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Development of an optical biosensor based on surface plasmon resonance phenomenon for fast diagnosis

A. Mazzeo*[1]; G. P. Canal [2], M. I. Alayo[1]

1 Polytechnic School, Department of Electronic Systems Engineering / University of São Paulo, SP 05508-010, Brazil
2 Institute of Physics, Plasma Physics Laboratory - Tokamak / University of São Paulo, São Paulo, SP 05508-090, Brazil

Background

Biosensors are considered the tools of the future for diagnosis and monitoring of diseases due to their high reliability, fast response, small size, low complexity and reduced cost, when compared to other devices. With the pandemic caused by the new coronavirus (SARS-COV-2), the need for the development of fast and portable biosensors has become a public health issue. Among the various types of biosensors available on the market, the optical devices based on surface plasmon resonance (SPR) phenomenon has shown additional advantages such as high sensitivity and real-time detection capability. Surface Plasmon Resonance (SPR) is a phenomenon in which p-polarized light, incident at a certain angle on a metal-dielectric interface, causes a charge density fluctuation which it propagates on the surface metallic. This phenomenon occurs only at a particular angle that satisfies a resonance condition and causes a significant reduction of the light intensity reflected at the interface. In this work, we present an experimental SPR system, based on Kretschmann configuration the so-called prism-coupler model, for the identification of biological samples. The system was validated using samples of different chemical solutions and calibration curves for protein dosage are being produced. We are also going to present in this work the development of a miniaturized portable SPR prototype, without moving parts which is composed of a laser, biconvex lenses, a polarizing lens, a commercial prism and a CCD camera.

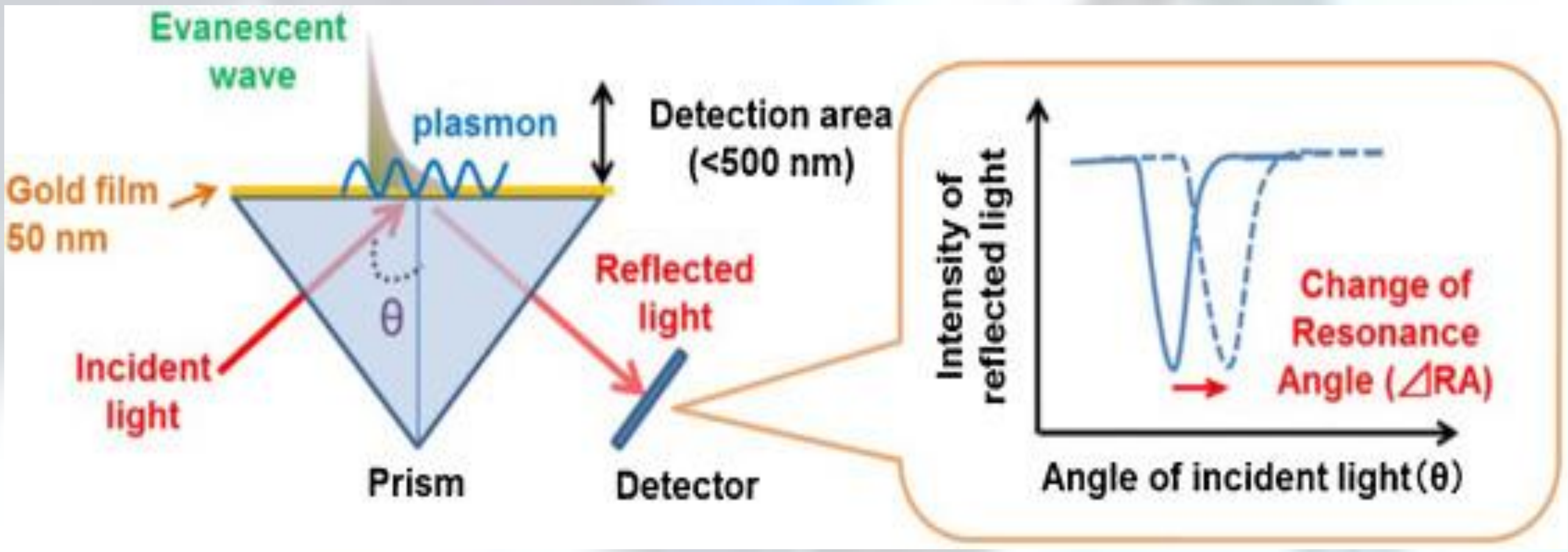

Figure 1: Phenomenon of Surface Plasmon Resonance (SPR)

