

Fluorescence and Transient Absorption Spectra of Excimer Laser Mixtures

Alexey O. Levchenko¹, Nicolai N. Ustinovskii and Vladimir D. Zvorykin

P.N. Lebedev Physical Institute, Leninskii prosp. 53, 119991 Moscow, Russia

Fluorescence and transient absorption spectra of various rare gas mixtures with additions of fluorine-containing gases and nitrogen under e-beam pumping were investigated with the original time-gated probing technique. The obtained results allow us to specify KrF laser kinetics. Amplification of radiation at broadband trimer $\text{Kr}_2\text{F}(4^2\Gamma \rightarrow 1,2^2\Gamma)$ transition was demonstrated.

The KrF-laser operating at $\lambda = 248$ nm can be rated as a future driver for a fast ignition scheme [1,2]. Also, an attractive possibility of using $4^2\Gamma \rightarrow 1,2^2\Gamma$ transition of Kr_2F trimer for the ultra-short pulses amplification was discussed in [3]. Kr_2F trimer is generated in the gain medium of KrF laser along with KrF dimer. Its fluorescence maximum is located around 400 nm and so it is overlapped with the second harmonic of Ti:Sa laser, which hence could be used as a master oscillator. Wide bandwidth of $4^2\Gamma \rightarrow 1,2^2\Gamma$ transition (~ 70 nm, which corresponds to 10 fs spectral-limited pulse), long life time (~ 180 ns) and quite high saturation energy ($E_{\text{sat}} \approx 0.2$ J/cm²), allow one to expect high specific laser parameters. The gain coefficient for this transition was estimated in [4] as $g_0 = 0.002$ cm⁻¹; in earlier paper [5] weak lasing was obtained after short (~ 10 ns) and intense (~ 10 MW/cm³) pumping pulse. Apparently, the main hindrance for lasing is rather high transient absorption which appears during pumping. The purposes of this work were measuring of fluorescence and transient absorption spectra in different mixtures of noble gases, nitrogen and fluorine, in order to specify general kinetic processes in such laser mixtures and to obtain the amplification at $\text{Kr}_2\text{F}(4^2\Gamma \rightarrow 1,2^2\Gamma)$ transition.

Experiments were performed at Berdysk laser module [6], which was pumped by 80x120-mm cross-section e-beam of 50-A/cm² peak current, 70-ns pulse duration, and 250-350-keV average electron energy. Specific pumping power was of ~ 0.6 - 0.8 MW/cm³. Fluorescence and absorption spectra were registered at pressures from 0.2 to 2.5 atm in the spectral range from 190 to 510 nm with the broadband spectrometer equipped with CCD-array. A new original time-gated technique was developed; it consists in probing of pumped gas volume by erosion plasma radiation. The plasma was produced on the surface of teflon or copper targets by tightly-focused auxiliary laser radiation, which had the following parameters: $\lambda = 248$ nm, pulse duration ≈ 20 ns, pulse energy $E \approx 50 - 100$ mJ. The radiation of such erosion plasma had continuum-like spectrum in the range from 320 to 510 nm with a small number of spectral lines; its duration was shorter than 50 ns. The used technique allowed us acquiring a lot of detailed transient absorption spectra in a wide spectral range using a minimal number of shots. The fluorescence and transient absorption spectra were measured in pure rare gases: Ar, Kr, Ne; their mixtures: Ar/Kr, Ne/Kr, and also in mixtures with different additions: N₂, He, F₂, NF₃ and SF₆ in various combinations and with various pressures. Recorded spectra were analyzed and identified; the fluorescence and transient absorption spectra evolutions with total pressure of mixtures and partial pressure of additions were investigated. The quenching of transient absorption in rare gases and various mixtures by small additions of N₂ or NF₃ was demonstrated, a net small-signal gain coefficient $(0.5-1.0) \cdot 10^{-3}$ cm⁻¹ was obtained at $\text{Kr}_2\text{F}(4^2\Gamma \rightarrow 1,2^2\Gamma)$ transition.

Work was supported by Russian Foundation on Basic Research, Project No 08-02-01331, the Special Program of Russian Academy of Sciences for young scientists and "Science-support" foundation.

[1] Obenschain S.P., Colombant D.G., Schmitt A.J., *et al. Phys. of Plasmas*, **13**, 056320-1–11 (2006)

[2] Zvorykin V.D., Lebo I.G., Rozanov V.B., *Bull. Lebedev Phys. Inst.*, **9-10**, 20-29 (1997)

[3] Molchanov A.G., *J. Phys. IV France*, **133**, 665–668 (2006)

[4] Zvorykin V.D., Didenko N.V., Ionin A.A., *et al., Laser & Particle Beams*, **25**, 435–451 (2007)

[5] Tittel F.K., Smayling M., and Wilson W.L., *Appl. Phys. Lett.*, **37**(10), 862-864 (1980)

[6] Zvorykin V.D., Arlantssev S.V., Bakaev V.G *et al., Laser & Particle Beams*, **19**, 609–622 (2001)

¹ E-mail: Levchenk@sci.lebedev.ru