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Infrared laser-absorption sensing for combustion gases

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ABSTRACT

Infrared laser-absorption spectroscopy (IR-LAS) sensors play an important role in diagnosing and characterizing a wide range of combustion systems. Of all the laser-diagnostic techniques, LAS is arguably the most versatile and quantitative, as it has been used extensively to provide quantitative, species-specific measurements of gas temperature, pressure, composition and velocity in both laboratory- and industrial-scale systems. Historically, most IR-LAS work has been conducted using tunable diode lasers; however, today's researchers have access to a wide range of light sources that provide unique sensing capabilities and convenient access to nearly the entire IR spectrum ($\approx$ 0.8 to 16 μm). In particular, the advent of room-temperature wavelength-tunable mid-infrared semiconductor lasers (e.g., interband- and quantum-cascade lasers) and hyperspectral light sources (e.g., MEMS VCSELs, Fourier-domain mode-locked lasers, dispersed supercontinuum, and frequency combs) has provided a number of unique capabilities that combustion researchers have exploited. The primary goals of this review paper are: (1) to document the recent development, application, and current capabilities of IR-LAS sensors for laboratory- and industrial-scale combustors and propulsion systems, (2) to elucidate the design and use of IR-LAS sensors for combustion gases through a discussion of the modern sensor-design process and state-of-the-art techniques, and (3) to highlight some of the remaining measurement opportunities, challenges, and needs. A thorough review and description of the fundamental spectroscopy governing the accuracy of such sensors, and recent findings and databases that enable improved modeling of molecular absorption spectra will also be provided.

Contents

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