Objective

- ❑Build an optical-mechanical system based on the model recommended in the literature : prism-coupler model;
- ❑Build calibration curves by purchasing theoretical and experimental data;
- ❑Identify the optimal thicknesses for metallic films;
- ❑Functionalize the surface of metallic films for fast diagnostics

Methods

- ❑Analyzing the system models described in the literature (Kuo, 2011; Masson, 2017 and Moreira,2018), it was decided to build an automated system so that the prism is placed on a fixed platform. Parallel to this prism, there are two mechanical arms located one to the right and left of the prism. In each arm a polarized laser and an optical detector are fixed, respectively. Both arms move with the same speed using goniometers controlled electronically by a program developed in LabView software.
- ❑The deposition of a thin film of gold on a square glass slide with an area of 400 mm^2 was performed. This glass slide was placed on the top face of the prism and a microscopy oil was used in order to guarantee the copupling among the prism and the glass.
- ❑Numerical simulation were performed using the Matlab® software in order to determine the best thickness of the metallic film. Using this simulation program were also defined the best materials to be worked.

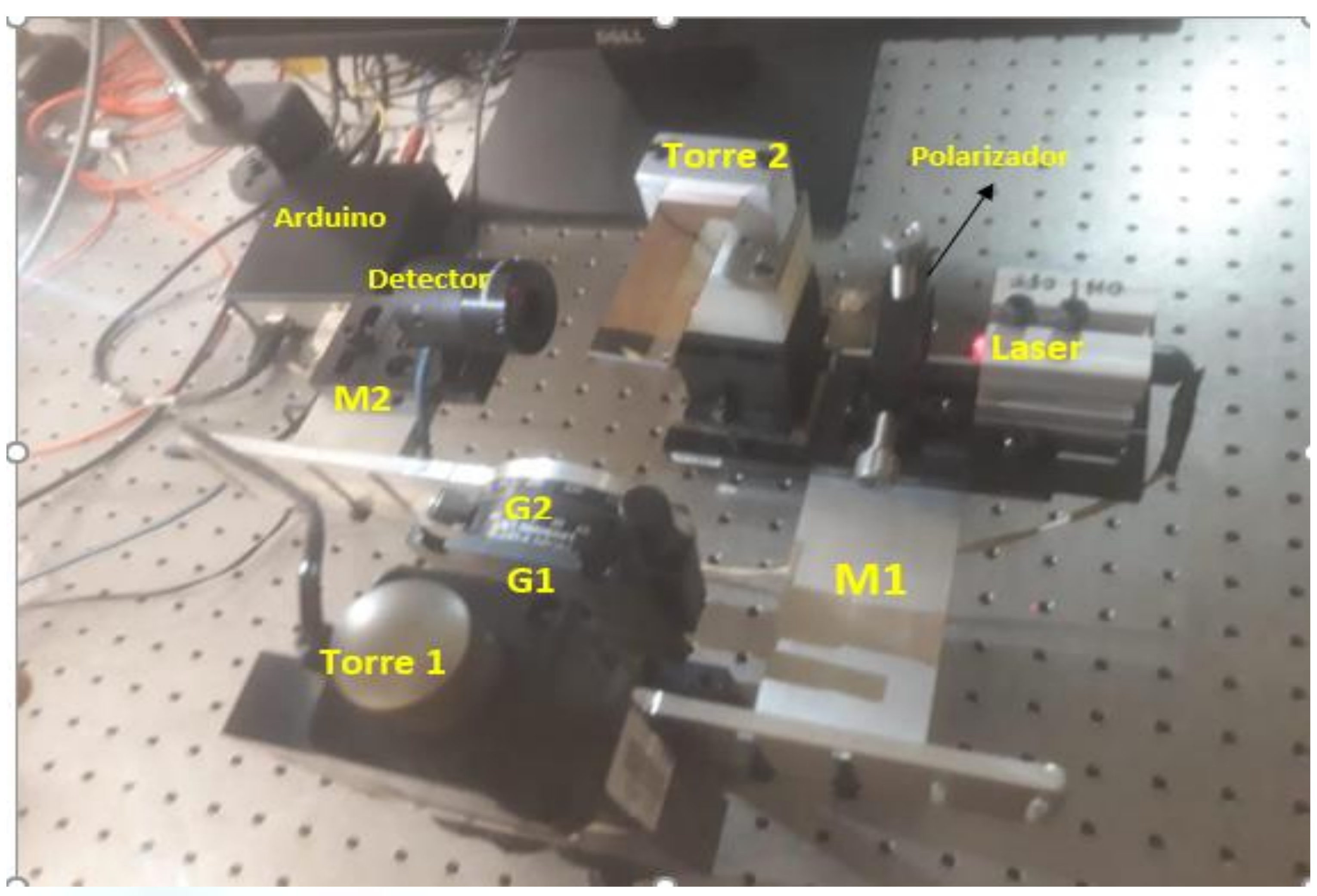

Figure 2: Photograph of the arms where are positioned the polarized laser and the detector. It is possible to see in the figure the platform where the prism is positioned.

