Electronic Nose, Data Evaluation for Cleanliness and Contamination Control in Cleanrooms, Machine Learning for decision making in production

Andreas Helwig[(*)1], Christian Keimel[1], Bahar Kilitoglu[2], Yann Goueffon[3]

[1] *Central Research & Technology, Airbus Defence and Space, 81366 Munich (Germany)*
[2] *Airbus Defence & Space GmbH, Claude-Dornier-Straße, 88090 Immenstaad (Germany)*
3 Airbus Defence & Space SAS, 31 rue des cosmonautes, 31402, Toulouse Cedex (France)

[(*)] Andreas.Helwig@airbus.com

The paper reports on a feasibility study concerning the detection of offgassing substances from assemblies that could deposit on optical systems or electronics of spacecrafts in the cleanroom and influence their performance dramatically. The sensitivity of an electronic nose is sufficient to detect these very small gas concentrations. The obtained gas signal carries both the absolute information on gas molecule content and the change of newly produced gas intensity over time. Employing a principal component model based evaluation, the smell of the material and the change in gas intensity can be visualised. Using the obtained gas kinetics for a batch analysis, a machine learning approach becomes feasible thus enabling a prediction and classification of unknown materials.

Satellites and telescopes are unique and so is their production environment. In order to protect optical equipment for space applications and electronics from molecular depositions, particles, and dust, the sensitive assemblies need to be manufactured and stored in cleanrooms. It must always be ensured that neither particles nor substances are introduced into the clean production area from the outside causing contamination of the sensitive surfaces. Following this approach we investigated if an electronic nose can be utilised to analyze if any volatile organic compounds (VOC) are offgassing from materials or subassemblies that are about to enter the cleanroom area. Electronic noses are highly sensitive to various gas species and increasingly employed for ambitious industrial applications [1] and beyond this even in space itself [2,3].

The feasibility study shows that outgassing of VOC from different types of material can be detected and analysed using an electronic nose and a model based machine learning evaluation approach. In order to estimate the amount of volatile compounds arising from the substrate, a time series measurement seems promising. The obtained gas signal carries the absolute information on gas molecule content and the change of newly produced gas signal intensity over time.

Employing a PCA model based evaluation, the material smell and the change in gas intensity can be expressed and visualised. Using the smell intensity and the change in gas kinetics for a batch analysis, a machine learning evaluation and prediction approach therefore becomes feasible. Using a PLSDA discriminant model unknown data sets can then also be predicted and classified.

References

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