CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY

Name(s)

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Project Number

S1917

Project Title

An Innovative Method for Observing Frustrated Total Internal Reflection (FTIR)

Abstract

Objectives/Goals

Frustrated Total Internal Reflection (FTIR) is an optical phenomenon important in many practical applications. The greatest difficulty in studying FTIR is designing an apparatus to observe it. While researchers have studied FTIR with precision instruments, we did not have access to them. The goals were to design and build an apparatus to allow us to easily observe FTIR, to determine the media separation distance at which we can observe it, to establish a relationship between media separation and evanescent wave intensity, and to determine agreement with theory.

Methods/Materials

We designed and built an experimental apparatus that utilized two optical media (a water film and water droplet) to observe FTIR. An oscilloscope detects a light signal, which is used to measure changes in evanescent wave intensity, and an electrical signal, which is used to establish the time of contact between two optical media. A photosensor measures the light intensity of a laser beam that undergoes TIR in a water film on top of a prism. Above the water film is a metal tube through which water flows. As a water droplet nears the water film, FTIR will decrease the reflected light intensity. A circuit is shorted when the water droplet contacts the water film below. Using an oscilloscope and photosensor, we can measure the delay between the light signal and the electrical signal.

Results

The time difference between changes in the light and electrical signals was found to have a mean of 0.75 ms. Mathematical models were fit to the oscilloscope traces, indicating a logarithmic relationship between evanescent wave intensity and media separation.

Conclusions/Discussion

We successfully observed FTIR. Our estimate of the distance at which FTIR is first observable, 15 nm, is in qualitative agreement with relevant theory. Experimental limitations may explain the difference between our results and theoretical expectations for evanescent wave intensity as a function of media separation. Further studies should consider instrumentation sensitivities and photodiode and signal conditioning circuits to improve signal fidelity to establish a relationship between evanescent wave intensity and media separation. Our apparatus provides sufficient precision to detect the delay between optical and electrical signals that allow the observation of FTIR. The use of two water media to observe FTIR is an innovative idea worthy of further study.

Summary Statement

An innovative method for observing Frustrated Total Internal Reflection was successfully developed and demonstrated.

Help Received

Dr. John C. Howe and Dr. Charles Barker were mentors; Intel COSMOS Research Grant funded effort; Dr. Jianxun Mou assisted in apparatus construction