Results

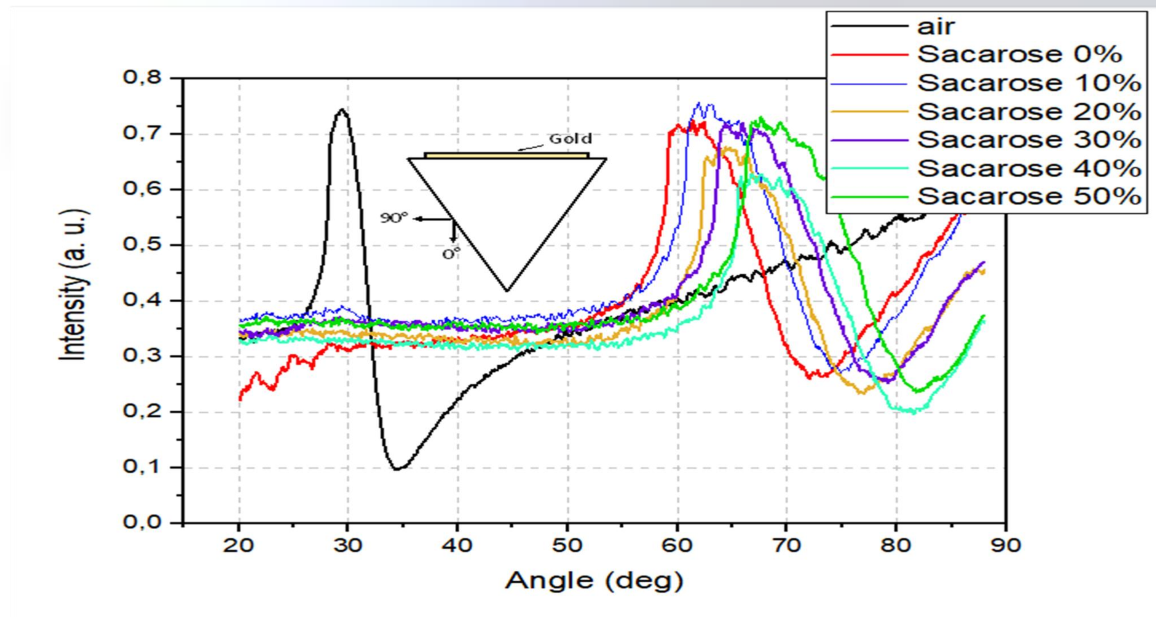

Figure 3: Calibration curves using sucrose solution with diferent concentrations

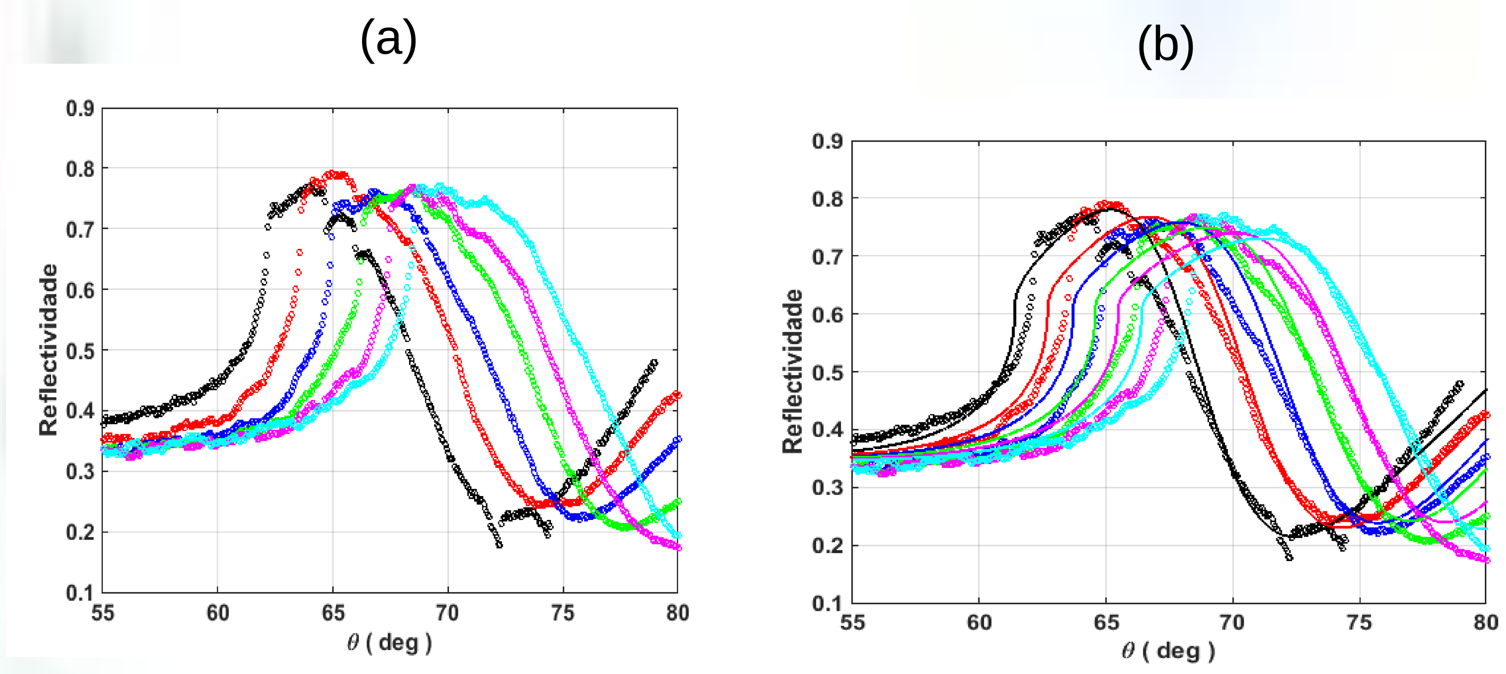

Figure 4: Experimental Curves of sucrose with different concentrations (a) and comparison between simulated and experimental curves of sucrose with different concentrations

