OPTIMIZED OPERATION OF OPTICALLY PUMPED NH₃ LASER EMISSION AT 12.08 µm AND 12.81 µm*

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Abstract: Based on the semi-classical density matrix equations, optimized operation of optically pumped NH₃ MIR laser emission at 12.08 µm and 12.81 µm was studied theoretically and experimentally. The effect of pump power, gas pressure and buffer gas N₂ on MIR output power were discussed in detail.

Keywords: optically pump NH₃ MIR laser, optimized operation

1. Introduction

Nowadays, optically pumped mid-infrared laser (OPML) has been widely used in high resolution spectrum studies and in laser photochemical reactions, example of which is the dissociation of Uranium hexafluoride (UF₆). However, OPML is more difficult to be realized than OPFIRL. This is because: a). no pump source which is more powerful, efficient and convenient and able to lase shorter wavelength coherent emission than CO₂ laser is available; b). both the initial state (source level) and the final state (lower lasing level) are in ground vibration state and the population difference between them is very small; c). electric dipole moment for vibrational-rotational transition in the molecule system is very much less (about ten times) than that for pure rotational transition. Since the first report of OPML emission at 12.81 µm from NH₃ by Chang and McGee[1], many efforts have been made to the improvement of OPML and great achievement have been

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achieved. In this paper, optimized operation of optically pumped NH$_3$ laser emission at 12.08μm and 12.81μm were studied, some important parameters were compared and discussed in detail.

2. Theoretical description

The symmetric top molecule NH$_3$ has four fundamental vibrational modes ($v_1$, $v_2$, $v_3$ and $v_4$), the frequency of $v_2$ mode is about 950cm$^{-1}$ and overlaps with that of CO$_2$ laser. MIR laser emission from NH$_3$ pumped by CO$_2$ laser is possible and has been studied for years by many authors\[2,3,4\]. In our study, NH$_3$ was assumed to be a three-level system. Part of the energy levels of NH$_3$ molecule related to optically pumped MIR laser emission at 12.08μm and 12.81μm was shown in Fig.1, where $s$ and $a$ denoted the inversion splittings of the energy levels (symmetric and anti-symmetric respectively). The pumping and lasing transitions were happened in the different parts of $v_2$ band, pumping on R branch and MIR lasing on P branch. The pump laser lines related to 12.08μm and 12.81μm transitions were CO$_2$ 9R(30) and 9R(16) respectively, $\delta_p$ was the pump frequency detuning. Also, part of the energy levels of buffer gas N$_2$ was depicted in Fig.1 for later discussion.

![Fig.1, Part of the energy levels of NH$_3$ molecule](image)