Q&A
Edwards Vacuum

Mark Andrews, Technical Editor of Silicon Semiconductor discusses the importance of abating Nitrous Oxide with Mike Czerniak Environmental Solutions Business Development Manager at Edwards.

Q Where is N_2O used?

A Nitrous Oxide (N_2O) is widely used in semiconductor manufacturing in chemical vapour deposition (CVD) of silicon oxy-nitride (doped or undoped) or silicon dioxide, in diffusion for oxidation and nitridation, in rapid thermal processing (RTP), and in chamber seasoning. N_2O also has a variety of other industrial and medical applications. Worldwide, the majority of N_2O (67%) comes from agricultural activities. Fossil fuel combustion and industrial processes, of which semiconductor manufacturing is a small part, accounts for 10%.

Q Why abate N_2O?

A After CO_2 and CH_4, N_2O is the 3rd most impactful human-induced greenhouse gas (GHG), accounting for 7% of emissions. This is as a result of its widespread use and its atmospheric lifetime of 114 years, which gives it a global warming potential (GWP100) of 298. Refined IPCC (intergovernmental panel on climate change) guidelines, to be released in 2019, will include new emission factors for N_2O. In addition to its global warming potential, N_2O is noxious, with a threshold limit value (TLV) for daily workplace exposure of 50 parts-per-million. Even though semiconductor manufacturing is only a minor emitter of N_2O, the industry has included limits on emission in its roadmap (ITRS/IRDS), primarily because it is a gas that can be abated and there is increasing pressure to do everything possible to reduce the industry's CO_2 footprint (to which N_2O contributes). Market pressure is also coming into play as green labelling is introduced and many customers are beginning to monitor emissions-per-product.

Q What are the options for abating N_2O?

A N_2O can be abated by oxidation or reduction. Catalytic reduction, though possible, is generally not suitable for semiconductor process exhausts, which often include corrosive gases or solids that can "poison" the catalyst. Edwards' preferred method for N_2O abatement is combustion in a reducing environment in a carefully controlled, inward fired combustor. The reducing agent may be methane (a commonly used fuel gas) or even a hydrogen-containing process gas such as silane (often used in conjunction with N_2O). The flow of the reducing agent must be closely regulated and synchronized, ideally with real-time signals from the process tool.

Oxidation, by combustion in air (in the absence of a reducing agent), will convert N_2O to NO_2, which then requires additional abatement, usually by scrubbing. Oxidation and NO_2 production can also occur unintentionally in a non-optimized reducing combustor.

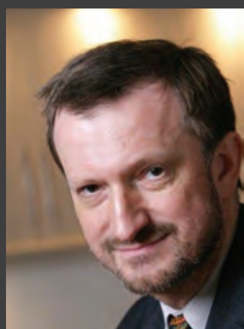
Q What about NOX?

A NOX is a generic term for mono-nitrogen oxides (NO and NO_2). These are produced during combustion in air, especially at high temperatures and in the presence of hot metal surfaces. NOX emissions cause smog, which can damage lung tissue, especially in vulnerable individuals. NO has a TLV of 25ppm and NO_2 of 3ppm. NOX eventually forms nitrous and nitric acids, components of acid rain. For these reasons, NOX emissions are tightly regulated in most territories worldwide.

Q What's the take-away?

A Both the IPCC and the ITRS recognize N_2O is a greenhouse gas pollutant that should be abated. Proven abatement technologies exist. Of them, reducing combustion has the advantage of minimizing the production of NOX, when executed in a carefully controlled, well-designed system synchronized with process gas flows.

About the author:



Mike Czerniak is Environmental Solutions Business Development Manager at Edwards. He earned his PhD in Electrical Engineering at Manchester University (UK) in 1982. His professional career began with Philips in their UK R+D labs and subsequently in their Nijmegen, Holland fab. He had subsequent marketing roles at UK-based OEMs including Cambridge Instruments, VSW and VG Semicon before joining Edwards in 1997. Mike has numerous published articles and patents to his name; he co-chairs two SEMI standards committees; participates in the IRDS; is a UK PFC expert on the United Nations IPCC (Intergovernmental Panel on Climate Change; he is now an IPCC lead author); he wrote the chapter on Vacuum and Environmental Issues in the Handbook of Semiconductor Manufacturing (2nd edition). He has been a Visiting Industrial Professor in the School of Chemistry at the University of Bristol since September 2017.

Edwards is a leading developer and manufacturer of sophisticated vacuum products, exhaust management systems and related value-added services.

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