CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

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Project Number

35651

Project Title

Designing and Constructing Photonic Crystals at 2.4 GHz

Abstract

Objectives/Goals

Photonics crystals are repeating structures made of two materials with different indices of refraction and are useful for many applications, mostly as filters, fibers, and waveguides. My hypothesis is that photonic crystals designed for visible light can be scaled to microwave frequencies.

Methods/Materials

I built a series of photonic crystals for testing at a microwave frequency (2.4 GHz). The crystals consisted of periodic layers and columns of drywall, separated by air. To test the properties of the photonic crystal, I used a tunable 2.4 GHz source modeled after a hobbyist RADAR designed by MIT. I built an RF range using foil-lined panels to contain the energy vertically and water bottles to absorb the energy around the perimeter of the range. To measure the properties of the photonic crystal, the transmit antenna illuminated the crystal and the receive antenna measured the transmitted and reflected power. I built one and two dimensional photonic crystals.

Results

I simulated the behavior of the photonic crystals with the intent to compare with the experiment. For the one dimensional crystal I used two calculations: one using the equation for a volume hologram and the other using the thin film characteristic matrix. When fully constructed, the one dimensional photonic crystal was designed to reflect up to 80% of the microwave energy. The measured reflectivity as a function of the number of layers in the crystal matched closely to the calculations predicting the crystal#s behavior. Closed form solutions don#t exist for two dimensional photonic crystals. I used FDTD software called MEEP to simulate its behavior. The two dimensional photonic crystal was designed to guide the microwave energy in specific directions. The simulations and the experimental data showed this, although the effect was weak.

Conclusions/Discussion

My hypothesis was that photonic crystals can be scaled across frequencies. The one dimensional photonic crystal performed as expected, matching the theory and reflecting a majority of the microwave energy. I discovered while testing this crystal that inaccuracy in the assembly severely limited the reflectivity. The two dimensional photonic crystal, guided some of the energy and behaved as a photonic crystal, but did not create a complete band gap because the index contrast was too small. Thus, my hypothesis was correct: photonic crystals can be scaled to microwave frequencies.

Summary Statement

I constructed photonic crystals at 2.4 GHz by scaling designs from other spectra and then compared the resulting crystals with calculations and simulations that I performed,

Help Received

Father provided some lab equiment.