USC University of Southern California

USC Viterbi School of Engineering

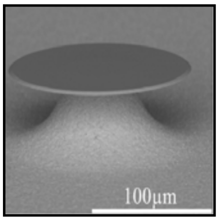
Ming Hsieh Department of Electrical Engineering

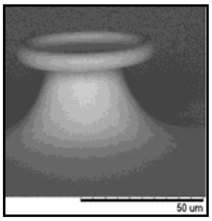
Thermal Nonlinearity Analysis of Toroidal Microcavities

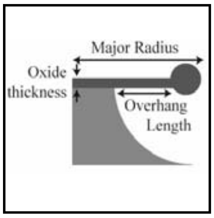
Soheil Soltani and Andrea M. Armani
Ming Hsieh Department of Electrical Engineering-Electrophysics, University of Southern California, Los Angeles, CA 90089

Introduction

Toroidal high quality factor (Q) optical resonant cavities can store optical signals for long periods of time. As such, very high intensity optical powers can build up, in these devices, from low initial signal levels. One of the interesting phenomena, outlined in detail here, is the thermo optic effect in our resonators. A portion of the circulating power is absorbed by the resonator and heats the resonator. Because of their relatively small area even with a small absorbed power, the resonators undergo a large temperature change.







Governing physics

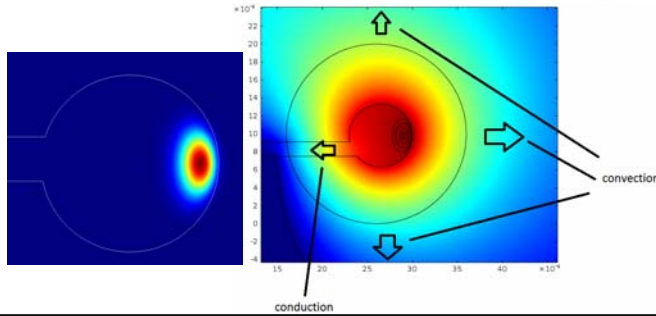
In a pure SiO2 microtoroid, this shift is larger than the linewidth of the device and is directly proportional to:

1-Input power
2-Q factor
3-Wavelength

$$P_{circ} = \frac{\lambda Q_0}{\pi^2 n_{eff} R_{meff}} \frac{K}{(1+K)^2} P_{in}$$

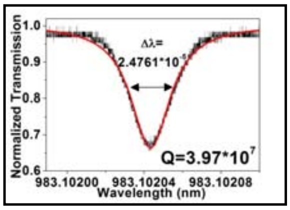
$$P_d = \sigma_0^2 |a|^2 = \sigma_0^2 P_{circ} t_r$$

$$\Delta\lambda / \Delta T = \lambda_o (\varepsilon_{eff} + (dn/dT)/n_{eff})$$

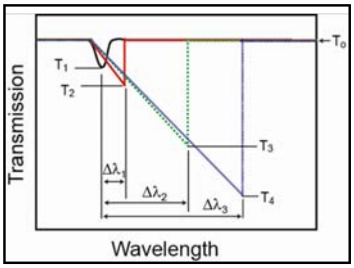


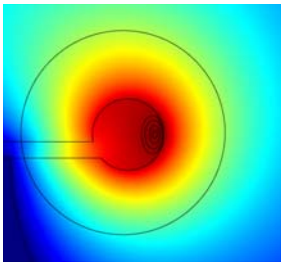
Theoretical Studies

The resonant frequency at low input power will have the ideal Lorentzian lineshape:



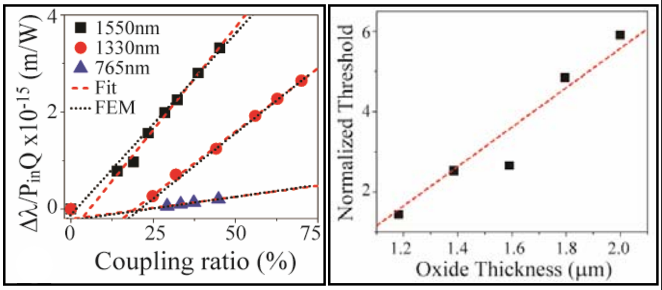
The resonant wavelength in an SiO2 cavity will redshift and broaden because of the thermo-optic effect.





Experimental results

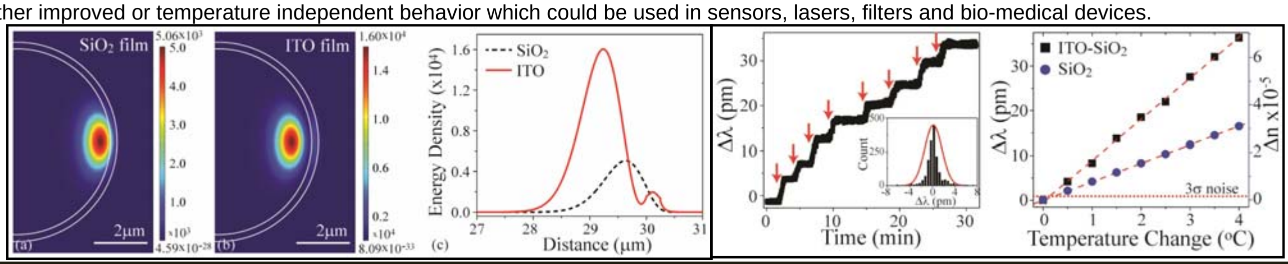
From the experimental results we can see that our model agrees with the experiment.



There is an obvious wavelength dependence as shown by the slope and threshold of the thermal output signal. This relationship is due to the formation of a single molecule water layer on the surface of the device.

Future Work

The main application of this experiment is to improve the knowledge base to inform intelligently designed devices in the future that have either improved or temperature independent behavior which could be used in sensors, lasers, filters and bio-medical devices.



Prof Andrea Armani's research group
Email soheilso@usc.edu

Ming Hsieh Institute
Ming Hsieh Department of Electrical Engineering