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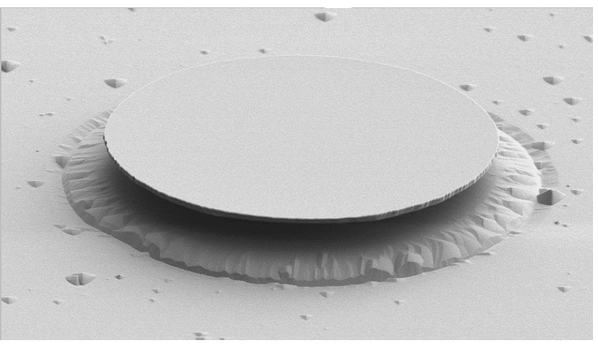

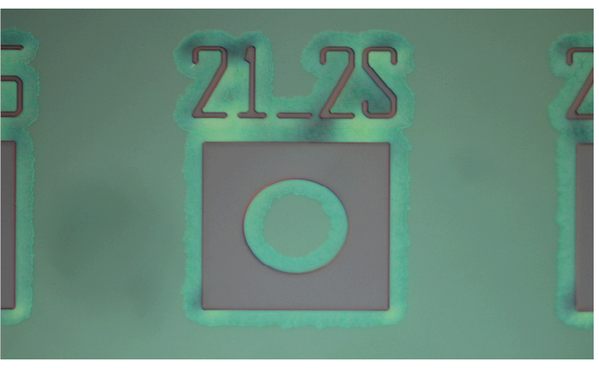

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Nonlinear Optics in $LiNbO_3$ Thin Films

James Kenneth Douglas
UNM, Ph. D. Nanoscience and Microsystems Engineering, May 2017
Manager: Keith Ortiz Mentor: Matt Eichenfield Org: 1719

Abstract

The objective of the project is to leverage Sandia's fabrication capability to create microdisk resonators that utilize a novel geometric phase matching technique for second harmonic generation (SHG).

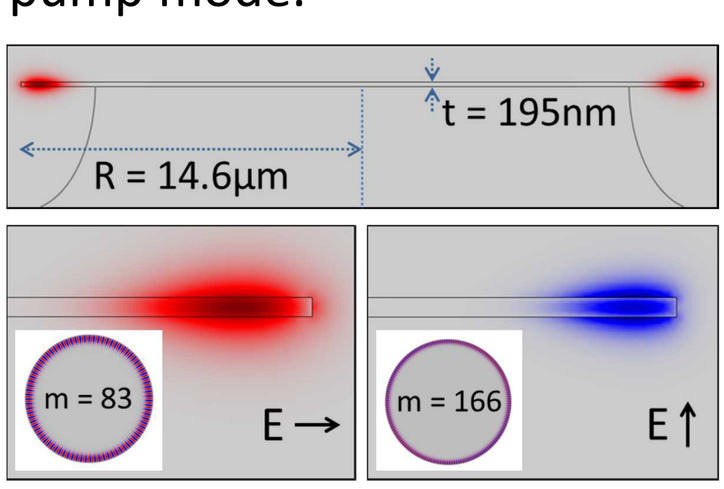
By using geometric phase matching in conjunction with the nonlinear optical properties of lithium niobate ($LiNbO_3$), we have been able to fabricate whispering gallery resonators that demonstrate SHG from 1550nm to 775nm with a theoretical conversion efficiency of 40%. We have also recorded Q-factors of 550,000 at 1550nm, higher than currently published results.

