LOW COSTSURFACE PLASMON RESONANCE

[1]CHEN-GUANG ZHANG, [2]CHING-SHU YEN, [3]SHU-YING CHEN, [4]SHWU-JEN CHANG, [5]JEN-TSAI LIU, [6]CHING-JUNG CHEN

[1,6]School of Electronic, Electrical and Communication Engineering, University of Chinese Academy of Sciences, No.19A Yuquan Road, Beijing 100049, China
[3,4]Department of Biomedical Engineering, I-SHOU University, No.8, Yida Rd., Yanchao District, Kaohsiung City 82445 Taiwan, R.O.C
[2,5]College of Materials Sciences and Opti-Electronic Technology, University of Chinese Academy of Sciences, No.19A Yuquan Road, Beijing 100049, China
E-mail: [5]jtliu@ucas.ac.cn, [6]cjchen@ucas.ac.cn

Abstract - A very low cost surfaceplasm on resonance (LC-SPR)based on 3D printer technology is developed. The system consists of a detecting unit, a signal processing unit and an own designed software on PC. The detecting part includes a 650nm laser source, a photodiode, two SGSP YAW-100, Au coated sheer glass, a triangular prism, and other components were printed by a 3D printer. The signal processing unit comprises an analog amplification circuit and an open source hardware Arduino Mega2560 board as the MCU. The own designed software on PC has been developed to control the whole system. The total cost of this SPR is less than 10,000 RMB. The performance and stability had been tested by detecting the resonance angle in air and water. The results showed LC-SPR has high performance and stability.

Keywords - Surface Plasmon Resonance, 3D printer, Arduino.

I. INTRODUCTION

Surface plasmon resonance (SPR) is an effective, non-invasive, label-free and real-time detection method. SPR is widely used in field such as food safety, biomedical, disease diagnosis ad proteomics to detect and identify viruses, hormones and proteins [1,2, 3, 4]. In order to excite surface plasmons in a resonant manner, use a different incident angle electron or light beam (visible and infrared are typical) which impingeson the interface between the glass (prism) and the metal film (Au film). The surface plasmon wave propagating along the interface can be monitored by recording the intensity of reflected light [5].

Although surface plasmon resonance is a powerful technique to analyze biomolecular interactions in on-line dynamic in a label free environment. However, the cost of the instrument designed by the surface plasmon resonance technology is still extremely expensive due to the complicated configuration of optics, electronics andother components[6].

Therefore we propose use 3D printing technology to reduce the cost,especially, in fabricate complex components of the low cost surface plasmon resonance (LC-SPR), except commercial parts such aslaser source, light signal sensor,etc. [7, 8]. Furthermore, it also needs to keep high performance and stability.

II. DETAILS EXPERIMENTAL

2.1. Materials and Procedures

The automatic rotate platform is SGSP YAW-100 from Pividi co Ltd. This SGSP can rotate with a high angle resolution up to0.002°, and also a controller with two channels of this type of SGSP is purchased. A Cube3 3D printer from 3D systems is used to print thecomponentsneeded. 650nm laser PM-R200-650from PuHuaas the signal source and a photodiodeS1337-1010BR from HAMAMATSU as a light signal sensor are purchased. Triangular prisms, polaroid and some sheet glasses are purchased from PuXi Company. Matching oil to eliminating fresnel diffraction is from Cargille LABs. The control unit is an open source Arduino mega2560 board. AD823 amplifiers for analog signal processing and ADXL335 accelerometer for angle detection are from ADI. PCB boards from Kingsten are used to fabricate the analog circuits.

2.2. System description

The developed system consists of a signal detecting part by which we can transduce the light signal into electronic voltage signal, an analog circuit, and a micro-control unit to maintain the sampling, store, and transfer the electronic voltage signaldata and alsoto obtain the status of the SGSP YAW-100. The self-made software on PC can control the whole system. System block diagram is as Fig.1.

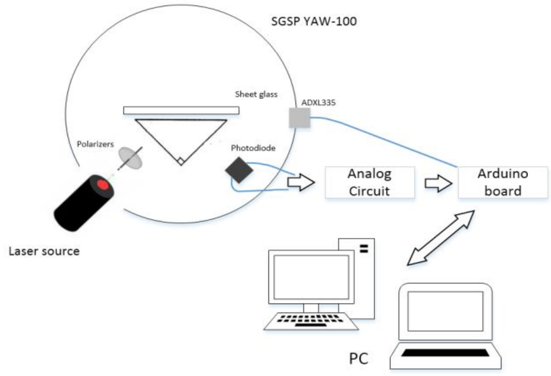

Fig.1. System block diagram.

