Lithium-niobate-based Cavity Resonator-Integrated Guided-mode Resonance Filters

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Introduction

Context

- **Guide-Mode Resonance Filters (GMRFs - review paper ¹):**
 - Spectral filters with less complex layer structure than thin-films
 - Q up to 10^4
 - Angularly tunable response
 - Demonstrated enhancement of nonlinear interactions but with large beams ²⁻⁴
- **Cavity Resonator Integrated Guided-mode Resonance Filters (CRIGFs)**
 - CRIGF=GMRF section in a cavity ⁵
 - ✓ Spatial (mode) localisation ($\sim 1-100 \mu\text{m}$)
 - ✓ Q up to 10^3
 - ✓ Wider angular acceptance than GMRF ⁶
 - ✗ Spectrally-fixed filters
 - ✓ Used as wavelength-stabilizing filters in extended-cavity diode lasers ⁷⁻⁹

This work

- Fabrication of CRIGFs on a material platform compatible with nonlinear interactions
- Demonstration of tunability

Characterisation Setup

Design

Spatially-resolved characterisation

Observation

- Asymmetry in spectral map along grating lines

Analysis

- Period variations along grating lines
- Imperfect unmoding during NIL

Characteristics:

- $R_{\text{max}} = 32 \pm 2\%$
- $Q \sim 1600$

Temperature tuning

Analysis: Parameters^{13,14} :

$$\frac{\partial n_{\text{LiN}}(1550\text{nm})}{\partial T} = 3.3 \cdot 10^{-5} / \text{K}$$

$$\frac{\partial n_{\text{SiN}}(1550\text{nm})}{\partial T} = 2.45 \cdot 10^{-5} / \text{K}$$

$$\frac{\partial n_{\text{SiO}_2}(1550\text{nm})}{\partial T} = 0.95 \cdot 10^{-5} / \text{K}$$

$$\alpha_{T, \text{subs}} = 0.75 \cdot 10^{-5} / \text{K}$$

Fabrication

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Conclusions

- ✓ First demonstration of CRIGF on Lithium Niobate On Insulator (LNOI)
- ✓ Characteristics : $R_{\text{max}} = 32 \pm 2\%$ and $Q \sim 1600$ at 1554.5 nm for $8.65 \mu\text{m}$ -wide grating-coupler structure
- ✗ Performance affected by NIL unmoding step
- ✓ Thermally tunable response over 1.2 nm with resonance shift rate of 0.038 nm/K
- ✓ Tuning characteristics reproduced numerically using reported parameters

Future work

- Devices with integrated heaters / electro-optic tuning