Local Optical Diagnostics of High-Temperature Gas Media Using Laser-Induced Gratings

D.N. Kozlov[a,b], V.D. Kobtsev[b], V.V. Smirnov[a,b]

[a]*A.M. Prokhorov General Physics Institute, Russian Academy of Sciences, Vavilov str. 38, 119991 Moscow, Russia*

[b]*P.I. Baranov Central Institute of Aviation Motors, ul. Aviamotornaya 2, Moscow, 111116 Russia*

dnk@kapella.gpi.ru, kobtsev,vitaly@gmail.com, vvs@kapella.gpi.ru

Laser-induced gratings (LIGs) are spatially periodic modulations of the complex refractive index of a medium [1]. LIGs result from resonant or non-resonant interactions of gas molecules with the laser field in the form of the interference fringes created by a pair of focused pump beams from the same short-pulse laser. The beams are made to intersect at a very shallow angle in a small interaction volume. The fringe spacing is defined by the pump wavelength and the beams intersection angle. At resonant excitation a spatially-modulated variation of the population difference of the energy levels involved may produce a population grating. Subsequent collisional deactivation of the excited species is accompanied by the heat exchange with the medium that may result in formation of thermal gratings. In addition, a non-resonant electrostrictive contribution to LIGs is generated at any pump wavelength. The thermal and electrostrictive contributions reproduce a superposition of a standing acoustic wave and a stationary density modulation. LIGs are detected by diffracting a CW read-out laser beam, which intersects the planes of the fringes in the interaction (probe) volume at the appropriate Bragg angle, on the related spatial variations of the refractive index, and detecting the temporal evolution of the diffracted radiation power. The parameters of the LIG signal temporal profile provide information on local gas temperature and mixture composition [1, 2].

The application of the technique is exemplified by the results of the investigation of collisional deactivation of singlet $O_2(b\ ^1\Sigma^+_g)$ molecules resonantly excited by a 10-ns 762-nm laser pulse in high-pressure 4.3 vol % H_2/O_2 mixtures in the temperature range 291-850 K. The physical, rather than chemical, deactivation was shown to dominate in the collisions of H_2 with $O_2(b\ ^1\Sigma^+_g)$ and $O_2(a^1\Delta_g)$ up to temperatures of 780-790 K at time delays up to 10 μs after the excitation pulse.

References

1. H.J. Eichler, P. Günter and D.W. Pohl, Laser-Induced Dynamic Gratings, Springer, Berlin, 1986.

2. J. Kiefer, P. Ewart. Laser diagnostics and minor species detection in combustion using resonant four-wave mixing. Progress in Energy and Combustion Science, 37 (2011) 525.