Non-linear transmittance properties of dielectric slab waveguides

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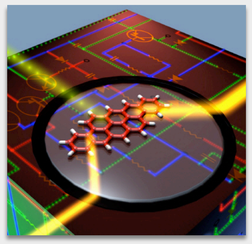
Photonic Circuits

Simply put, a photonic circuit is analogous to an electric circuit, with one important difference – it is photons that are being manipulated, not electrons.

The chief advantages are speed and size; photonic circuit components can (theoretically) be made orders of magnitude faster and smaller than their electronic counterparts.

The difficulties are in manufacturing these components, and moreover generating and guiding the light where it is needed. Photons do not follow wires like electrons do.

This is where waveguides come in. The design and study of waveguides will make photonic circuits more practical, more cost-efficient, and more functional.



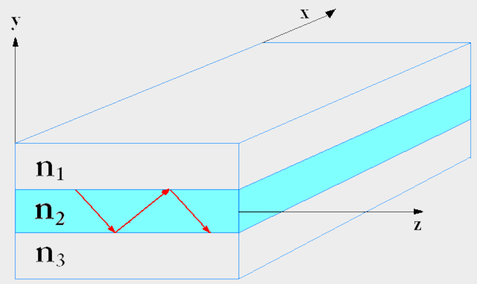
Artist's view of a photonic circuit.

Dielectric Slab Waveguides

An optical waveguide is a structure that guides electromagnetic waves. There are different types of waveguides like dielectric slab waveguides (also called planar) and metallic waveguides. We characterized dielectric slab waveguides, which are typically used at optical frequencies. The dielectric slab waveguide consists of three layers of materials with different refractive indices, extending infinitely in the directions parallel to their interfaces.

Electromagnetic waves can be confined in the middle layer of the dielectric waveguide by total internal reflection. This occurs only if the refractive index of the middle layer is larger than that of the two surrounding layers. In the real world, dielectric slab waveguides are not infinite in the direction parallel to the interface, but if the size of the interfaces is much larger than the depth of the layer, the slab waveguide model will be a good approximation.

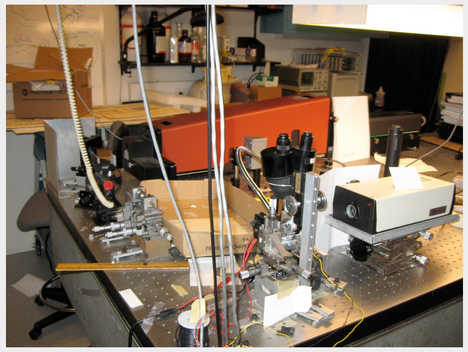
parts adapted from http://en.wikipedia.org/wiki/Waveguide_(optics)



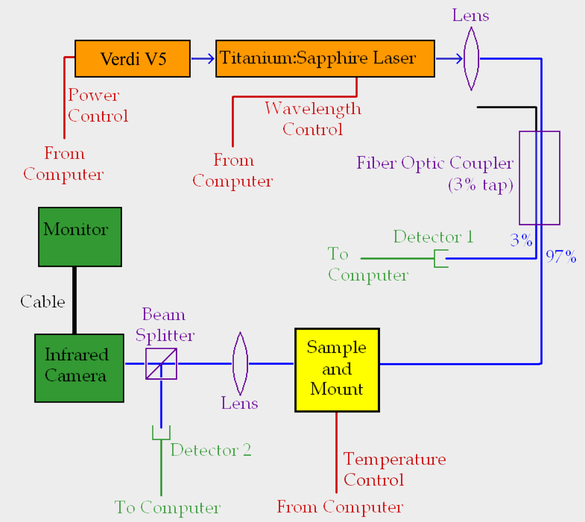
Experimental Setup

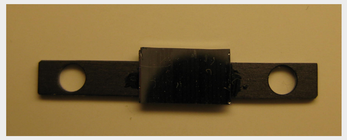
Lab setup description of the automated devices used to characterize waveguides

The Coherent Verdi V5 laser is used as the driving laser. The wavelength of Verdi V5 output laser is 532 nm, and the power is between 1 and 5.5 W. The Coherent Titanium: Sapphire laser is excited by the laser coming from the Verdi V5 laser and the wavelength of the Sapphire laser is in the range of about 800 nm to 1 μm. This laser then goes through several lens and its orientation is adjusted by a mirror. After its orientation is adjusted, the laser goes into a optical fiber which splits into two branches. The energy propagating in one of the two branches is 97% of the energy propagating in the optical fiber before the splitting. This 97% optical fiber branch is used to characterize the waveguide sample. The waveguide sample is placed on the mount where the mount (waveguide) temperature can be controlled. The laser coming from the 97% branch goes through the waveguide sample and is collected by the measuring devices to determine its power. This whole process was automated by a Labview program which can perform power, wavelength, and temperature scans on the waveguides being characterized.



Lab Setup





Above, is a Waveguide used in the lab.

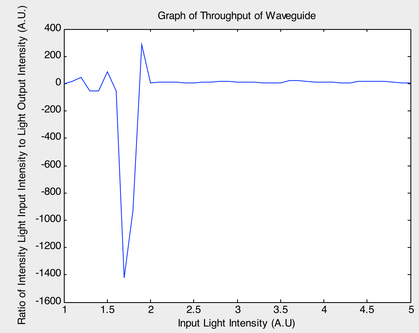
LabVIEW Automation

•LabVIEW employs a flowchart programming style that replaces traditional code with logic gate type structures.
•Our code was implemented in a hierarchical structure with small programs controlling the individual input components and larger programs controlling the synchronization of smaller tasks.
•The LabVIEW programs had to manage the one input-output port that we had for the lab. Occurrences were used to prevent two or more programs from accessing the Data Acquisition board at the same time.

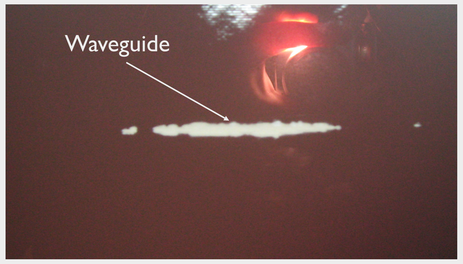
Calibration:
•Automating the program necessitated calibrating the stepper motor and the laser to work with the computer to allow for automation of a variable wavelength arrangement.
•A DigiKrom 240 Monochromator was used to calibrate the number of steps of a stepper motor required the change one wavelength on the laser.

Results

Below is a graph of the Input light intensity (A.U.) to the ratio of the light entering the waveguide to the light leaving the waveguide.



The above graph, and picture below demonstrates the successful automation of the lab setup. We can see the waveguide being illuminated during a test below, and above represents some data for a waveguide that was tested in the lab.



Conclusions and Future Work

•Control programs were written for each portion of the lab.
•An overall control program to characterize waveguides was implemented and demonstrated successfully.
•Future work includes further streamlining the implementation of the program to include automatically stopping a test once a waveguide reaches its nonlinear region
•Future work includes employing the lab setup to characterize additional waveguides.

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