Alex Atanasiu, ‘05 E 90 Proposal 11/12/04

Thermodynamic Properties of Waveguides
Faculty Advisor: Lynne Molter

Introduction

One of the interesting areas that I have come across in my science education in general is the subject of dielectric waveguides. This topic came up when I was first introduced to Maxwell’s Equations for electromagnetic waves in Physics 8. In Physics 112 (Intro to Electrodynamics Seminar), I am currently studying the solutions to these equations more deeply, and in Physics 115 (Modern and Quantum Optics), we have studied waveguides and the evanescent fields that they produce.

This topic, however, has had perhaps more important implications in the research that I have been conducting with Professor Moscatelli in the Department of Physics and Astronomy. In that experiment, we are trying to use slab waveguides of SiON to guide light of two separate wavelengths, producing a pattern of evanescent light fields capable of guiding a neutral atom above the surface of the waveguide itself.

This task has far reaching implications into the field of quantum computing: currently, there is a substantial amount of funding for experiments that attempt to use magnetic fields to guide neutral atoms, but the approach of using light fields has theoretical advantages over magnetic fields (for instance, they can be switched more quickly).

It would be helpful for my physics research to understand more than just the basics of waveguide configurations, and it is likely that my future education and research interest will focus on systems related to optics, so I would like to gain more experience in working with high-power lasers and optical instrumentation.

Thus, I have decided to pursue a research-oriented E90 project that incorporates some theory on waveguides themselves with a tangible experiment. I will be measuring and attempting to model the thermodynamic properties of selected waveguides. This task involves studying the relevant theory, designing mounts for the optical components and aligning the experiment, and finally, attempting to automate the experiment in Labview, which will help teach me more about computer interfacing. This might seem like a lot to accomplish in one semester, but I will be working with Professor Molter to carve out a reasonably sized project from among these different possibilities.

Theory

I will be working through analytic solutions of our waveguide systems in question; this amounts to solving the differential equations for wave propagation in dielectrics with complicated sets of boundary conditions. I will also be using numerical simulations to check and reinforce this analytic treatment.

From both of these treatments, I should be able to extract relationships for the absorption and transmission of the system as a function of incident wavelength and also as a function of temperature. These relationships can then be fit to experimental data.

Setup

The experiment will take place in the Optics and Photonics lab in Hicks basement. The lab includes an optics table with a partial setup, and most of the tools that I will need to complete the project. This setup includes a fully functional Argon Laser (though it may need a bit of realignment), and many of the components that I will be using (fiber couplers, some mounts, etc.).

For the short term, we need to order thermoelectric coolers/ heaters, and to design mounts for these instruments, and eventually we will incorporate these pieces into the existing setup to produce a complete experiment. It is my understanding that we have functional waveguides already built, so their design and/or fabrication is not a part of this project.

Finally, we need to automate the experiment. We are not starting from scratch in this capacity, but we have very little existing code to work with, and I have had only very limited experience in Labview. We need to update Labview this semester, and with Professor Molter's guidance I will begin the programming over the winter; this timetable should give me "free" time to learn the language and debug any existing code on my own and without significant time pressure.

Data Analysis and Conclusions

My final data should be fairly straightforward relationships of power transmitted versus input power for given values of temperature and input wavelength. By comparing these curves over a range of wavelengths and temperatures we should be able to test our theoretical model.

Though this is the final goal, there are many intermediate measurements and controls that will need to be taken into account. The most notable of these are intermediate power measurements to make sure that the laser is producing the desired output power and coupling into our optical fiber correctly, as well as temperature measurements to ensure that our thermoelectric heater is delivering a steady and even temperature across the waveguide.

Timetable

In order to avoid cramming to finish my project at the end, I have divided up my remaining time on this project into four more or less equal chunks of time. I have set up intermediate deadlines so that I can begin working on other aspects of the project if something gets delayed. I have not provided a more detailed, week by week schedule because until I have learned more about the background of the experiment, it is very difficult to determine exactly how much time I will spend on each portion of the project and break up each segment into weekly subtasks.

Fall ’04, Second Half: Read up on theory, figure out and learn how all of the equipment in the lab works, order parts still needed for the experiment.

Winter Break: Begin Labview programming, continue/finish reading theory (maybe write a brief paper), come up with mount designs and a final design of the experiment.

Spring ‘05, First Half: Finish Labview programming, build mounts, arrange experiment, begin, and if possible, finish taking data. If there is time, delve into the possible applications to my physics work.

Spring ‘05, Second Half: Finish taking data, analyze data, finish write-up (the theory, and documented code and experimental setup sections should have been completed by the first half of spring term). Present work.