Point-of Use Abatement Unit Bypass for NF_3 – Based CVD Chamber Clean Applications

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The conversion to NF_3-based chamber cleans from previously used clean gases, such as CF_4 and C_2F_6, has resulted in a significant reduction in PFC Emissions but has greatly increased the amount of fluorine in the clean effluent. This increase in fluorine emissions can cause accelerated corrosion in point of use abatement units and corresponding exhaust infrastructure under certain conditions. One solution to this corrosion problem is a bypass loop for the abatement unit.

CVD tools use an NF_3 chamber clean to remove unwanted deposition on the plasma chamber components. The combination of the large chamber volume, timed endpoint at 50% overetch, and the inefficiency of cleaning creates large concentrations of fluorine in the pumping section. CVD chambers that utilize silane typically have a point of use abatement in the exhaust line to destroy the silane prior to entering the house exhaust system. With an increased volume of process wafers comes an increase in fluorine emissions, which can result in abatement unit and post abatement exhaust line failures. In this case, the combustion chamber liner of the abatement unit is made from Inconel. With the operating temperature of 800 degrees centigrade, the liner will deteriorate in approximately 3 months due to the exposure to fluorine. In most cases, liner failure results in heater element failure. Past the combustion chamber is a wet scrubber section called a demister used to cool gasses. At this point the fluorine reacts with the water to form hydrofluoric acid. When the HF concentration is high enough, the demister section and the post abatement unit exhaust lines corrode. This failure causes ten days of downtime to replace the lines every four to six weeks.

Because there was multiple problems with the system, there were multiple solutions. One option proposed was to replace these abatement units with units that are designed to tolerate higher fluorine concentrations. This, however, would have been a costly and time-consuming option. Furthermore, most of the installed base of abatement units were functioning properly and otherwise would not need to be replaced. The solution to bypass the abatement unit during the chamber clean such that the fluorine-containing effluent would not flow through the abatement unit was selected because it alleviated the corrosion issue for a minimal cost and allowed existing abatement units to remain in service.

Post abatement unit exhaust lines were specified as three inch 316 stainless steel with a inner coating of .03” of Halar. The Halar coating was used because it has been proven to be highly resistant to hydrofluoric acid environments. [1] The bypass system uses two valves connected to the roughing pump exhaust via a Tee. The normally open valve is connects to the exhaust line going to the input of the CDO. On the other side of the tee is a normally closed valve that connects directly to the PES duct to bypass the CDO. When the NF_3 gas stick is activated in the chamber gas box, the output nupro valve pneumatic signal is tied into a pressure switch. Whenever the pressure switch is activated, the pump exhaust is sent directly to the scrubbed exhaust duct. There is a manual controller for abatement unit maintenance activities. Because the HDP process uses an idle plasma to maintain the chambers temperature when the chamber is idle, an abatement unit maintenance event or failure also requires a chamber wet clean. Because of the bypass, maintenance can safely work on the abatement unit without shutting down the idle plasma. A micro switch is attached to the actuator of the normally open valve that interlocks the output nupro for the silane gas stick. If the system is left in manual bypass mode or there is a valve failure, the silane will not flow and the chamber would go into an alarm state. The interface is designed so that it can integrate with any CVD tools.

[1], Vartanian, et.al. “Fate of Fluorine in Exhaust from NF_3 Based CVD Chamber Cleans, 199th Meeting of the Electrochemical Society, PV 2001-6, p.79.