Automated data acquisition Surface Plasmon Resonance (SPR) based on LabVIEW

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Abstract. Evanescent wave is the result of Attenuated Total Reflection (ATR), Surface Plasmon Resonance (SPR) occurs at a specific angle on condition ATR. When a beam is passed through a prism, the beam will experience a reflection on the part of the prism which is in contact with the sample. The result of this reflection to be captured by the detector, On the condition of SPR weaken the intensity of the reflected beam of laser light that occurs because the refracted exponentially away from the boundary of the medium. The LabVIEW-based program has been created that can be used as a tool for experimental SPR, using Motor SHOT 602 and Lock-In Amplifier (SR510). Programs that have been made already equipped with the condition automation starts of movement Motor 2 (Prism), Motor 1 (Detectors), Readings Voltage detectors by Lock-In Amplifier (SR510) and storage of results (time, a position of the motor 1 and 2, the voltage read Lock in Amplifier). Automation program is made by studying the way of the light at Surface Plasmon Resonance (SPR), to determine the relationship between the rotational angle of motor prism and the rotational angle of motor, it can be used for control the position of the sample on the prism and the detector in a program based on LabVIEW.

1. Introduction

Total Internal Reflection (TIR) is an optical phenomenon that occurs when the light penetrates the boundary of a medium with the angle of incidence greater than the critical angle, it could lead to total reflection events that occur at the boundary of the medium [9], but in this case, does not mean that all light will be reflected - there is a bias wave which decays exponentially with distance from the interface known as evanescent waves. Evanescent wave is the result of Attenuated Total Reflection (ATR), Surface Plasmon Resonance (SPR) occurs at a specific angle on condition ATR [5].

Surface Plasmon Resonance (SPR) is an optical phenomenon when the electromagnetic (EM) with a certain energy shot at a certain angle, resulting in a resonance that occurs in the electron on the surface of metal - dielectric interfaces. Surface Plasmon Resonance (SPR) is an optical technique that can be used to monitor molecular interactions on substrates in situ. Surface Plasmon Resonance (SPR) allows to study and determine the kinetic parameters of interactions between molecules in real time without the need for labeling [2, 4, 8].
Figure 1. Configuration Experiment Surface Plasmon Resonance

An already polarized laser beam passed in a specific direction toward a metal sample which has a smaller refractive index than the refractive index Prism. In particular, the Prism angle swivel when the angle Prism at an angle greater than the critical reflection, the light will be reflected occur on the inside of the Prism which comes into contact with the sample. The resulting reflection rays then want to be captured by detectors. The phenomenon of Surface Plasmon Resonance (SPR) occurs at a certain angle, when the angle of incident light on the prism is greater than critical angle prism. This occurs when the momentum of a laser beam of the same value with momentum of electrons in the sample, the result is the electrons separated from the sample and interact with laser light until it reaches the resonance condition, the result of this condition is a decrease in the intensity of the laser beam which wants to be captured by detectors [5]. On this configuration, data retrieval is done by changing the angle of motor Prism. With the change in motor position prism, then the motor position detector should also be changed.

SHOT 602 is one tool that can be used as a support of this experiment because SHOT 602 features 2 motors, adjustable swivel angles manually on his tools, or through the computer using specific applications. The company's production of Motor SHOT 602 is Sigma Koki. In terms of usage, Sigma Koki issued a sample application that can be used to control the motor SHOT 602. One of the software being used is LabVIEW (Laboratory Virtual Instrumentation Engineering Workbench). Problems occurred is a program issued by the company is less efficient because of limitations in each function, one program only has one function. Therefore, the complexity of the software program style needs to be reduced to make it more efficient and effective.

Based on these problems, this research aims to create a program based on LabVIEW that can be used to control the Motor SHOT 602 with style program that is simpler and improves the level of efficiency of the program, by means of combining multiple functions into one program. The new things that want to add is a process automation from the program between motor 1 and motor 2 with knowing the relationship between the rotational angle of Prism (Motor 2) and rotational angle of detector (Motor 1).

2. Theory

Motor SHOT 602 connected to the computer using the RS232 interface and commands given are then sent through Hyper Terminal application. LabVIEW is used for processing and visualization of data in the areas of data acquisition, control and instrumentation, as well as the Automation Industry [1]. Process automation program, created by knowing the relationship between the rotational angle of Prism (Motor 2) and rotational angle of detector (Motor 1), can be seen in the picture below:
Figure 2. Relationship between $\psi$ and $\mu$ [3,9]

Figure 2 shows the relationship between rotational angle of prism $\psi$ (Motor 1) and rotational angle of detector $\mu$ (Motor 2), can be calculated using the following equation [3,9]:

$$\mu = \psi + (90^\circ - \angle YGX - \angle HGY)$$  \hspace{1cm} (1)

The Angel $\angle YGX, \angle HGY$ can be searched by using Snell’s Law. Snell’s Law is a formula used to describe the relationship between the angles of incidence and refraction, when referring to light or other waves passing through a boundary between two different isotropic media, such as water, glass, or air. Snell's law states that the ratio of the sine of the angles of incidence and refraction is equivalent to the ratio of phase velocities in the two media, or equivalent to the reciprocal of the ratio of the indices of refraction.

