LEHIGH UNIVERSITY

Center for Optical Technologies

All Optical Network Thrust:

Imaging of photonic device structures using confocal luminescence and Raman microscopy

V. Dierolf, Chr. Sandmann, and Z. Fleischman

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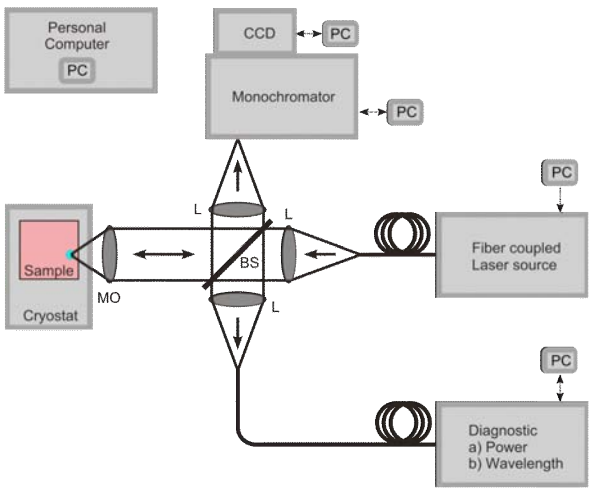
Motivation

Many photonic devices have features sizes in the sub-micron scale in through dimensions and hence the use of regular microscopy comes to its limits. Moreover, there are instances in which no contrast at all can be achieved in a regular microscope. Examples are: ferroelectric domain patterns in periodically poled $LiNbO_3$, doping levels and profiles in waveguides and fibers. Other methods like SIMS and selective etching are available but are destructive.
In our approach, we use confocal microscopy and obtain atomic level information by the combination with optical spectroscopy

Experimental Set-up



- Home-built
- 400nm spatial resolution
- several modes of operation possible (regular confocal, emission, and Raman)
- For each point on the sample a spectrum is measured

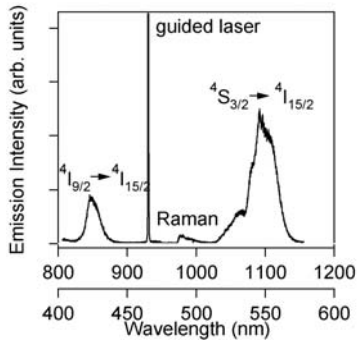
Evaluation Method

Method of Moments

$$M_o = \int_{-\infty}^{\infty} I(E)dE \quad \text{(total intensity)}$$
Concentration

$$M_1 = \frac{1}{M_o}\int_{-\infty}^{\infty} I(E)EdE \quad \text{(average emission wavelength)}$$
Changes in local environment

$$M_n = \frac{1}{M_o}\int_{-\infty}^{\infty} I(E)(M_1 - E)^n dE \quad \text{(n = 2, spectral width)}$$
Change in local disorder

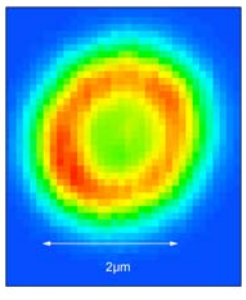


- The integrals are evaluated over the spectral area of interest
- The different modes of operation can be used simultaneously

