Characterization of NF_3 Chamber Cleans on Multiple CVD Platforms

Brian Goolsby, Victor Vartanian, Laura Mendicino,
Jason Rivers, Jason Vires
Motorola DigitalDNA^{TM} Laboratories
Austin, TX 78721

Michael Turner, Sey-Ping Sun, Christine Esber
Advanced Micro Devices
Austin, TX 78741

The initial success of NF_3 as an alternative gas for CVD chamber cleans prompted its widespread adoption in the semiconductor industry. The focus has now shifted toward optimizing both the quantity of gas used and the time required to achieve chamber cleanliness. Minimizing these variables translates to lower COO and increased throughput but requires considerable effort in recipe development and qualification. While wafer data and historical tool performance are ultimately required to validate a new clean recipe, analytical data can assist in its development. The proposed report is based on analytical data collected during chamber cleans on two CVD tools. In each case, multiple recipe conditions were investigated in an effort to find an optimal clean for a given material. In one case, a clean after every other deposition (2X) was being tested as a replacement for the conventional clean after every deposition.

Residual gas analyzer (RGA) and optical emission spectroscopy (OES) data were collected at the tool level (on chamber), while Fourier transform infrared spectroscopy (FTIR) and a fluorine chemical sensor (FCS) were used to investigate emissions downstream of the mechanical pumps. The concentrations of by-products as determined by analytical instruments were used as indicators of the clean recipe's progress. For example, SiF_4 emissions were expected to diminish if the removal of Si-containing chamber deposits neared completion (Figure 1). Using multiple analytical devices, a more complete picture of tool conditions was realized than with a simple endpoint detector. The instruments provided additional information about emissions from downstream deposits, potential chamber kit damage, and formation of unexpected species. Data were also taken during marathon wafer cycling to observe changes in tool performance over time. An example is shown in Figure 2, where plasma fluctuation is shown to increase as a marathon progresses, possibly indicating an inadequate clean recipe.

FTIR data was used to determine the conversion efficiency of the clean gas, reportedly very high for the Remote Clean plasma unit (1) but less efficient in other systems (Figure 3). The percent reductions of chamber clean by-products over the course of each clean were determined. For optimized recipes, projections of improved gas use and throughput will be reported. One chamber realized a 20% reduction in overall clean time accompanied by a 30% decrease in NF_3 demand. The global warming impact from chamber cleans will also be addressed.

References

1) Mendicino et al., *Evaluation of Applied Materials' DxZ Remote Clean Technology*, ISMT Tech. Transfer 99113842AENG, 1999.

Figure 1: RGA profile for an improved NF_3 chamber clean recipe.

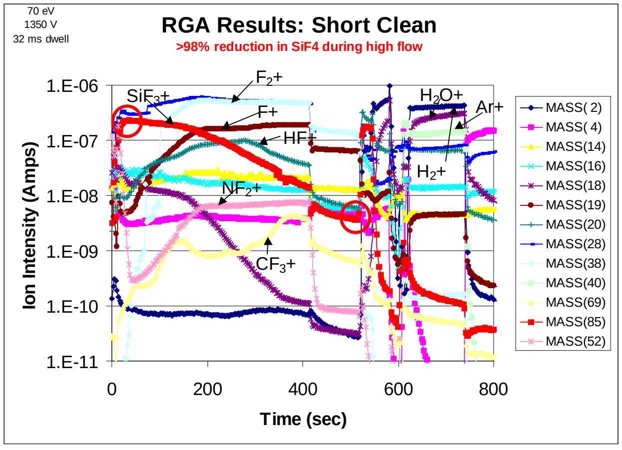

Figure 2: OES response at three points in marathon.

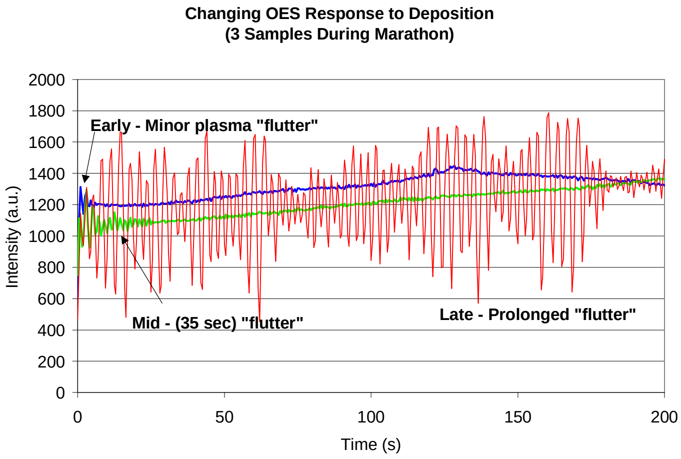

Figure 3: FTIR spectrum displaying unutilized NF_3 chamber clean gas.