Measurement and Reduction of Greenhouse Gas Emissions of Process Tools

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Semiconductor chip manufacturing utilizes a wide variety of chemicals and gases, some of which find their way into the environment. For example, perfluorocarbon gases (PFCs), such as CF_4, C_2F_6, and C_3F_8, are used in large volumes for etching and chamber cleaning. When these molecules are subjected to an electrical discharge, they form highly reactive radical species, which do the etching. However, once released to the outside environment, these molecules can persist for thousands of years. In addition, PFC gases are believed to contribute to the warming of the Earth's atmosphere and are categorized as greenhouse gases (GHG).

Over the past two decades, a focus of semiconductor manufacturers has been reduction of GHG emissions, through a combination of etch-gas substitution, process recipe optimization, and abatement. These efforts have driven the development of standardized measurement protocols, including the International Sematech Manufacturing Initiative (ISMI) protocol, which governs process tool emissions characterizations, and in the U.S., EPA methods, which are generally concerned with environmental monitoring.

Balazs NanoAnalysis has more than a decade of experience executing on-site analysis projects relating to process tool exhaust characterization, abatement system qualification, and stack testing.

Figure 1 describes the physics of chamber cleaning, using a fluorine-based gas to etch and remove silicon-based residues. The concentration of silicon tetrafluoride (SiF_4) emitted by the chamber is a widely used metric for cleaning progress.

Fig. 1

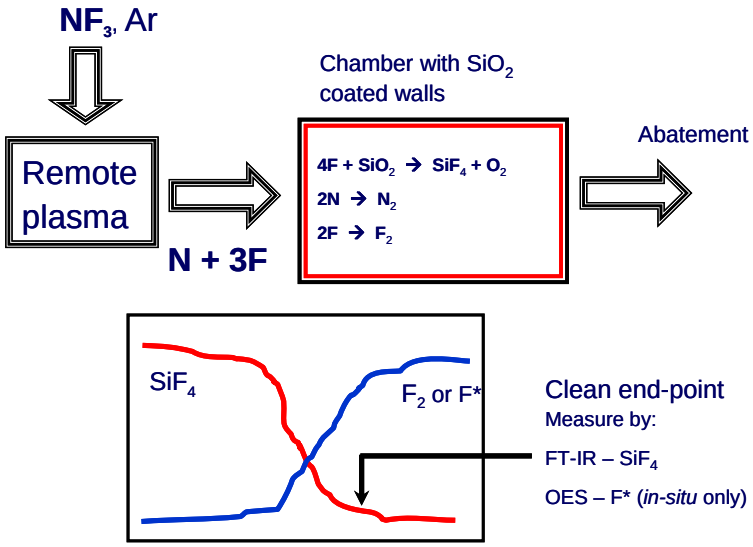

Figure 2 displays the technical approach used by Balazs for process tool exhaust testing, utilizing Fourier-transform infrared spectroscopy (FT-IR).

Fig. 2

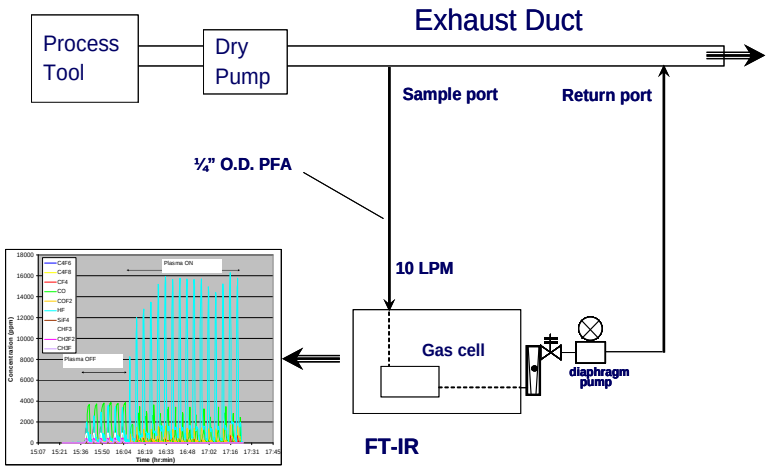

Figure 3 contains a photo of the FT-IR itself. In some cases, other analysis methods may be required, including ultraviolet/visible (UV-Vis) spectroscopy, and impinger and filter sampling.

Fig. 3

It goes without saying that every project presents unique technical objectives and that the analytical approach must be adapted to the objectives, based on a careful consultation with the client. Balazs NanoAnalysis' combination of semiconductor process knowledge, analytical expertise, and variety of measurement tools make it well qualified to make these projects a success.