Introduction

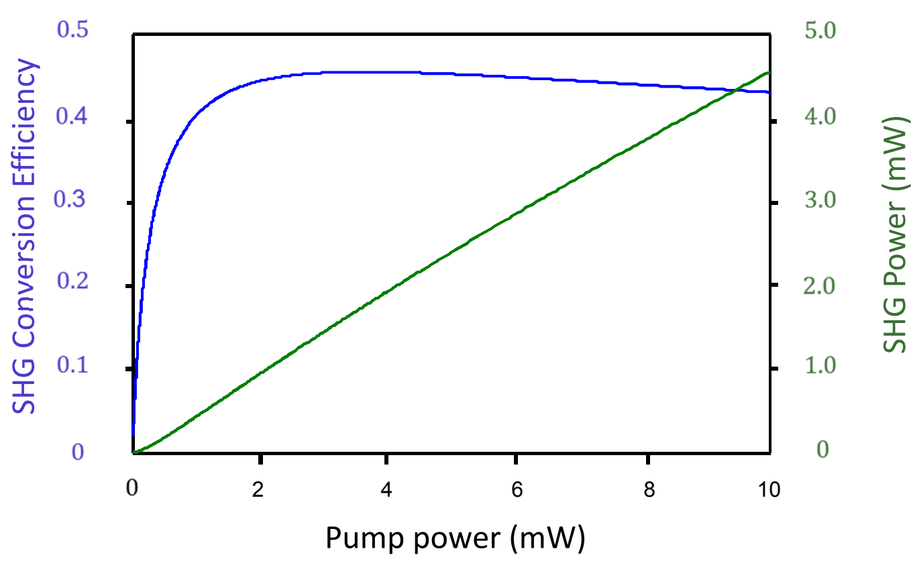
In this poster we describe the micromachining techniques we developed and used to fabricate the $LiNbO_3$ resonators. We also present the experimental setup as well as the initial results demonstrating high Q-factor $LiNbO_3$ resonators that produce SHG.

Device Architecture

The thin film structures demonstrate geometric birefringence due to the sub wavelength device thickness in the Z-direction (λ/8 for 1550nm pump and λ/4 for 775nm SH). This device geometry forces the vertically polarized SH mode out into the air, lowering its effective index. The lowered effective index of the SH mode allows phase matching with the radially polarized pump mode.



Simulated pump (1476nm in red) and second harmonic (738nm in blue) modes of $LiNbO_3$ microdisk. Geometric dispersion allows phase matching of the two modes.



FEA simulations of conversion efficiency from pump to second harmonic

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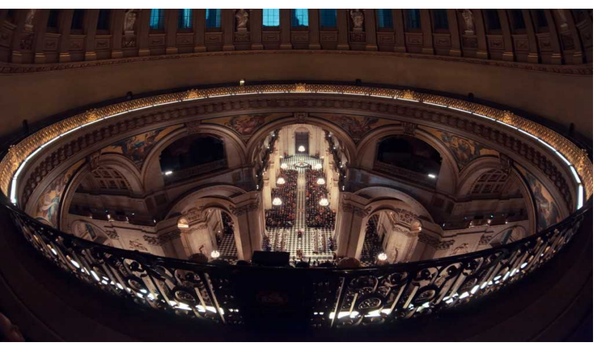
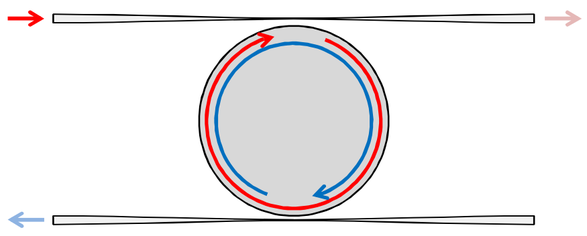
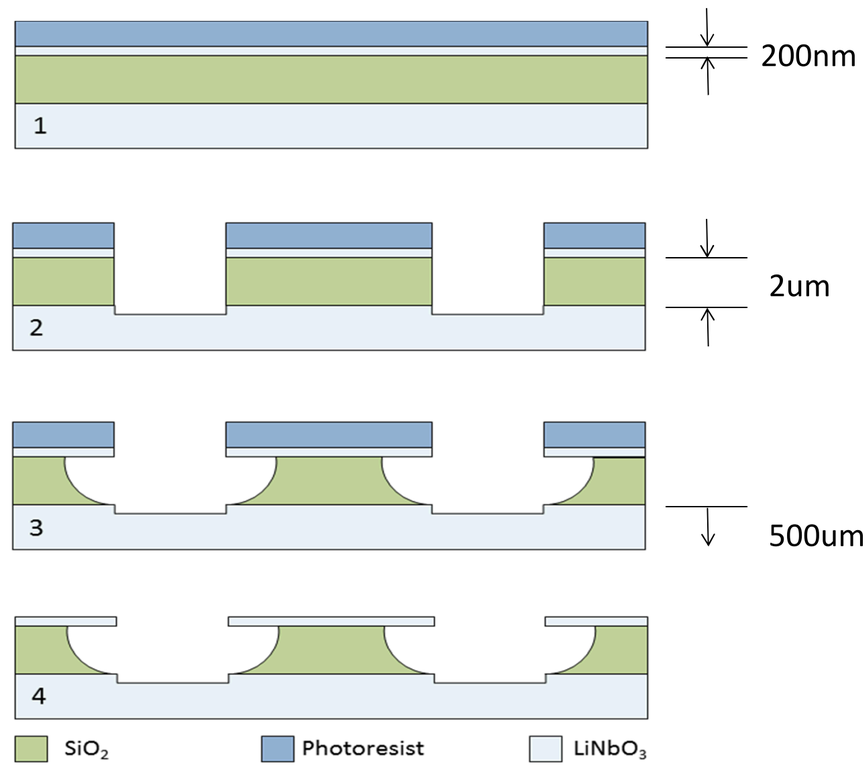




