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Mechanical Engineering

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To whom it may concern,

The Hanson Research Group has been actively involved in research at the High Temperature Gasdynamics Laboratory at Stanford University for over 40 years, resulting in over 100 Ph.Ds being awarded. The group has published over 1000 technical papers, contributing to advances in shock wave physics and chemistry, laser spectroscopy, advanced optical diagnostics and sensors, chemical kinetics, combustion science and advanced propulsion.

To keep pushing the frontier in these fields, we require analytical instrumentation that can operate under the experimental conditions that are dictated by the research questions: We need to achieve a high signal-to-noise ratio at short timescales of microseconds, while studying a broad spectral range to observe multiple chemical species. In addition, high spectral resolution is required to resolve narrow absorption lines of small molecules at low pressures.

Mid Infrared absorption spectroscopy is well suited to approach these challenges due to its sensitivity, specificity and robustness. Within the range of available tools, dual-comb spectroscopy is particularly interesting, because it offers a broadband laser spectrum without any tuning, as required with most other laser-based systems. The resulting spectral coverage and absence of mode hops are very useful for gas dynamics applications and the high rep rate of Quantum Cascade Lasers allows particularly high time resolution on the order of one microsecond.

As IRsweep started to offer integrated mid-IR dual-comb spectrometers, we tested an IRis-F1 and subsequently purchased a unit. In the demo campaign, we were able to detect a broadband absorber fuel (propyne), its pyrolysis over the duration of several hundred microseconds and the oxidation into water with its narrow absorption lines over a spectral range of 60 cm^{-1}. The system integrated well with our shock tube facility, a dynamic experimental environment that presents challenges such as vibration, beam-steering, and optical emission. These issues were overcome by the high output power and lock-in amplification characteristics of the dual-comb system. The two week test campaign yielded a peer-reviewed publication (Pinkowski et al., "Dual-comb spectroscopy for high-temperature reaction kinetics", Measurement Science and Technology, 31, 5, 2020), highlighting the opportunity to greatly increase the amount of spectroscopic information that can be obtained from a single laser diagnostic.

In conclusion, the IRis-F1 combines high spectral and temporal resolution with a spectral coverage that is high enough to detect multiple species in one experiment and to sample broadband and narrowband absorbers. This combination of features is very useful in high temperature gas dynamics applications and we plan to continue to exploit this technique in our laboratory for both kinetics studies of new species and other novel diagnostic applications.

Sincerely,

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