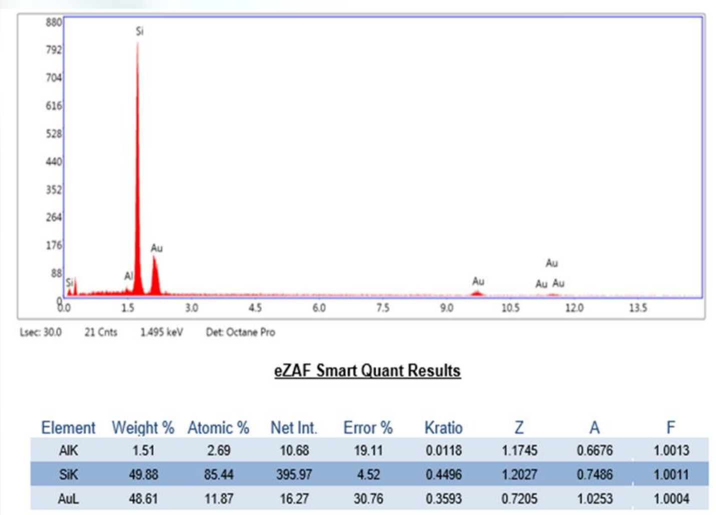

Figure 5: Characterization of the thin metallic film of gold by Energy Dispersive Spectroscopy (EDS)

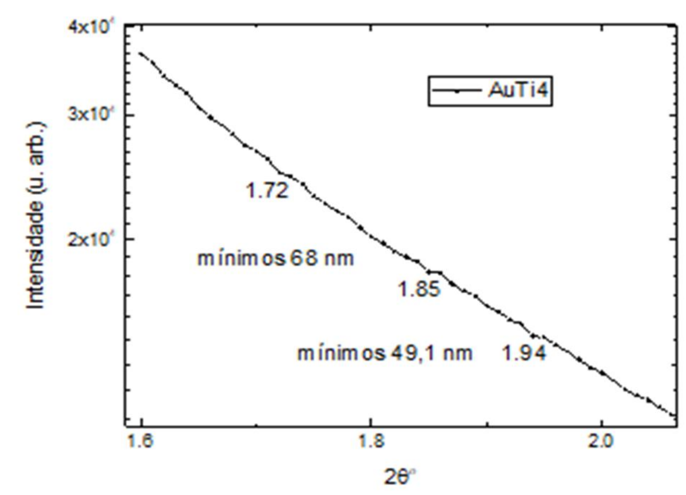

Figure 6: Characterization of the thin metallic film of gold by X-Ray Diffraction

Prototype Design

Figure 7: Prototype based on a system composed of lenses, laser and prism

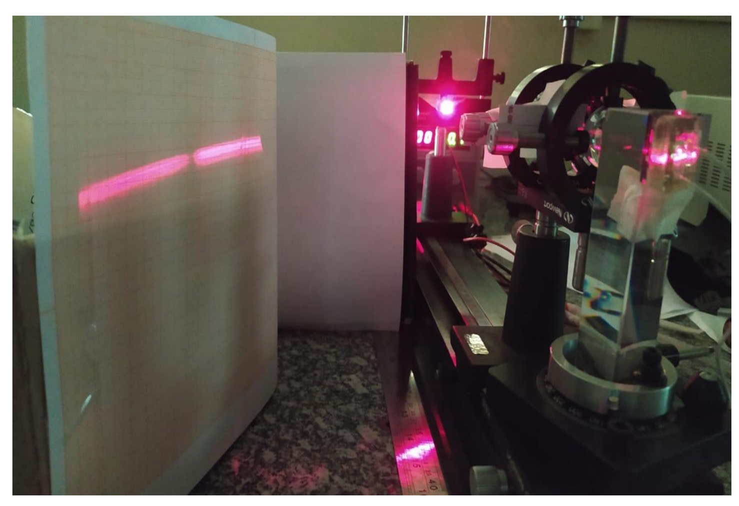

Figure 8: Image showing the resonance position of the water using the prototype

Partial Conclusions and Future Perspectives

- ❑ The system is reproductive for chemical solutions
- ❑ The prototype model proved to reproduce the results of the bench model
- ❑ In future works we intend to perform the functionalization of the surface of gold in order to use the system in the analysis of biological samples.

References

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