2.2.1 Signal detecting

Two SGSPs are used in this design, and they are arranged in coaxial manner. The laser source and the photodiode are fixed on these two SGSP separatelyon the same side using components printed by the 3D printer. The triangular prism is also fixed on the same side with the laser source and the photodiode and the midpoint of one of its hypotenuse is in the center of the SGSP.The rotation of the SGSPs is controlled by the self-made software on PC, these two SGSPscan rotate synchronously in contrary direction in order that the photodiode can receive the light signal all the time emitted by laser source.The rotation angle range of the laser source in Fig.1 is from 0 degree horizontally to 90 degree vertically, with an angle resolution of 0.002 degree, so does the photodiode. An accelerometer sensorADXL335 is attached on one of the SGSP as the angle reference.The laser emitted is first polarized by the polaroid and then reaches the Au coated sheet glass through the triangular prism, thus the laser is modulated by the sheet glass. After this, the modulated laser arrives the photodiode via the triangular and is transduced into electronic voltage signal. This signal is amplified by analog circuits to the measurement range of the ADC integrated in the micro-controller.

2.2.2 Analog Circuit

To achieve a high magnitude signal, a 1MΩshunting resistance is used with the photodiode.The voltage range of the signal generated by photodiode is 0~0.3V. The measurement range of Arduino Mega2560 built-in ADC is 0~3.3V with 10 bits resolution.In order to fit the measurement range, the ADC analog circuit is utilized to amplify the original signal.

Considering the high resistance of the signal source, a high input resistance operator amplifier AD823 is used as OP-AMPs. The input resistance is $10^{13}\Omega$, which eliminates the influence of the OP-AMP's input resistance on the signal source. Fig.2 is the circuit diagram.

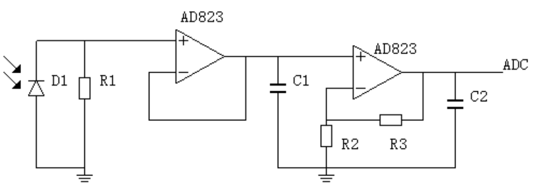

Fig.2.Analog amplification circuit.

2.2.3Micro-control unit

In this design we used an open source hardware Arduino Mega2560 board as the micro-control unit. Arduino Mega2560 has 10bits built-in ADCs, 256KB flash, 4KB SRAM. The highest ADC sampling data rate is 10 kHz. The sampling data rate and the storage of this board can satisfy our demand.

In this design, Arduino Mega2560 board can read the ADXL335 signal, and the readout data of ADXL335 can be used to set the base angle of the SGSP. While the SGSPs are rotating, the board can use the built-in ADC to sample the analog signal at 1 kHz sample rate, store, and transfer the data by serial port to PC for further analysis.

2.2.4 Software

Functions of the self-developed software includes the connection of the SGSP controller and Arduino Mega2560 board by serial ports andcontrol of the whole system. The obtained data is calibrated and displayed in real time.

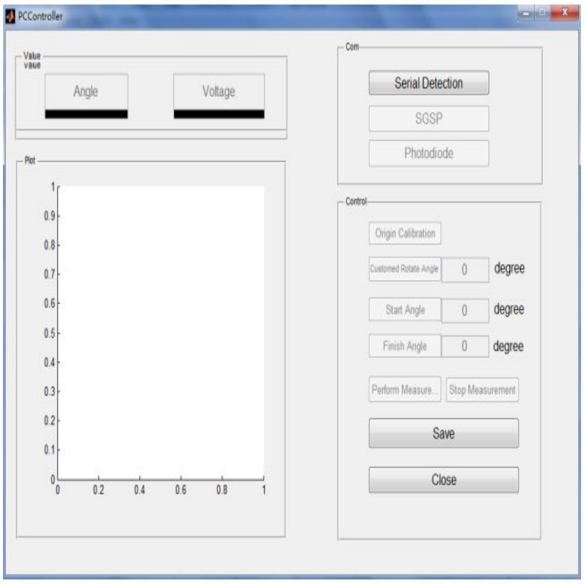

Fig.3. Software GUI.

2.3. 3D printing

The whole system are all printed using 3D printer Cube3, except the laser source,triangular prism,light signal sensor and the SGSPs.

These components' models are designed by usingsolidworks. The printing configuration is set to 70μm per layer and the strongest printing structure to get high manufacture precision and strength.

