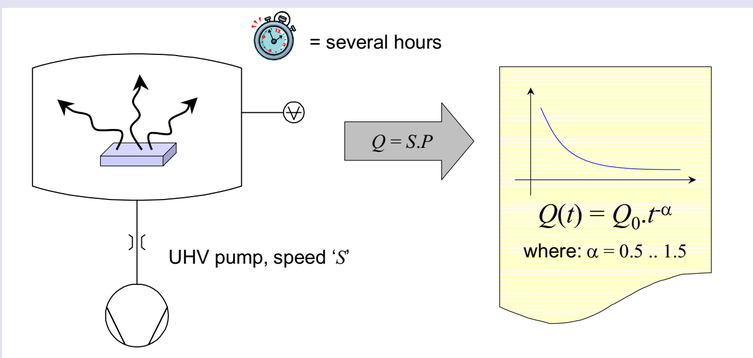
Outgassing of water and hydrocarbon species from surfaces will have a strong influence in the operation of next generation lithography tools (157nm and EUV). Numerous measurements in the literature show that in the medium term (1 to 100hrs) outgassing from technical surfaces can be described by a power law of the form $Q=Q_{10}.t^{-\alpha}$, where Q is the outgassing rate (mbar.l/s) and the dimensionless constant α can vary between 0.5 and 1.5 but is typically near unity for metallic surfaces. This relationship breaks down at very short timescales since $Q \rightarrow \infty$ as $t \rightarrow 0$, and $\int Q.dt \rightarrow \infty$, neither of which is a physically sensible result.

Outgassing of water and hydrocarbon species at ~1 minute or less is an important technological problem for controlling contamination in load-locks of EUV production tools, where throughputs of 50-120 wafers/hour are required, and partial pressures of H_2O and CxHy must be strictly controlled around the projection optics.
We have used the pressure rise method to measure sub 1-minute outgassing rates of a mock loadlock assembly. The results show that outgassing rates for stainless steel are significantly less than those predicted by the above relationship, and are notably sensitive to the concentration of contaminants in the venting gas.

These measurements are reported in conjunction with those in contamination poster #3, Quasi Steady-State Measurements of sub 1-minute Vacuum Outgassing Rates, and Application to EUV Photoresists. N. Condon et al. [1]

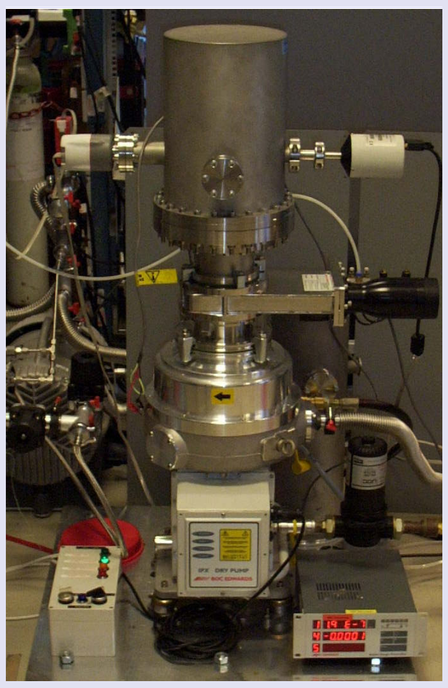
2 Traditional Measurement of Outgassing

- Measurements of outgassing published in the literature are made by the 'Throughput Method' [2]
- A chamber containing the sample is pumped by a UHV pump of a known speed (S), and pressure (P) is recorded as a function of time, typically between 1 and 100 hours
- The outgassing rate Q(t) is calculated from Q = pump speed x pressure
- Fundamental surface physics shows that the pressure (and hence outgassing rate) can be expected to closely follow $Q(t) = Q0.t^{-\alpha}$
- Clearly NOT VALID for short times, since $Q \rightarrow \infty$



