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Real-Time FTIR Monitoring of Parts per Trillion Level Vapor Intrusions

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Background/Objectives. Low level vapor and aerosol emissions, even those of a transient nature, from various open or leaky chemical process activities can cause environmental and health concerns, as well as detrimental impacts on product yields (as with semiconductor wafer manufacturing, for instance). Characterization of these intrusions may call for real-time monitoring techniques, but achieving adequate pptv-level sensitivities with temporal measurement resolutions is challenging. The nature of vapor intrusion testing often involves the collection of multiple time integrated air samples at strategic points within an indoor/outdoor area of interest, followed by laboratory analysis of these samples via some precision analytical method(s), ala EPA Method TO-15. The air sampling containers usually are specially prepared canisters, cylinders, tedlar/Teflon bags, sorbent tubes, filter media (for particulate/aerosol matter), or even wet impingers. All of these require some preparation prior to field used and are not capable of providing “real-time” measurement results on-site. Also, any information associated with vapor intrusion events that may be considered transient or intermittent is lost as these sampling schemes combine volumes of air over a period of time before any analysis takes place. Such information would be critical in understanding the chemistry and byproduct formation associated with certain vapors, as well as their acute exposure impact on local workers/inhabitants and industrial/manufacturing processes.

Approach/Activities. Presented here is an air monitoring method based on specialized signal-to-noise enhancements of an extractive Fourier Transform InfraRed (FTIR) spectrometer. The hardware and software enhancements incorporated in this system have been proven in the Geosyntec laboratories to enable sub-ppbv detection limits for various gaseous acids and amines, some gaseous and aerosolized arsenic compounds, and some VOCs. Laboratory calibration and EPA Method 301 field validation procedures, as this measurement method was initially qualified for the accurate monitoring of fluorinated greenhouse gas emissions from semiconductor acid exhaust stacks, were carried over to additional field measurement campaigns at some semiconductor fab cleanrooms, outdoor agricultural sites and select indoor public facilities.

Results/Lessons Learned. The measurement method presented here is an EPA recognized one that can provide detection and profiling for multiple target analytes, simultaneously, to enable on-site characterization of emissions with ample temporal resolution. Recent work at Geosyntec has focused on developing “enhanced” FTIR instrumentation and quantitative analysis software to drive down real-time detection limits (DLs) to levels well below 1 ppbv. The system has been configured as a continuous emission monitor (CEM), where automated operation with remote control access produces measurement data every 6-8 minutes consecutively across multiple air sampling points. Field evaluations of the CEM’s figures of merit (measurement DLs, accuracies, precisions, etc.) specifically pertaining to trichloroethylene (TCE) and tetrachloroethylene (PCE) are presented. Examples of real-time DLs pertaining to other chemical groups of relevance to semiconductor manufacturing (organic amines, ammonia, acids, arsenic aerosols/vapors), fertilizer plus other industrial processes (ammonia, acids), and oil/gas refining plus various industrial solvents (select VOCs) are listed in Table 1.