2.4. Experimental procedure

The designed system is as Fig.4. First, the Au coated sheet glass is put on top of the triangular prims with matching oil in the gap between the triangular prims and the Au coated sheet glass. After this configuration, we connect the SGSP controller and the Arduino Mega2560 board to PC. When the connections success, the origin point calibration is performed, following this, the scan scope is set to the experiment angle range, and the device will move back and forthbetween this angle scope and samples are collected synchronously with the moving of the SGSP. The real time raw data is displayed on the screen, and it will be saved in the software's current directory forfiltering using moving averaging method foranalysis[9, 10, 11].

To validate the stability of the designed LC-SPR, we use the designed device to detect the resonance angle in air condition for at least one hour, the resultsare shown in Fig.5. Also, we had conducted an experiment to detect the resonance angle in ionized water condition, and the result is shown inFig.6.

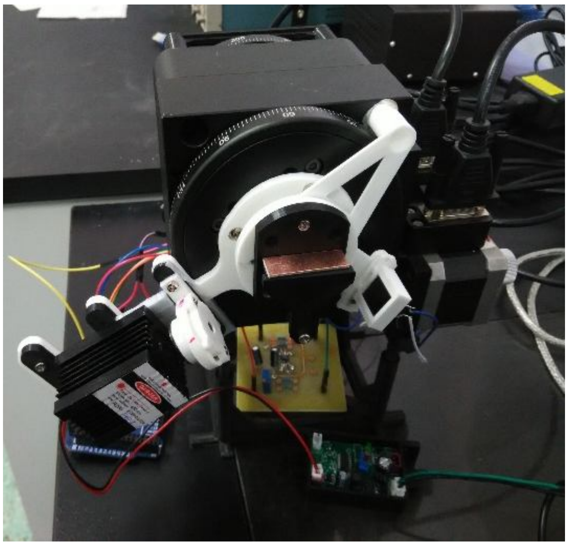

Fig.4. The designed SPR.

III. RESULTS AND DISCUSSION

The raw data sampled by the designed device is filtered using moving average method. Fig.5 is the signal we obtained using the designed SPR in air condition, we can easily observe the resonance angle. During the one hour experiment, this device showed high performance and stability, and the measured resonance angle has a very low drift range from 43.338 degree to 43.322 degree, which is mainly caused by the increasing temperature of the triangular prism.

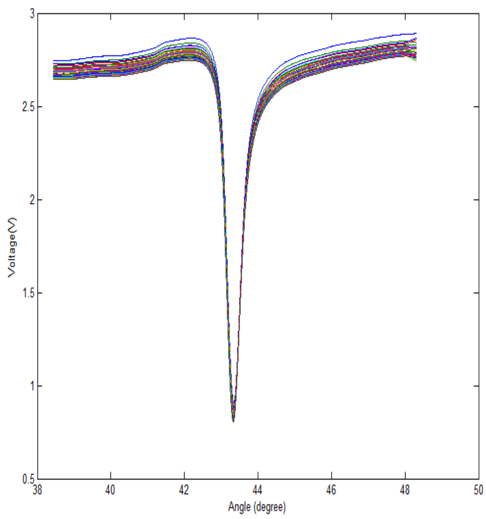

Fig.5.The signals obtained when the designed SPR scans in air condition (14 cycles).

Fig.6 is the signals in air and water condition. It shows that the designed LC-SPR can accurately detects the resonance angle in air condition and water condition.

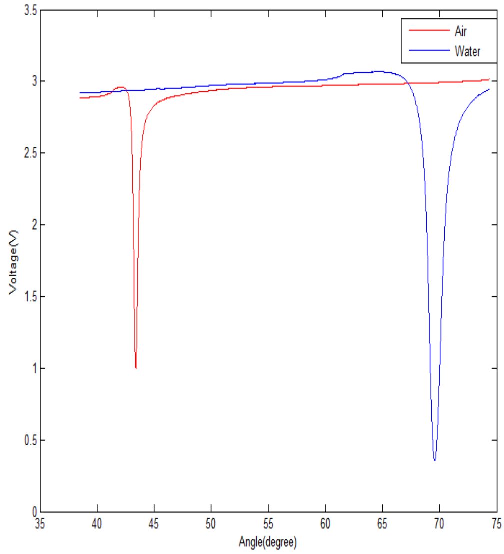

Fig.6.Resonance angle in air and water condition, the red line is the signal in air conditionand the blue line corresponds to water condition.

CONCLUSIONS

We have developed a very low cost surface plasmon resonancebased on 3D printer technology.The total cost of this LC-SPR is less than 10,000 RMB. To validate the performance of this device, we have measured the resonance angle in air and water condition, and it showed high performance and stability. For further study, we will focus on expanding the functionality of this LC-SPR, making a multi-functionLC-SPR.

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