Highly Sensitive Measurements of PFAS from material off-gassing by TOFWERK's AMC Analyzer

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Introduction

Among the wide variety of airborne molecular contaminants (AMCs) that need to be systematically monitored during semiconductor manufacturing processes, per- and polyfluoroalkyl substances (PFAS) are increasingly of interest due to their negative impact on the environment and human health. The production of PFAS in the semiconductor industry is associated with material off-gassing and in some cases with production processes as secondary products. Given both the vital importance of high-quality chip production and the growing concern about PFAS, it is critical to find efficient ways to understand and mitigate these emissions in semiconductor manufacturing.

The extremely sensitive and versatile TOFWERK Semicon AMC Solutions offer state-of-the-art technology to measure the emissions of dozens of these compounds simultaneously, in real time, without sampling preparation, and with extraordinary precision. A single AMC monitor or analyzer can provide a wealth of information about airborne PFAS emissions even at parts-per-trillon (pptv) concentrations, providing users with unprecedented insight into the sources and abatement of these compounds.

Experimental Setup

To assess the capabilities of the AMC Solutions for PFAS measurement, sample resins commonly used in semiconductor manufacturing materials were heated in a temperature-controlled oven, as shown schematically in Figure 1. The oven emissions were then measured by an AMC Analyzer, one of two Semicon AMC Solutions offered by TOFWERK.

Off-Gassing of PFAS from Resin Samples

Figure 2 shows examples of the PFAS emissions measured from two different resin samples in the experiment. As the temperature steps up in four increments from just over 100 °C to 250 °C, the PFAS off-gassing emissions generally increase. Nine different species of PFAS, all measured simultaneously, were detected at concentrations ranging from less than one pptv to around one ppbv.

The state-of-the-art soft chemical ionization used by the AMC Analyzer allows the user to confidently identify a wide range of PFAS simultaneously and

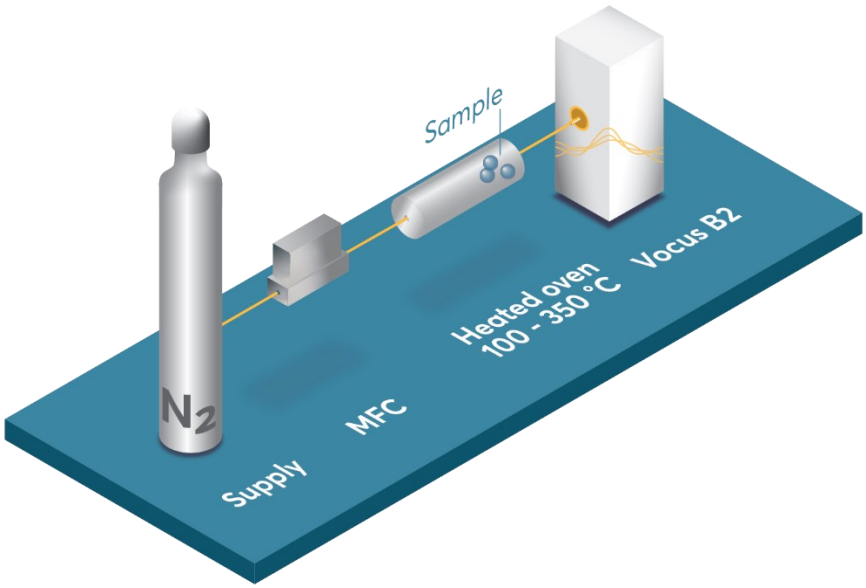

Figure 1: Experimental setup used in this study.