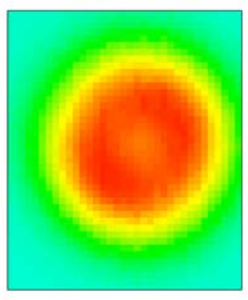
Applications

Doping Profile of Rare Earth doped fiber

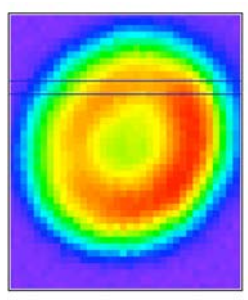
Emission Intensity
Er-concentration



Guided 980nm Mode



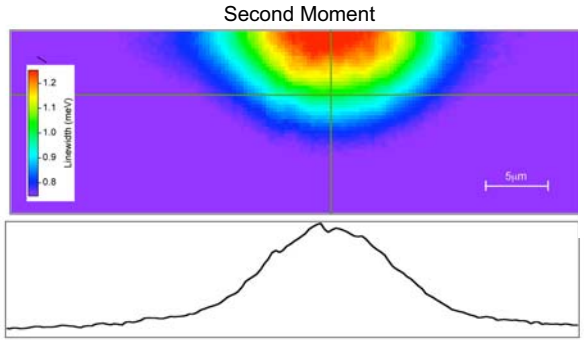
Emission Peak Position
Strain



Samples from ACREA AB in Sweden

Waveguide Imaging

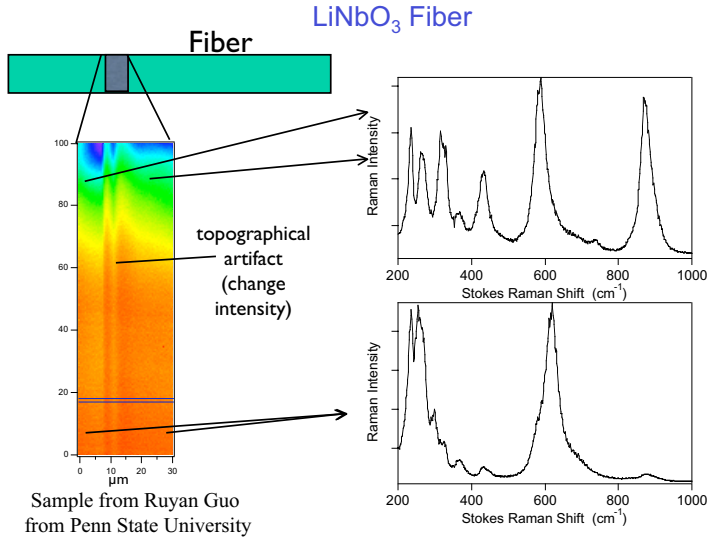
Second Moment



The addition of Ti ions into the crystals weakens the local electric field and causes a shift in emission energies. Furthermore, the disorder is increased leading to a broadening of the peaks

Samples from the group of W. Sohler, University of Paderborn, Germany

$LiNbO_3$ Fiber

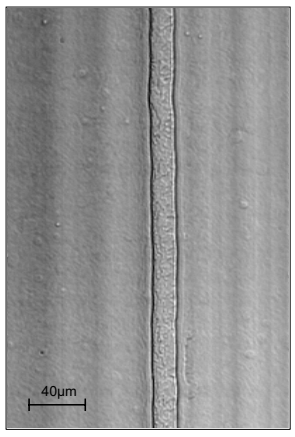


Raman Spectra for different orientation of the ferroelectric axis are different

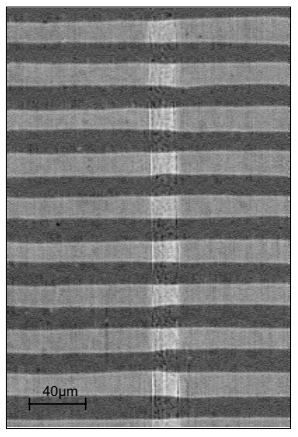
Sample from Ruyan Guo from Penn State University

Periodically Poled $LiNbO_3$

confocal reflection

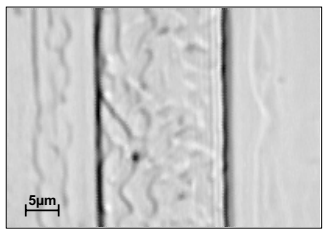


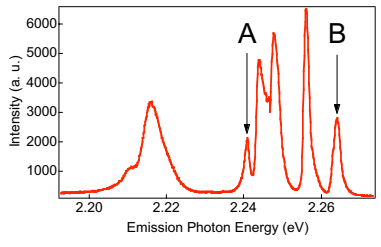
confocal luminescence



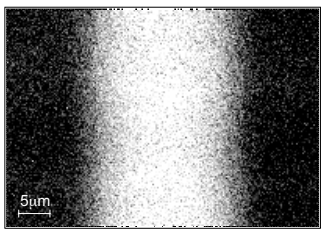
Domain Inversion at room temperature leads to rearrangement of defect structure and a change of the local electric field in the vicinity of the Er ions

confocal reflection

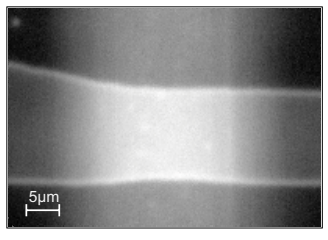




Second Moment of Peak A



First Moment of Peak B



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