<u>NDnano Nurf Project Summary 2012</u>

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Project title: Silicon Micromachining for Terahertz Waveguide Circuits and Components

During this project I've acquired a variety of very important skills. First, I've learned how to describe the properties of a waveguide based on parameters such as height and width. I've learned how to use a simulation program to accurately predict the behavior of a waveguide, and how to use a design program to draw a photolithographic mask. Finally, I've learned how to use a number of clean room machines used for nanofabrication.

By using my waveguide design and method of fabrication, others can construct waveguides to efficiently transfer power in terahertz frequency circuits.

Waveguides are a very useful tool for transmitting power in high frequency applications. A waveguide is able to transfer power with very low losses. However, as the frequency of a signal increases, the wavelength of that signal decreases. This means that terahertz frequency waveguides must be very small, because the size of the waveguide is dependent on the wavelength of the signal. It becomes very difficult to produce the necessary features using traditional techniques because they are so small. So, my goal was to use micromaching techniques to build a waveguide on a silicon wafer that would work within a terahertz frequency circuit.

Before fabricating the waveguide, I needed to first check my design using computer simulation. The simulation results confirmed my predictions and verified that the waveguide had the correct characteristics and behavior (Figure 1). Next, I needed create a pattern for the waveguide to put on the silicon wafer. In order to build the waveguide using photolithographic techniques, I needed to construct two separate halves of the waveguide and then attach the halves together to create the channel. So, the design needed to include marks to be used for alignment of the two halves. Using AutoCAD, I was able to accurately draw all of the necessary features. Next, I transferred this design to a photolithographic mask, which was then placed on the silicon wafer. When light is shined on the mask, it passes through in some areas and is blocked in others, producing the pattern from the mask on the silicon wafer. Finally, I developed the wafer which prepares the wafer for etching and allows the pattern to be clearly seen under a microscope (Figure 2). In the future, the wafer needs to be etched and diced. The two halves need to be placed together and attached to create the final waveguide.

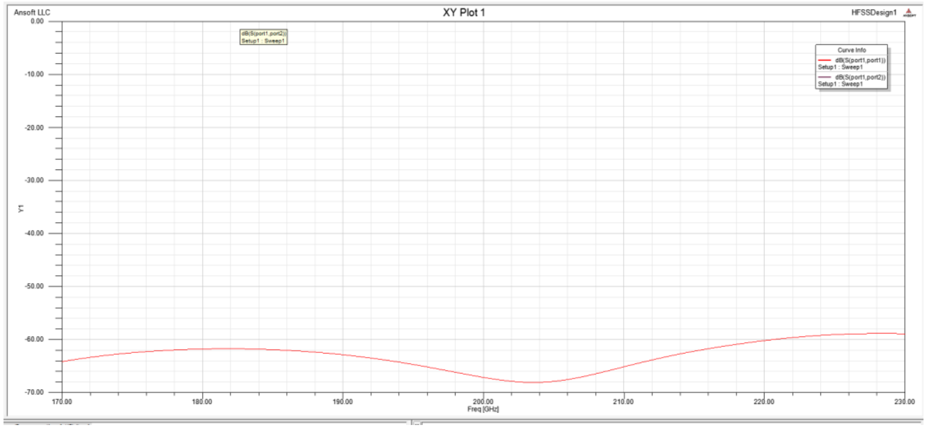

Figure 1a.) Graph of waveguide simulation results for the frequency range of the waveguide. Return loss (red line) indicates high power transfer. Insertion loss (purple line) indicates low power loss and is always 0.

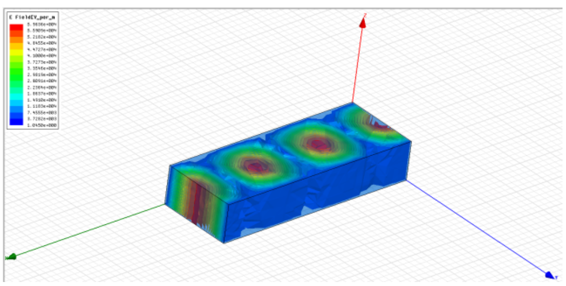

Figure 1b.) Simulation of the electric field inside a waveguide segment.

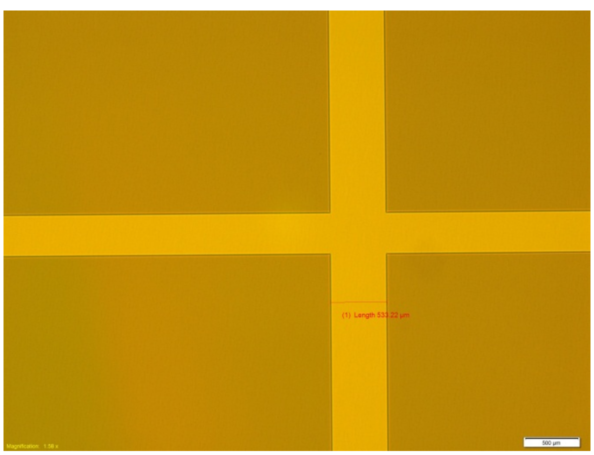

Figure 2a) Waveguide segment and horizontal dicing line

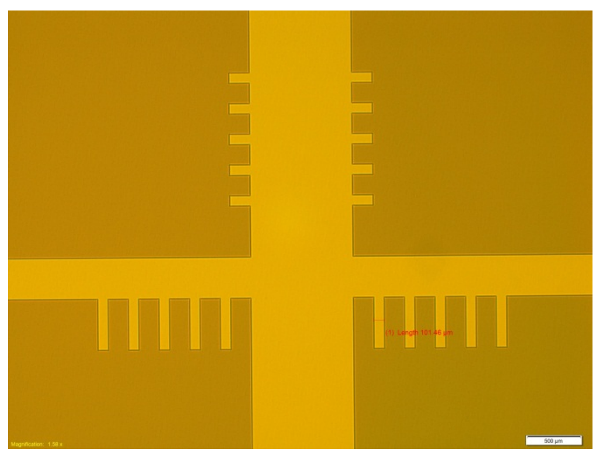

Figure 2b) Alignment marks on silicon wafer.