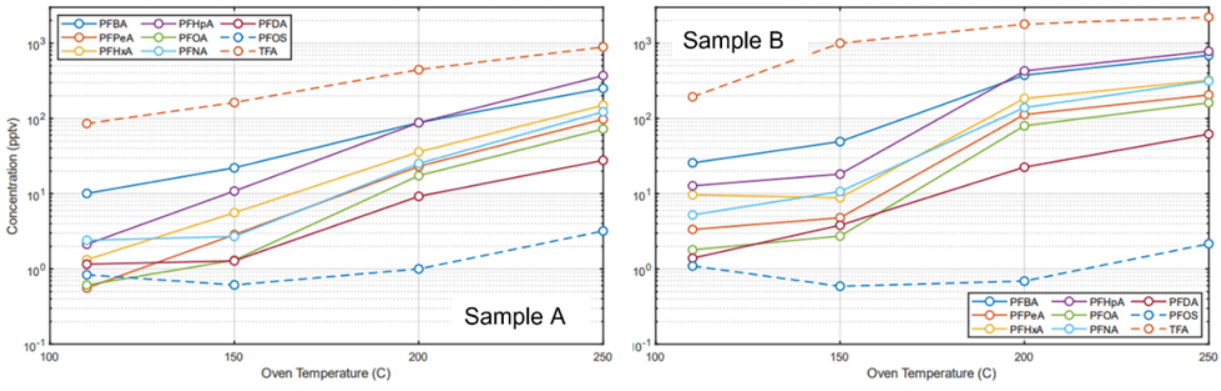

Figure 2. Concentration of nine species of PFAS versus oven temperature with concentrations averaged to each oven temperature setpoint and data background subtracted from blank (empty oven) measurements.

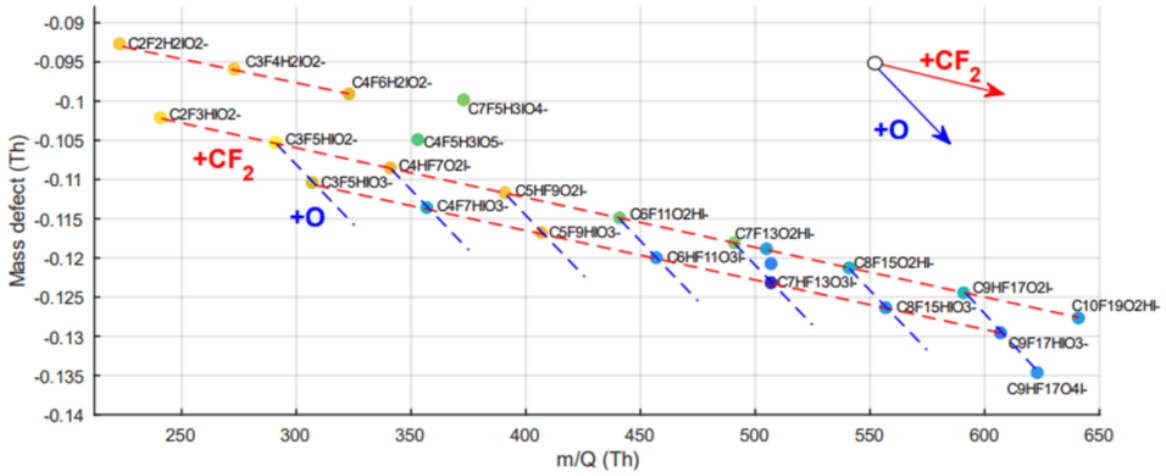

Figure 3. Complete PFAS observed from resin sample plotted as log of the observed signal by mass to charge and mass defect.

without fragmentation, which can be an issue in higher-energy ionization techniques. Figure 3 plots the mass defect of 24 molecules against their molecular mass (molecule combined with the reagent ion, in this case I-) [1]. The dashed lines show the addition of either CF2 (red) or O (blue) to the parent molecule giving a direct insight to the formation of not only PFAS, but molecules associated with PFAS as well protecting the environment and paving the way to a sustainable future in one of the world's most critical industries.

Conclusion

Because of its speed, soft ionization, and extraordinary sensitivity, the Swiss-engineered TOFWERK AMC Analyzer is uniquely suited to measure PFAS emissions efficiently and reliably. One compact, portable instrument can detect and identify dozens of PFAS molecules in seconds, providing a crucial first step in understanding these important chemicals,

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References

[1] Riedel, T. P. et al., 2019, *Gas-Phase Detection of Fluorotelomer Alcohols and Other Oxygenated Per- and Polyfluoroalkyl Substances by Chemical Ionization Mass Spectrometry,* Environmental Science & Technology Letters, 6(5), 289–293. https://doi.org/10.1021/acs.estlett.9b00196