Evolution and Status of a Multi-Kilowatt Electric Iodine Laser Effort

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Plasmatronics' controlled avalanche-based electric oxygen iodine generator achieves 30% conversion from O_2 into $O_2{}^1\Delta$ at 40-50% electrical pump efficiency, wherein 2400 watts is imparted into the $O_2{}^1\Delta$ flow stream. A special I_2 disassociation-combined ejector mixing scheme has been developed in our quest to realize kW-class extraction from a 20 cm-wide, Mach 2.5, laser channel. Latest results of gain and output power measurements will be presented.

The electric oxygen iodine laser (EOIL) offers a vastly more practical, implementable, and safer alternative to its predecessor, the chemical oxygen iodine laser (COIL), particularly for airborne or otherwise mobile military applications. Despite its promise and after 25 years effort, laboratories around the world have not succeeded in providing the known basic physical requirements needed to electrically convert O_2 into $O_2{}^1\Delta$ with the fractional yields and efficiencies necessary to make a practical laser. Today the record power generated from an EOIL device is only 6.5 watts.

In order to achieve good $O_2{}^1\Delta$ fractional yield, it is necessary to impart on the order of 70-100 kJ/mole O_2 while efficiently removing the waste heat energy from the generator so that the gas temperature does not rise above ~420°K. The generator must be excited by an electric field on the order of 10 Td – far below the glow potential. Therefore, ionization must be completely externally sustained.

In this paper, a 30% conversion from O_2 into $O_2{}^1\Delta$ operating at substantial oxygen mass flow rates (0.045 moles O_2/sec at 55 torr) and electrical efficiency reaching 40-50% is reported. The $O_2{}^1\Delta$ flow stream being produced carries 2400 watts. Ionization is supplied by means of applying short (tens of nanosecond) pulses to the $O_2{}^1\Delta$ generator at 50,000 PPS, at a potential of about one order of magnitude above the breakdown potential. This develops a quasi-steady adjustable DC current to flow through the generator, being conducted under the force of a DC, 8 to 12 Td, independently tunable pump E-field. Thereby, 130 to 180 kJ/mole O_2 may be imparted to the gas.

The generator consists of 24 each, 1 cm-in-diameter tubes that are submerged in rapidly circulating cold fluorinert. Heat is efficiently removed so that the gas temperature, initially 273ºK, raises only by 125ºK. Fortuitously, $O_2{}^1\Sigma$ production is eliminated at higher pressure. Essentially all other spectral lines are dwarfed in comparison the $O_2{}^1\Delta$ line. At higher pressure operation, large quantities of O_3 and UV photons are produced by controlled avalanche pulses, which react to convert $O_2{}^1\Sigma$ into $O_2{}^1\Delta$, thus enabling an unexpectedly high electrical efficiency of 40-50%.

The primary ($O_2{}^1\Delta$ bearing) and secondary (I_2 vapor bearing) flow streams are rapidly and homogeneously mixed while I_2 is simultaneously disassociated. This is accomplished using a supersonic ejector-pumped mixing section combined with an electric discharge. $O_2{}^1\Delta + I \rightarrow O_2 + I^*$ occurs by means of kinetic collisions upon mixing. The mixed flow streams are immediately expanded to M = 2.5 within a 20 cm-wide, transverse-laser cavity, where lasing occurs according to $I^* \rightarrow h\nu + I$. Gain and power measurements to date will be presented.

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