

Riccardo Dal Moro*

Maria Virginia Manna**, Fabio Melison*, Giovanni Battista Ariemma**, Vincenzo Rosati**, Vicente Castro**, Lorenzo Cocola*, Pino Sabia**, Luca Poletto*

*National Research Council of Italy, Institute for Photonics and Nanotechnologies, CNR-IFN, Via Trasea 7, 35131 Padova, Italy; ** National Research Council of Italy, Institute of Sciences and Technologies for Sustainable Energy and Mobility; CNR-STEMS, Via Marconi 4, 80125 Napoli, Italy.

riccardo.dalmoro@cnr.it

Monitoring of Oscillating Combustion Regimes via 4 Hz Raman Gas Analysis

This work demonstrates the application of multi-pass Raman spectroscopy [1,2] for the temporally resolved analysis of dynamic reactions. This technique allows us to analyze dynamic phenomena with an high sampling rate (4 Hz), enabling the temporal characterization and detection of molecular species not commonly targeted with conventional combustion diagnostic tools such as gas chromatography, electrochemical gas sensing, and absorption spectroscopy. In our study, we have characterized the gases generated by methane combustion in a Jet Stirred Flow Reactor (JSFR), in particular within the thermo-kinetic oscillation regime, retrieving quantitative information about the concentration of the species (N_2 , H_2 , H_2O , CO_2 , NH_3 , CH_4 and CO). An example of an oscillating reaction measurement is shown in Figure 1. The reaction under study is CH_4/O_2 combustion under high N_2 dilution. Measurements were performed at 4 Hz with a signal integration time of 250 ms, all primary molecular species characterizing the reaction are quantified and the anti-phase behavior between reactants (CH_4 , O_2) and products (CO_2 , H_2O) is clearly visible. This study showcases the power of multi-pass Raman spectroscopy for capturing fast-dynamic events. The system allows for comprehensive 'wet' gas analysis, bypassing the limitations of conventional sampling lines that often require water removal.

The activities have been performed in the framework of the project "TASMA – Advanced Technologies for Smart Manufacturing", funded by Regione Veneto, PR Veneto FESR 2021-2027, CUP B13C25004530002.

References

- [1] R. Dal Moro, F. Melison, L. Cocola, and L. Poletto, "Raman Spectroscopy for Temporally Resolved Combustion Gas Diagnostics," *Appl. Spectrosc.*, vol. 78, no. 12, pp. 1263-1269, Dec.2024, doi:10.1177/00037028241277575.
- [2] Dal Moro, R.; Melison, F.; Cocola, L.; Poletto, L. Raman Spectroscopy for Monitoring NOx and N2O in Combustion Products. *Sensors* 2026, 26, 3180. <https://doi.org/10.3390/s26103180>

Figures

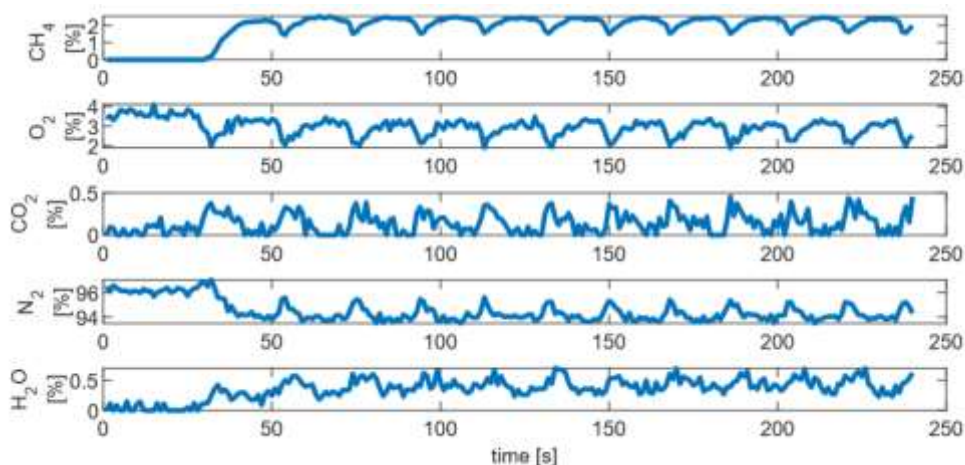


Figure 1: Example of the oscillation regime in a CH_4/O_2 combustion with high N_2 dilution, sampling rate 4Hz.