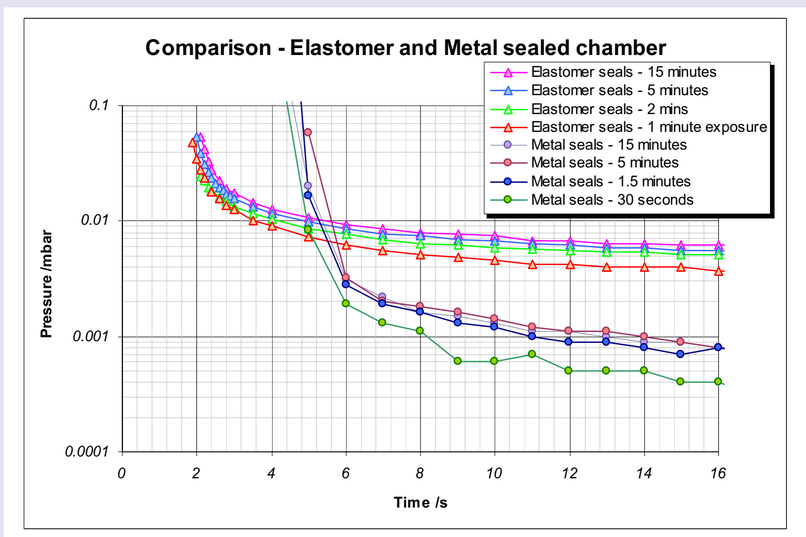
3 Experimental Outline

- The chamber was pumped using a BOC Edwards IPX 500l/s dry pump. This pump operates from atmosphere to $<10^{-6}$mbar without the need for a backing pump. It can also withstand an atmospheric dump of air at the inlet.
- The chamber was all metal sealed and could be isolated from the pump by a 100mm gate valve.
- Pressure was measured using a capacitance manometer and a wide range gauge, which is capable of measuring from atm to 10^{-9}mbar.
- The chamber was systematically purged with dry nitrogen and pumped to achieve a pressure of $5x10^{-7}$mbar or better before each test.
- The controlled venting was carried out to laboratory air at approximately 55% relative humidity.



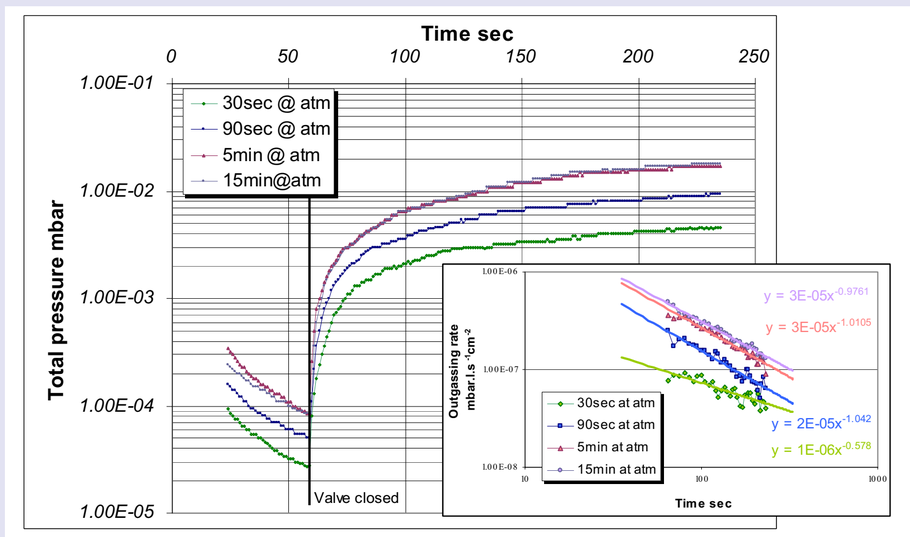
4 Results Part I

The graph below displays pump down times for a mock loadlock chamber vented to atmospheric laboratory air for varying times. The comparison is between a chamber which is all-metal sealed and one which is elastomer sealed.



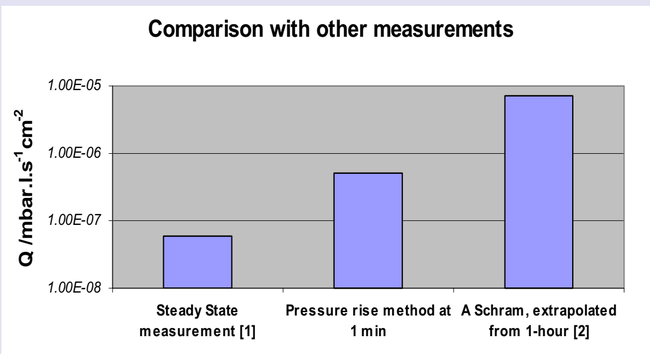
5 Results Part II

The main graph shows the pressure rise measurement as a function of time for different venting times to laboratory air.
The inset shows the calculation of the short term outgassing rate.



6 Conclusions

- The results of the pump down show a marked difference between the two differently sealed chambers. Outgassing in the elastomer sealed chamber limits the total pressure in the short term by over one decade compared to the metal sealed chamber.



- The pressure rise measurements show that in the short term the ultimate pressure in the system is strongly affected by the time of venting to laboratory air. Significantly, after 5 minutes venting there is no change.
- Measurements made by two short-term methods indicate that outgassing measurements made by the throughput method (after several hours) and extrapolated back to ~ minutes, are an overestimate by a factor of 10-100.

7 Future Work

Further work is planned:

- To investigate the expected increased outgassing load due to a silicon wafer in place.
- To characterise a loadlock pump down and venting procedure, which could minimise the influence of outgassing into the wafer stage.
- In conjunction with steady state outgassing measurements, described in contamination poster #3, the development of a detailed theoretical understanding of short-term outgassing.

For more information about BOC Edwards Lithography Subsystems visit the Lithography Subsystems website at
www.bocedwards.com

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[1] N Condon et al - Contamination Poster #3, 2nd EUVL Symposium
[2] A Schram - Le Vide, No. 103, pp 55-68, Jan/Feb 1963
[3] P A Redhead - J. Vac. Sci. Technol. A 13(2), Mar/Apr 1995

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