Fabrication

The whispering gallery resonators were fabricated using state of the art lithium niobate on insulator (LNOI) wafers.

1) Pattern Mask
2) 8 min Ar Ion Beam Dry Etch
3) Vapor HF Release
4) Remove Mask

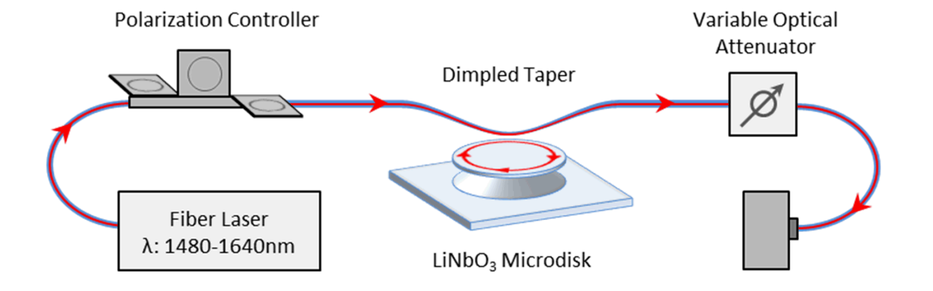


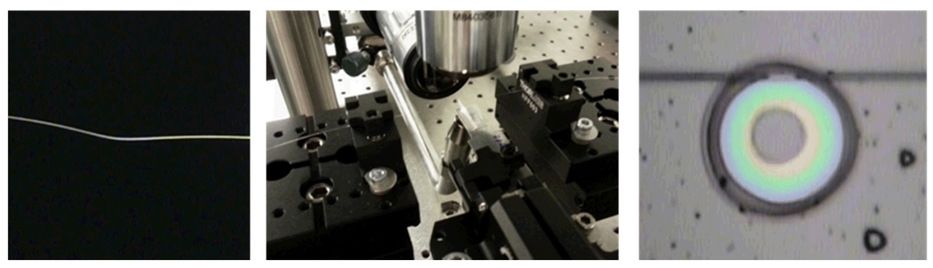
Micromachining process for $LiNbO_3$ resonators

