Title: Metrology for Airborne Molecular Contaminants II

Abstract

One of the major issues affecting product yield in the microscale manufacturing of semiconductors is Airborne Molecular Contamination (AMC) which is detrimental to the product as it increases electronic defects and it leads to higher production costs. However, the current instrumentation and methods used in industry cannot provide traceable and reliable measurements of AMC at lower amount fractions and over faster timescales. Therefore, metrology focused on new ultra-sensitive and real-time spectroscopic techniques and high accuracy reference materials at trace concentrations for key AMC is required to improve manufacturing processes, to control contamination and thereby increase industrial competitiveness.

Keywords

Airborne molecular contamination, real-time analysis, semiconductors, spectroscopy, gas metrology, environmental monitoring.

Background to the Metrological Challenges

Airborne Molecular Contamination (AMC), in the form of vapours or aerosols, is a major issue for the advanced manufacturing of microelectronics. Technological progress in the semiconductor industry is driven by the ability to operate at an ever smaller scale with increased complexity, and requires AMC trace detection and improved real-time measurements to enable corrective actions before product yields are affected and valuable data is lost.

Currently the available instrumentation for detection of trace levels of AMC is often not fit-for-purpose due to high costs, large size, slow measurement rate and limited reliability. Commercially available spectroscopic instrumentation provides sensitivity around the nmol/mol level but this level of sensitivity takes typically five minutes of data averaging. However, the relevant levels of AMCs can be down to the nmol/mol level and below, making their detection challenging. Therefore improved instrumentation and gas metrology to access measurements of AMC at lower fractions below 1 nmol/mol and with faster measurement timescales lower than 5 s are required to meet industrial specifications. In addition, reference materials and real-time spectroscopic methods are needed to target HCl, one of the key AMCs, for which there is currently no metrological infrastructure.

The availability of suitably accurate and traceable gas standards and instrumentation for AMC measurement at amount fractions relevant to current and future demands of the semiconductor fabrication and associated industries, is essential for effective development of real time, continuous AMC cleanroom monitoring solutions to drive down production costs. Therefore the development of such gas standards will not only allow end users to have confidence in their monitoring operations (using effective trace measurement solutions) but will allow instrument developers to better understand and overcome the challenges associated with AMC.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the traceable measurement and characterisation of airborne molecular contaminants.

The specific objectives are

1. To develop ultra-sensitive and real-time spectroscopic methods for the detection of critical airborne molecular contaminants (AMCs) (e.g. NH_3, HCl and water vapour) with target detection values lower than 1 nmol/mol and in less than 5 s. In addition, to determine the optimal spectral windows for such techniques based on High Resolution Transmission (HITRAN) calculations and component availability.
2. To develop traceable static and dynamic reference materials for use with real time monitoring for priority AMCs in a nitrogen matrix at less 1 nmol/mol, and for HCl at 10 µmol/mol, using methods to produce dilutions higher than 10000:1 for AMCs with a target accuracy better than 0.5 % relative. In addition to develop instrumentation and novel passivation techniques to optimise the long-term stability of dynamic reference materials for AMCs.
3. To compare, and perform field tests of, different spectroscopy techniques for real-time AMC detection, including an investigation of typical AMC monitoring scenarios (e.g. monitoring filter breakthrough and confined environments). The target time resolution for the spectroscopy techniques is better than 5 min and with a sensitivity lower than 1 nmol/mol for AMCs.
4. To develop traceable dynamic or static gas transfer standards for AMCs or opto-analytical transfer standards for the validation of measurement techniques commonly used in clean rooms (e.g. ion-mobility spectrometry), including the use of in-situ calibration techniques.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (e.g. accredited laboratories and instrument manufacturers), standards developing organisations (e.g. ISO TC 158, CEN TC 264, International Society for Automation (ISA) Standard 71.04-1985 and standards bodies associated with European Waste Incineration Directive 2000/76/EC and the Ambient Air Quality Directive 2008/50/EC) and end users (e.g. the semiconductor and electronics industries).

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. In particular, proposers should outline the achievements of the EMRP JRP IND63 'Metrology for airborne molecular contamination in manufacturing environments' (MetAMC) and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.5 M€, and has defined an upper limit of 1.8 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the "end user" community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the "end user" community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the semiconductor and electronics industries sector.

You should detail other impacts of your proposed JRP as specified in the document "Guide 4: Writing Joint Research Projects (JRPs)".

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards

- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.