Abstract: A Surface Plasmon Resonance (SPR) device is required to find the SPR angle of a metallic surface where the surface has minimum reflectivity of light emitted to it. The project concerns the design and implementation of an optical reflectance measurement system for the characterization of surface plasmon resonant structures. The NIU Electrical Engineering department requires one of these devices for the course known as ELE 421 (Biomedical Sensor Engineering). This should be a portable and modular device which has a large possible range which the angle of incidence can be and the light for this device should be a polarized beam. The device is required to emit p-polarized light, have a low enough weight to be lifted by one person, and be modular so that components of the device that directly relate to the measurements made by the device can be replaced.

1. Introduction

Current devices that can explore the SPR phenomenon are very costly. Lower end devices from NanoSPR cost $5,000 \(^1\), and this amount is much greater than the intended $1,000 budget for this project. The most common method to exhibit the SPR effect is through a method called angular SPR in which a predetermined wavelength of light between 400 to 700 nanometers is incident upon a metal sample, usually gold or silver, and the light intensity is recorded at various half angles between 0 and 90 degrees with respect to the sample to obtain the reflectivity dips which correspond to the SPR condition.

Environmental screening, gas detection, and healthcare testing are all modern day uses of the SPR phenomenon. There are also uses of SPR technology in discovering material properties, biosensing, life sciences, drug discovery, and food analysis \(^2\). Thus, there are many areas of research where SPR devices can be useful tools.

2. Methods and Materials

The changing angle is achieved in the device by having two trolleys travel symmetrically along a semicircular rail. One trolley contains a laser and the other contains a detector circuit. These trolleys are motorized and are calibrated to be symmetric on the rail. The device is highly adjustable for many variations of samples, lasers, and receiving circuits (meaning they are interchangeable) and the entire system has easy angular and two-dimensional adjustability. Some other adjustability is possible such as being able to rotate the laser about the fastener which secures the laser clamp and some level of vertical adjustability in the detector circuit.

This design takes a premade trolley and rail system to assign the travel path but replaces the trolley platform with a 3D printed version that is appropriately designed for everything that gets attached to the platform. This new 3D printed trolley base reduces the angle between the two trolleys when they reach the arc center-point of the semicircular railing, from approximately 24 degrees to 21.7 degrees. A visual representation of both the trolleys approaching the vertex of the rail is depicted in figure 1. The ability for the trolleys to get closer to each other at the vertex of the railing expands the maximum angle that the device could measure the light intensity at angles of incidence in the range of 21.7 to 180 degrees relative to the sample.

![Figure 1: 3D model of the components of the device including baseplate, rail, trolleys, motors, and power supply at the minimum angle condition](image-url)
The device uses a homemade light detector circuit out of basic electronic components such as a photodiode, amplifiers, resistors and capacitors. This minimizes the cost of purchasing a photodetector from a vendor with an added benefit of positioning the photodiode in a custom location. This photodetector is modular so it can be replaced in the future with any other photodetector that meets similar dimensions.

An Arduino Uno microcontroller controls the signals that are sent to the stepper motors and the output of the photodetector circuit and motor encoders. The motors themselves allow for a resolution of 400 steps/revolution and the encoders give the ability to track the number of steps that the stepper motors take. This can be incorporated into the Arduino's program to calibrate the trolley positions for higher device accuracy. The stepper motor driver known as the L6208 is used to decode pulses received by the Arduino as directions for the stepper motors to rotate clockwise or counterclockwise and allow for micro-stepping to achieve greater resolution in data capturing.

3. Results and Discussion

Using a plotting function in LabView (or equivalent program), the angle between the trolleys to the sample (angle of incidence) versus the intensity of light detected can be graphed. This graph should show a large dip where the shallowest point is considered the SPR angle of incidence. The graph can be viewed in real time by the Arduino sending serial data to the controlling program such as LabView. Through such external program, the data from this graph can be saved into a file that is on the computer that the Arduino is connected to. There are also some external safety procedures that are implemented through the Arduino via physical buttons or switches that send interruption signals to the Arduino to stop certain parts of the program depending on which interrupt was activated. In the user interface there are also on-screen buttons to stop certain actions of the program from occurring.

4. Conclusion

The device designed is a cost-effective solution for Northern Illinois University and can be used as a tool for students in the course ELE 421 to get hands on experience of being able to view the SPR phenomenon in real life and not just in videos and simulations. Secondly, it can be used as an experimental unit for faculty research. Lastly, the design of this device could also be a useful reference for other researchers building or working with SPR devices.

![Diagram of light detector circuit](image)

Figure 2: A representation of the assumed output graph for the designed device

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References