

Homework #2

High Resolution Spectroscopy

Due date: Wed. May 12, 2010

To build a VCSEL, optical resonators with high quality factor Q are needed. These in turn require mirrors with power reflectivity > 0.99 , which can be challenging to fabricate with epitaxial growth. The transmission spectrum of such a Fabry Perot cavity, without an absorbing active region, should consist of a single narrow transmission peak at the cavity resonance, plus transmission side lobes outside of the mirror stop band. The width of the transmission peak is related to the mirror reflectivity, as in the lecture notes, and can be used to determine the reflectivity and cavity Q .

One such cavity was reported in Christmann, *APL* **89**:261101 (2006), and measured with the following setup:

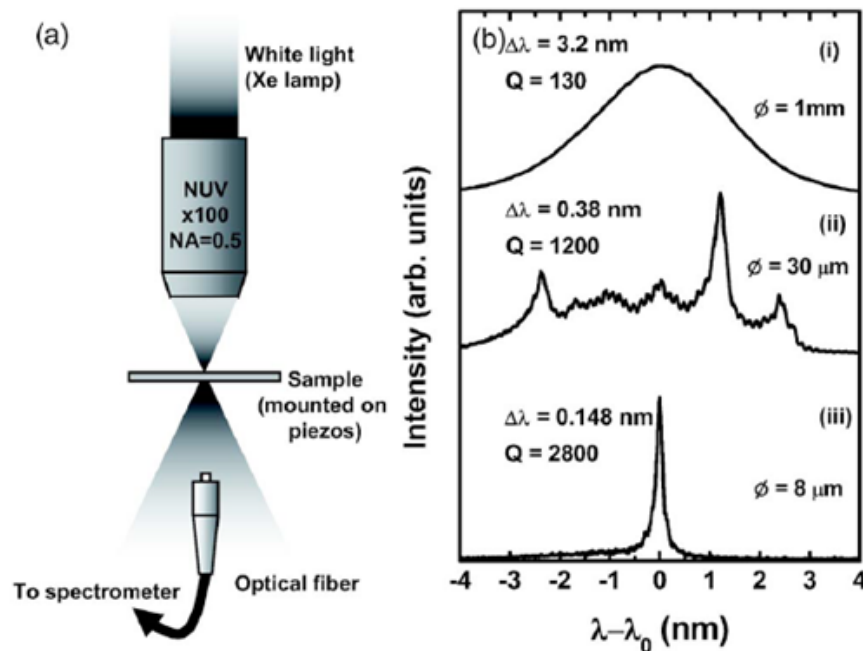


FIG. 1. (a) Experimental setup. (b) Transmission spectra acquired with different spot sizes: (i) 1 mm, (ii) 30 μm , and (iii) 8 μm . Each spectrum is plotted relative to λ_0 , the cavity mode position: (i) $\lambda_0 = 419.9\text{ nm}$, (ii) $\lambda_0 = 416.1\text{ nm}$, and (iii) $\lambda_0 = 418.4\text{ nm}$.

Christmann, *APL* **89**:261101 (2006)

The incident light was focused to a small spot to reduce spreading of the spectrum due to variations in growth thickness and composition. The optical fiber, with a 400 micron core diameter, was placed far enough away from the sample to restrict the half cone of rays accepted to 0.6 degrees, to reduce spreading of the spectrum due to angular shifts of the resonance. The spectrometer included a CCD detector, and achieved a spectral resolution of 0.012 nm. This resolution was about 10x better than the FWHM of the peak, insuring that the true peak amplitude could be detected in order to accurately determine the FWHM.

The goal of this assignment is to find a commercially available spectrometer and CCD to duplicate this measurement. Some things to consider:

- Grating pitch, size, blaze wavelength, and grating order
- Spectrometer focal length, f/#, input slit width if any, diffraction or aberration limits
- CCD performance specifications
- Dynamic range, to insure the true top and bottom levels can be determined accurately
- Light level, integration time, stray light limited background

Assume the Xe arc lamp has a spectral radiance of $2000 \text{ W/m}^2\text{-nm-sr}$, and the objective lens transmission is 100%. Design for an 8 micron spot diameter on the sample, and assume the transmission is 100% at the resonant wavelength of 418.4 nm. Neglect any loss in the short fiber. Describe the system quantitatively, with equations before numbers. Justify any assumptions that you make.

Some vendors of interest:

www.horiba.com/scientific/

www.princetoninstruments.com

www.mcphersoninc.com

www.jascoinc.com/

www.oceanoptics.com

www.varianinc.com