Post-pump PFC abatement by atmospheric microwave plasmas: completion of metal etch beta test

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An atmospheric pressure surface wave microwave technology is being developed for post pump abatement of waste PFCs in nitrogen. High density (10^{12}-10^{15} cm^{-3}) atmospheric surface wave microwave discharges are intrinsically well suited for high rate PFC conversion in typical flow and concentration conditions at primary pump exhausts (1000-10000 ppmv in 20-60 slm N_2 per pump). The surfaguide-based plasma source features a proprietary ceramics discharge tube cooled by a dielectric fluid for reliable operation in presence of the highly energized fluorinated plasma medium. It was also designed for broadband impedance matching for minimal sensitivity to user process variations and fluctuations.

Following a successful alpha-test, a metal etch beta test was conducted at a customer's fab on a waste stream from an SF_6/W plug etch-back process implemented on three identical Applied Materials Precision 5000 platforms in parallel.

PFC abatement rates were quantified primarily by quadrupolar mass spectrometry. In addition, the CLEANSENS non-dispersive infrared photometer was extensively qualified for SF_6 emissions monitoring. After calibration with standard SF_6/N_2 mixtures, analytical results were systematically compared to QMS and FTIR data in the field and laboratory. Measurements dispersion did not exceed 1% in all cases. The CLEANSENS is now adopted as a standard tool for routine evaluation of abatement rates.

At moderate effluents dilution rates (N_2 flush # 20-30 slm per pump), abatement rates widely in excess of 95% were obtained for up to 3 chambers plugged, with an improvement margin allowing to anticipate that the system will be still suitable for 4 chambers.

At very high effluents dilution rates (50-60 slm per pump), abatement rates were still > 95% for 2 chambers. Plugging of 3 chambers represents a practical limit for the current version of the plasma source in such conditions.

The endurance test (24 hr operation for 2 months) revealed that the discharge tube lifetime is no longer a matter of concern as no sign of ceramic material removal was noted. Potential downtime could arise only from condensates build-up downstream of the abatement plasma, a situation that had been anticipated in piping and collecting traps design. Preliminary chemical analyses confirm that this is aggravated by the presence of residual water vapor in compressed air used as oxygen source (adjuvant gas for the PFC conversion chemistry). After optimization, the collecting trap maintenance frequency remains acceptable whereas the SF_6/W chemistry represents a worst case from this standpoint.

Cost of ownership analysis for a fully dry post-pump plasma PFC abatement solution (including the downstream CS CLEAN SYSTEMS dry-bed scrubber for fluorinated corrosives removal) shows a substantial advantage over classical thermal systems, in addition to other benefits (no fuel feedstock, no fluorinated water reprocessing…).

Energy balance compares also favorably to pre-pump plasmas, despite the fact microwave atmospheric discharges are not very far from thermal equilibrium.

Next generation plasma sources are in preparation for achieving > 95% abatement rate on 4 etch chambers and more at high dilution, in view of retrofitting of older fabs.

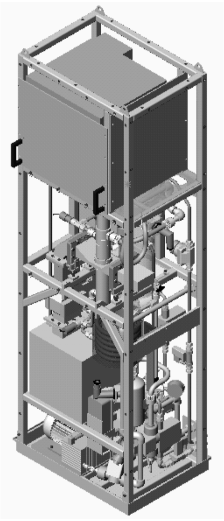

Fig.1. Overview of PFC plasma abatement unit for metal etch beta-test

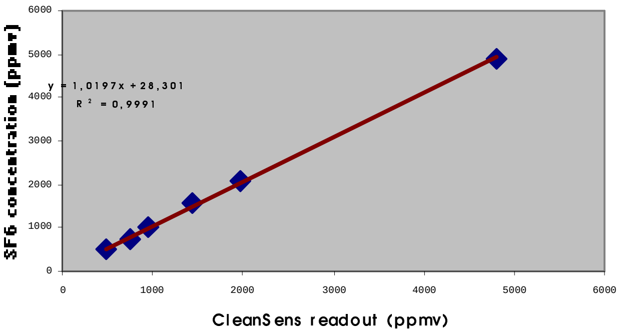

Fig. 2. Calibration curve of CLEANSENS non-dispersive IR photometer for SF_6

Ø int tube (mm)	SF_6 flow (sccm)	O_2 flow (sccm)	N_2 flow (slm)	abatement rate IR (%)	abatement rate CS (%)
8	25	40	40	92	93
8	50	75	40	95	96
8	75	110	40	96	97

Table I. Comparison of SF_6 conversion rates measured by

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CLEANSENS and FTIR.