CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

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Project Number

S1806

Project Title

How Do You Frustrate Total Internal Reflection? The Mysterious Evanescent Wave

Abstract

Objectives/Goals

Frustrated total internal reflection (FTIR) is a concept used very often in modern day to create touch screen technology. The goal of this study was to examine the effect of the distance from the interface and the different wavelengths of the source light on the decay of evanescent waves and FTIR.

Methods/Materials

Two wavelengths, red laser light (635 nm) and microwaves (2.85 cm), were tested. The red laser#s critical angle for total internal reflection in a glass prism was found, and the intensity of the evanescent wave at increasing distances from the interface was directly measured with a photometer at a different incident angle. Prisms filled with styrene pellets were used to test the decay of the evanescent wave through FTIR for microwaves. After measuring the critical angle of one prism with the microwave emitter and receiver, a second prism was added and the voltage of the refracted wave in FTIR was measured with a multimeter at two different incident angles.

Results

All the data of the relative intensity as a function of distance were fitted with an exponential decay function; the graph for the red laser required two exponential functions, while both graphs for the microwaves only required one function. Decay length of the evanescent wave was obtained through this fit. For both wavelengths, the evanescent wave decayed exponentially with distance. The red laser decayed much faster than the microwaves for both angles. Between two incident angles in the microwave, the intensity for the greater incident angle decreased faster.

Conclusions/Discussion

Decay lengths obtained from the fit of experimental data were compared to the values calculated by a theoretical equation. The experimental and theoretical values for microwave fit fairly well, while the values for the red laser did not. This is because the red laser has a shorter wavelength and decays very quickly, and to get more accurate measurement, the distance should be varied in the nanometer length scale. This experiment showed that the decay of the evanescent wave directly corresponds to the wavelength of the light source. As for multi-touch screen technology, the sensitivity of touching and the allowed distance for touching depend on the wavelength of the light source. FTIR by a red laser requires a firm press for the touch screen and FTIR by microwave can be sensed even when the direct touch is not made.

Summary Statement

This experiment investigates FTIR and the evanescent wave and determines that the decay length directly corresponds to the wavelength of the light source, while further noting the relationship between FTIR and multi-touch screen technology.

Help Received

Parents helped with poster; Borrowed microwave emitter and receiver from Dr. Leung at CSULB; Dr. Li provided helpful comments and discussions.