Investigation of E-Beam-Pumped Krypton Fluoride Laser towards a Viable Driver for Inertial Fusion Energy

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An overview of the research being carried out at e-beam-pumped **Kr**ypton **F**luoride GARPUN laser system of Lebedev Institute in collaboration with the other Institutions is presented. It is emphasized the critical issues of KrF laser as an efficient and viable rep-rate driver for the **I**nertial **F**usion **E**nergy. The experimental data are the base for 3D numerical simulations predicting operation parameters of IFE-scale drivers. Testing of new UV optical materials and coatings resulted in the improved stability of laser windows against various adverse factors.

While MJ-class Nd glass NIF and LMJ laser facilities will be completed soon for thermonuclear ignition experiments [1] IFE program is underway considering **D**iode **P**umped **S**olid **S**tate **L**aser and e-beam-pumped KrF laser as prime candidates for rep-rate, high-efficient and durable drivers [2]. To date 60 J, 10 Hz, 2.7×10^5 shots were demonstrated at DPSSL Mercury at LLNL, meantime 700 J, 2.5 Hz, 10^5 shots were achieved with Electra KrF laser at NRL [3]. The ongoing research with KrF lasers aims at obtaining $\geq 3\times10^8$ shots in continuous operation of laser module scalable to 28-kJ energy with $\geq$6-7 % overall efficiency that are the bench mark for **F**usion **T**est **F**acility design [4]. Two facilities at Lebedev Institute, multi-stage 100-J, 100-ns GARPUN [5] and high e-beam current density ELA [6], although operating in single shots, produce the knowledge about KrF laser physics and technologies, which contributes to FTF supporting research.

Here we are reporting about fluorescence and transient absorption spectra of e-beam-pumped rare gases Ne, Ar, Kr, their binary and excimer mixtures with halogens F_2, NF_3, SF_6, and small additions of N_2 and He. The spectra were measured by time-resolved and original time-gated techniques using capillary discharge or laser plasma sources for probe light. Being the base for the kinetics interpretation this research purposes achieving higher intrinsic efficiency and more adequate simulation of KrF laser with 3D numerical codes. Being verified with the experimental data, they were used to predict parameters of IFE-scale drivers. Relative to the fast-ignition concept, the same KrF drivers were shown to be capable amplifying both high-energy ns-length pulses for target compression and high-intensity ps-length pulses for fuel ignition. A broadband transition of trimer $Kr_2F(4^2\Gamma\rightarrow1,2^2\Gamma)$ was considered for amplification of fs-length pulses. E-beam transport, which is responsible for laser pumping and optics degradation under scattered electrons and bremsstrahlung X-rays, was investigated both experimentally and in Monte Carlo simulations. A number of UV optical materials for KrF laser windows were examined in regard of electron and soft X-ray irradiation. Fluorine-resistant coatings with extremely low water content were developed and characterized using IR Fourier spectroscopy and atomic force microscopy.

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