GaSb-based single-mode distributed feedback lasers for sensing

James A. GUPTA*, Andrew BEZINGER, Jean LAPOINTE, Daniel POITRAS, Geof C. AERS

National Research Council of Canada, M50 Montreal Road, Ottawa K1A 0R6, Canada

* corresponding author e-mail

GaSb-based tunable single-mode diode lasers can enable rapid, highly-selective and highly-sensitive absorption spectroscopy systems for gas sensing. In this work, single-mode distributed feedback (DFB) laser diodes were developed for the detection of various trace gases in the 2-3.3um range, including CO2, CO, HF, H2S, H2O and CH4. The lasers were fabricated using an index-coupled grating process without epitaxial regrowth, making the process significantly less expensive than conventional DFB fabrication.

The devices are based on InGaAsSb/AlGaAsSb separate confinement heterostructures grown on GaSb by molecular beam epitaxy. DFB lasers were produced using a two step etch process. Narrow ridge waveguides were first defined by optical lithography and etched into the semiconductor. Lateral gratings were then defined on both sides of the ridge using electron-beam lithography and etched to produce the index-grating.

Effective index modeling was used to optimize the ridge width, etch depths and the grating pitch to ensure single-lateral-mode operation and adequate coupling strength. The effective index method was further used to simulate the DFB laser emission spectrum, based on a transfer matrix model for light transmission through the periodic structure.

The fabricated lasers exhibit single-mode operation which is tunable through the absorption features of the various target gases by adjustment of the drive current. In addition to the established open-path sensing applications, these devices have great potential for optoelectronic integrated gas sensors, making use of integrated photodetectors and possibly on-chip Si photonics waveguide structures.