Micromachining process for $LiNbO_3$ resonators

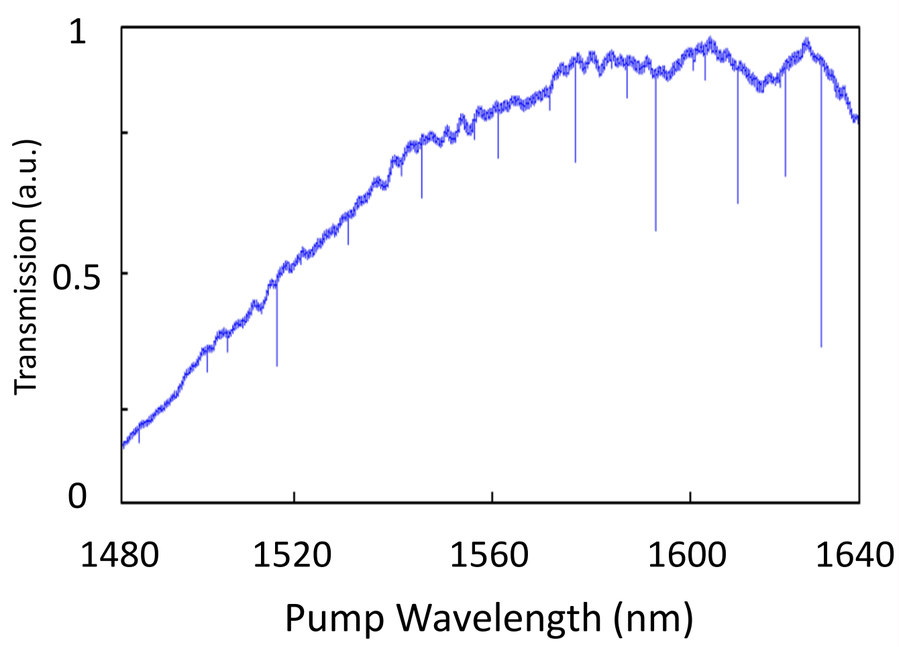
Characterization

The $LiNbO_3$ resonators were fabricated with thicknesses ranging from 180nm to 220nm and radii from 5um to 60um. We have observed whispering gallery modes between 1480nm and 1640nm as well as 765nm and 781nm. The microdisks modes were evanescently probed with a tapered optical fiber. Maximum measured intrinsic quality factors are Q_0= 550,000 for the pump wavelength and Q_0= 15,000 for the SH wavelength. These values exceed existing published values.



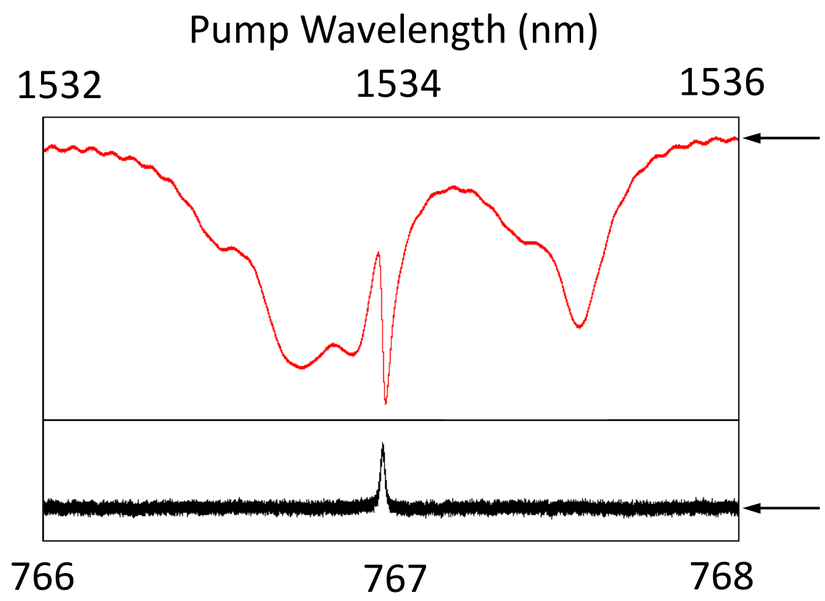


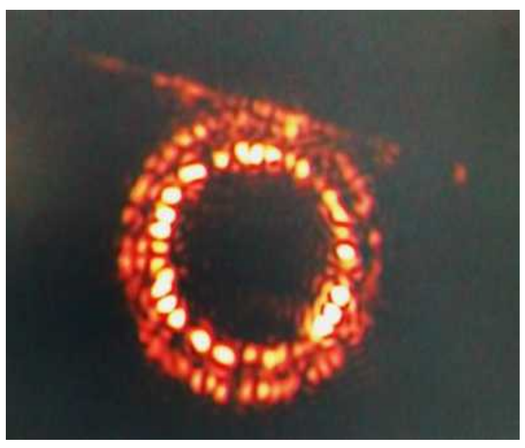
Dimpled Fiber Setup Testing



Nonlinear Optics

By phase matching the whispering gallery modes at both the pump and SH wavelengths we were able to convert radially polarized 1550nm light into vertically polarized 775nm light.





Second harmonic generation from $LiNbO_3$ disk

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