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**Above Threshold Analysis of Quasi-Guided Optical Waveguide VCSELs for Single-Mode High-Power Application**

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**Proposed Solutions - Quasi-Guided Structure**

- **Quasi-guided VCSEL**
  - Higher-order modes are less guided than fundamental mode
  - Photonic band gap radiative mechanism
  - Index contrast is made smaller in active region

**Quasi-Guided VCSELs - Simulation**

**Parameters of the simulated case**

- Radiation loss of LpLp and L1L2 vs J and Q

**Thermal Lensing Analysis of QGOW VCSELs**

- Thermal lensing causes droop in current-voltage curves
- Thermal lensing effects are also strongly dependent on current level

**Spatial Hole Burning Analysis of QGOW VCSELs**

- Spatial hole burning affects the radiation loss in QGOW VCSELs

**Numerical Model for 2D Lateral Mode Analysis**

- Wave equation (Fourier differential equation)

**Thermal Profile in QGOW VCSELs - Green Function Method**

- Thermal lensing effect on QGOW VCSELs

**Proposed Solutions - Quasi-Guided VCSELs**

- Substrate width is increased for single mode operation
- Higher-order modes are less guided than fundamental mode
- Photonic band gap radiative mechanism
- Index contrast is made smaller in active region

**Effective Index Model of VCSELs**

- Effective Index Model of Quasi-Guided VCSELs

**Radiation Loss of LP01 and LP11 vs J and Q**

**Analysis of ARROW VCSELs**

- ARROW VCSELs + Antiguiding channel

**Numerical Flow Chart for Above Threshold Analysis of QGOW VCSELs**

- Thermo-optical analysis is performed using finite difference methods
- Wave equation (Fourier differential equation)


**Characteristics of Antiguided Structure**

- Antiguided Single Mode VCSELs

**Spatial Hole Burning in QGOW VCSELs**

- Spatial hole burning effects on radiation loss in QGOW VCSELs

**Numerical Model for 2D Lateral Mode Analysis**

- General Solution

**Thermal Sensing of Antiguided VCSELs**

- Thermal sensing effect is studied in detail

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**Thermal Lensing and Spatial Hole Burning Effects on Radiation Loss in QGOW VCSELs**

- Thermal lensing causes droop in current-voltage curves
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**Thermal Lensing in QGOW VCSELs**

- Thermal lensing effect on QGOW VCSELs

**Numerical Flow Chart for Above Threshold Analysis of QGOW VCSELs**

- Thermo-optical analysis is performed using finite difference methods
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