Compact widely tunable room temperature Terahertz Molecular Lasers from 250 GHz to 4.6 THz

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Quantum cascade lasers (QCLs) are the dominant source in the mid-IR and have found a wide range of applications in chemical sensing, trace gas monitoring, biomedical and spectroscopy. However, their performance falls short in the Terahertz gap. Other THz lasers, such as molecular lasers, have similar limitations in addition to a large footprint. We have realized a compact, room temperature, widely frequency-tunable, bright THz QCL pumped molecular laser (QPML) based on rotational population inversion. By identifying the essential parameters that determine the suitability of a molecule for a terahertz laser, almost any rotational transition of almost any molecular gas can be made to lase. Using Nitrous oxide (N_2O) as the gain medium we demonstrated tunability over 37 lines spanning 0.251 to 0.955 terahertz, each with kilohertz linewidths [1]. We have recently achieved lasing in methyl fluoride (CH3F) QPML, where we showed laser operation between 250 GHz and 1.255 THz – line tunable over more than 1 THz [2]. We additionally measured the emission frequencies of more than 70 individual laser lines between 300 and 755 GHz. The CH_3F QPML was shown to exhibit a low lasing threshold (reduced by a factor 7 compared to our previous work with nitrous oxide), thus making methyl fluoride a promising gain medium for many QPML applications. Finally, we have recently reported explored the potential of the ammonia QPMLs to produce powerful, broadly tunable terahertz frequency lasing on rotational and pure inversion transitions [3]. After theoretically predicting possible laser frequencies, pump thresholds, and efficiencies, we experimentally demonstrated unprecedented tunability – from 0.763 to 4.459 THz – by pumping Q- and R-branch infrared transitions. with widely tunable quantum cascade lasers. We additionally demonstrated two types of multi-line lasing: simultaneous pure inversion and rotation– inversion transitions from the same pumped rotational state and cascaded lasing involving transitions below the pumped rotational state. We report single frequency power levels as great as 0.45 mW from a low volume laser cavity.

References

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