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$  \hspace{1cm} (2)

Law of sines \hspace{0.5cm} $$\frac{a}{\sin \alpha} = \frac{b}{\sin \beta} = \frac{c}{\sin \gamma}$$ \hspace{1cm} (3)

And find the length of the side of triangle

$$ab^2 = bc^2 + ac^2 - 2(bc)(ac) \cos(\angle acb)$$  \hspace{1cm} (4)

By using the three equations, the relationship between rotational angle of Prism (Motor 2) and rotational angle of Detector (Motor 1) can be determined. Based on the results of the calculation. The relationship between the rotational angle of the Prism ($\mu$) and rotational angle of detector ($\psi$) can be written as follows

$$\angle YGX = \sin^{-1} \left( \frac{XY \sqrt{2}}{YG \cdot 2} \right)$$  \hspace{1cm} (5)

$$\angle HGY = 180^\circ - \angle GYH - \angle YHG$$  \hspace{1cm} (6)

$$\mu = \psi + \left[ 90^\circ - \sin^{-1} \left( \frac{XY \sqrt{2}}{YG \cdot 2} \right) - (180^\circ - \angle GYH - \angle YHG) \right]$$  \hspace{1cm} (7)

With

$$XY = \sin(45^\circ + \varphi_1) \left( 2t - \left[ \sqrt{2t + \left( \frac{\sin\psi}{\sin(135^\circ - \psi)} \right)} \cdot \left[ \sin(90^\circ - \varphi_1) \right] \right] \right)$$ \hspace{1cm} (8)

$$YG = \sqrt{t^2 + XY^2 - 2t \cdot XY \cdot \cos 45^\circ}$$ \hspace{1cm} (9)
\[ \angle GYH = 135^\circ - \varphi l + \sin^{-1}\left( \frac{CY}{YG} \sin(135^\circ - \varphi l) \right) \]  
\[ \angle YHG = \sin^{-1}\left( \frac{YG}{R \text{ detektor}} \right) \cdot \sin(\angle GYH) \]  

With
\[ CY = \frac{\sqrt{2}}{2 \cdot \sin(90^\circ - \varphi l)} \left( 2t - \left[ \sqrt{2t} \left( \frac{t \sin \psi}{\sin(135^\circ - \psi)} \right) \right] \cdot \left[ \frac{\sin(90^\circ - \varphi l')}{\sin(45^\circ + \varphi l')} \right] \right) \]  
\[ \psi = \sin^{-1}\left( \frac{n}{n'} \sin \varphi l \right) \]  
\[ \varphi l = 45^\circ - \psi \]  

\( t \) is the high of prism.

3. Method
The laser beam is connected to the circuit chopper will produce a light that clipped in accordance with a frequency that is set up on a Signal Generator. The value of the frequency of the Signal Generator is what will go into Lock In Amplifiers as a frequency reference, so Lock In Amplifiers will only read the voltage value on the detector corresponds to the frequency of the incoming laser beam reference. The scheme and the conditions that need to be considered before the data capture process is running, it can be seen in figure 3 and figure 4.

![Figure 3. Scheme on Experiment Surface Plasmon Resonance](image)

![Figure 4. Set up Prism](image)

4. Result
Overall Program control and Data acquisition Surface Plasmons Resonance (SPR) that was made using the function of the tab control that divides some of the functions into specific parts. As for the parts comprising the initial settings, program control and data acquisition of the SPR, and read the results.
Figure 5. Front Panel Program Control and Data Acquisition Surface Plasmon Resonance

Figure 5 Shows that, the program is further divided into two parts. The first part is related to the Data acquisition and control Program SPR manually, and the second part is related to the Data acquisition and control Program SPR automatically.

Figure 6. Result of Program Control and Data acquisition Surface Plasmon Resonance Automatic

Figure 6 Shows one of the results obtained by using data acquisition and control Program SPR automatic. Those results are the result of data storage that has already been done. Stored data associated with the necessary quantities such as time, the voltage on the detector, the position of motor 1 and motor 2 position. The data already obtained automatically in a plot by the program by taking the angle Motor 2 as X axis and voltage on the detector as Y-axis. During the process of automation of data retrieval, the magnitude of change in the angle of turn of Motor 2 (Prism), can be changed during the process of data capture is running, it can be seen in Figure 6. To move the angle with a range of between 30.5 -44, with a transition each time is 0.50. While the rest of the corners with a 34.1-44 range, has a transition each time was 0.20, and for range, 34.1-43.1 has a transition each time of 0.50. This is done to simplify and speed up data retrieval in the process. In this 1-time data retrieval by using a sample of gold, all of the take-ups from the position of Motor 2 (Prism) 30.50 up to 84 with the taking of the data points as many as 110 were off 7 minutes 30 seconds. This automation program runs for 1 time point data retrieval takes 9 seconds, with parts, 3 seconds pause time to move the Motor 2 (Prism) in accordance with the added value of how much filled, 1 second pause time to move the Motor 1 (Detector) in accordance with the calculation Relationship of Motor 1 and Motor 2, 4.5 seconds pause time for 3 times the reading of Lock-in. and 0.5 seconds pause time to average his point and display the value in the form of graphs of 3 times the reading Lock-ins. The overall results obtained by running the Program Data acquisition and Control these SPR can be seen in Figure 7.
5. Conclusion
Has created a program control Motor SHOT 602 that can be used as an experimental tool for Surface Plasmon Resonance (SPR), by the condition of automation of the data collection process starts from the movement of the motor prism, the movement of the motor detector, reading the voltage value at the detector and data storage experimental results (date, time, position motor prism, position motor detector, the result of reading lock-in amplifier).

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