

Properties of a DC Glow Discharge Iodine Atom Generator

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Iodine atoms recombination in a dc glow discharge generator was studied using Laser Induced Fluorescence (LIF) method. Up to 80 % of iodine flow consisted of iodine atoms.

The use of iodine atoms instead of iodine molecules is a way of essential enhancement of efficiency of Chemical Oxygen-Iodine Laser (COIL). In this case singlet oxygen molecules consumed for I₂ dissociation can be converted into laser output. The dissociation of iodine containing molecules in electric discharge plasma is a promising method for production of iodine atoms. In those devices both the dissociation of molecules and recombination of iodine atoms take place. The concentration ratio of [I]/[I₂] at the discharge generator exit depends on the number of parameters and is not known beforehand. Moreover, an unknown part of iodine atoms becomes recombined during transportation to the point of mixing of iodine and singlet oxygen flows. The rate of iodine atoms recombination depends strongly on the gas temperature that change during transportation from the discharge generator to the laser medium. Thus, it is necessary to perform experiments to measure [I₂] densities in the carrier gas flow.

In order to measure the [I₂] concentrations at the exit of discharge generator and downstream the Laser Induced Fluorescence (LIF) method was used. The I₂(B-X) transition was excited by a diode pumped second harmonic Nd:YAG laser at 532 nm. This method allows measuring of [I₂] concentrations typical for the COIL active medium $\geq 10^{13}$ cm⁻³.

The iodine atoms were produced using a dc glow discharge described previously [1]. CH₃I was used as iodine precursor. The measurements were carried out at a gas pressure in discharge zone of 20 Torr, Ar flow rate of 2.5 mmole/s. The discharge voltage depended on the CH₃I flow rate and varied from 290 to 350 V. Calibration of the [I₂] measurement was fulfilled using the measured [I₂] concentration by means of absorption of light at 500 nm in the 50 cm length cell. The gas duct after discharge generator was a heated steel tube. The residence time was varied by moving a throttling orifice along the length of the gas duct.

The I₂ concentration measurements have shown that iodine atom densities at the output of iodine atom discharge generator depend on the CH₃I flow rate. The electric dc discharge iodine generator with coaxial electrodes and CH₃I as donors of iodine atoms allows getting of iodine atoms densities up to $\approx 10^{16}$ cm⁻³ at total Ar pressure near to 20 Torr. At that, the dissociation fraction of CH₃I and concentration ratio of $\xi = [I]/([I] + 2[I_2])$ at the discharge generator exit amounted to ≈ 0.5 and ≈ 0.8 respectively.

The I₂ concentration increased with residence time due to homogeneous and heterogeneous recombination. In our experimental conditions the substantial part of iodine atoms recombined during transportation from the exit of iodine generator to iodine nozzles (residence time ≈ 6 ms). The measured concentration ratio of ξ downstream of iodine nozzles was 0.2-0.5. Even so the singlet oxygen lifetime turned out to be about 30% longer, when iodine was produced from CH₃I in the discharge, compared to the conventional I₂ dissociation in the singlet oxygen flow. It was found that the products of methyl iodide dissociation and gas heating in this type of discharge have little or no adverse effect on the COIL active medium [1].

[1] Mikheyev P.A., Azyazov V.N., Shepelenko A.A. et al., Proc. SPIE **6346**, 63460J (2007)

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