Mid-infrared frequency comb spectroscopy of plasmas

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The development of optical frequency combs has severely revolutionized many fields of physical sciences, including the field of molecular spectroscopy. The combination of wide bandwidth and high spectral resolution offered by frequency combs makes them ideal for sensitive detection of multiple species simultaneously [1], as well as precise line position measurements [2].

In this contribution, recent research activities focused on the development and application of detection methods based on frequency combs in the 3.2 µm spectral region are presented. This includes: (i) The development of a dispersive-type spectrometer known as a virtually imaged phased array (VIPA) spectrometer [3]. Such spectrometers utilize a VIPA etalon to vertically disperse light, while a grating is used for horizontal dispersion of the comb light. An infrared camera captures the resulting two-dimensional images. (ii) The utilization of a home-built fast-scanning Fourier transform spectrometer (FTS) to simultaneously measure the complete rovibrational bands of several species. Both techniques are extensively employed in the investigation of N_2-H_2-CH_4 plasmas at low pressures (a few millibars) typical for plasma based nitrocarburizing processes. Additionally, recent measurements on ammonia formation in N_2-H_2 plasmas using a dual comb spectrometer operating at 9.4 µm are introduced and discussed.

The measurements of highly resolved spectra of complete rovibrational bands employing comb-based techniques provide accurate information about the population and energy distribution along the vibrational ladders of the targeted molecules. The findings and outcomes of these experiments will be thoroughly discussed.

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[2] I. Sadiek, et al., J. Quant. Spectrosc. Radiat. Transfer. **255** (2020) 107263.
[3] I. Sadiek, N. Lang, and J. H. van Helden, Optical Sensors and Sensing, paper LM4B.5 (2022).

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