Surface Plasmon Resonance: Exciting Waves and Metal Films

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Introduction:

Surface Plasmon Resonance is a popular technique that takes advantage of wave behavior at an interface to detect and/or identify materials and molecules. The purpose of this project was to answer the question "*how can SPR be used to characterize thin metal films?*" There were two main components to the project allowing the team to get closer to answering this question:

1. Measure gold film thickness using atomic force microscopy
2. Develop an experiment and setup that can be used to quantify plasmon resonance in response to three variables: film thickness, type of metal, and source light intensity

Surface Plasmon Resonance (SPR):

SPR is often used to sense the presence of biomarkers. The phenomena is caused by the interaction of two wave types which form along the boundary of two dielectric materials:

- Evanescent wave – forms when light is totally internally reflected and decays exponentially as distance from the interface increases
- Surface plasmons – forms when free electrons in the metal film are excited and oscillating

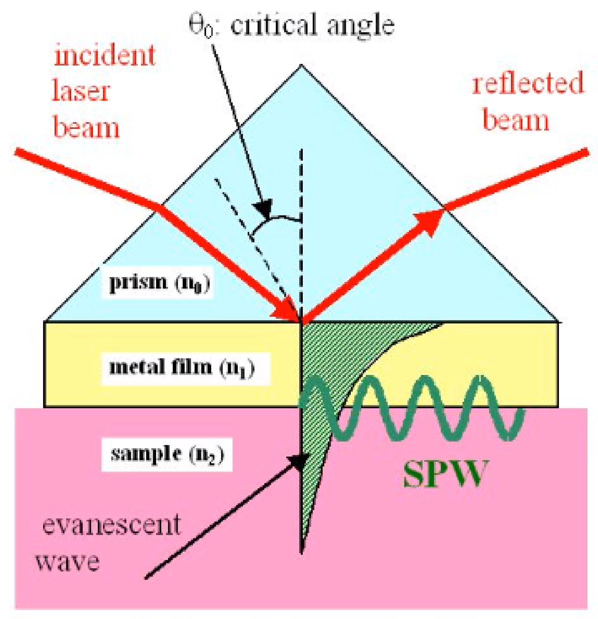


Figure 1: Illustration explaining SPR technique[1]

Measuring Film Thickness with AFM:

Atomic Force Microscopy (AFM): method for gathering accurate topography data on samples with surface feature sizes on the nanoscale

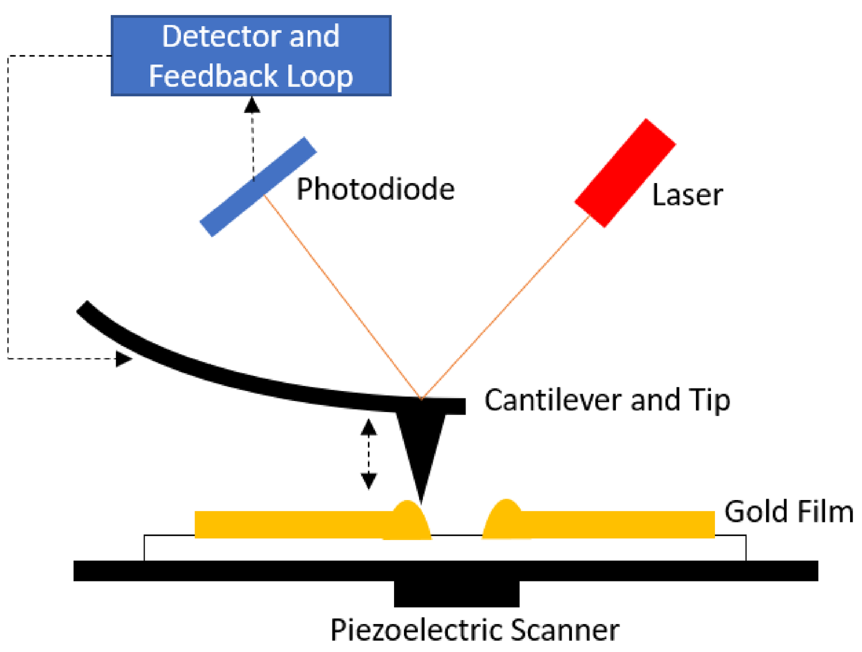


Figure 2: Illustration explaining atomic force microscopy and how it is used to measure film thickness by scanning across a thin film "step"

Procedure:

- Gold film is deposited on a glass microscope slide using sputter coater 'auto-cycle' (30 second cycle)
- A scratch in the gold film is made, exposing the glass substrate and creating a step representative of the film thickness
- AFM is used to measure the step height and estimate the coating thickness each time the sputter coater 'auto-cycle' is run

Results:

Cycle 10x = 97.62 nm

Cycle 6x = 49.89 nm

Cycle 2x = 25.41 nm

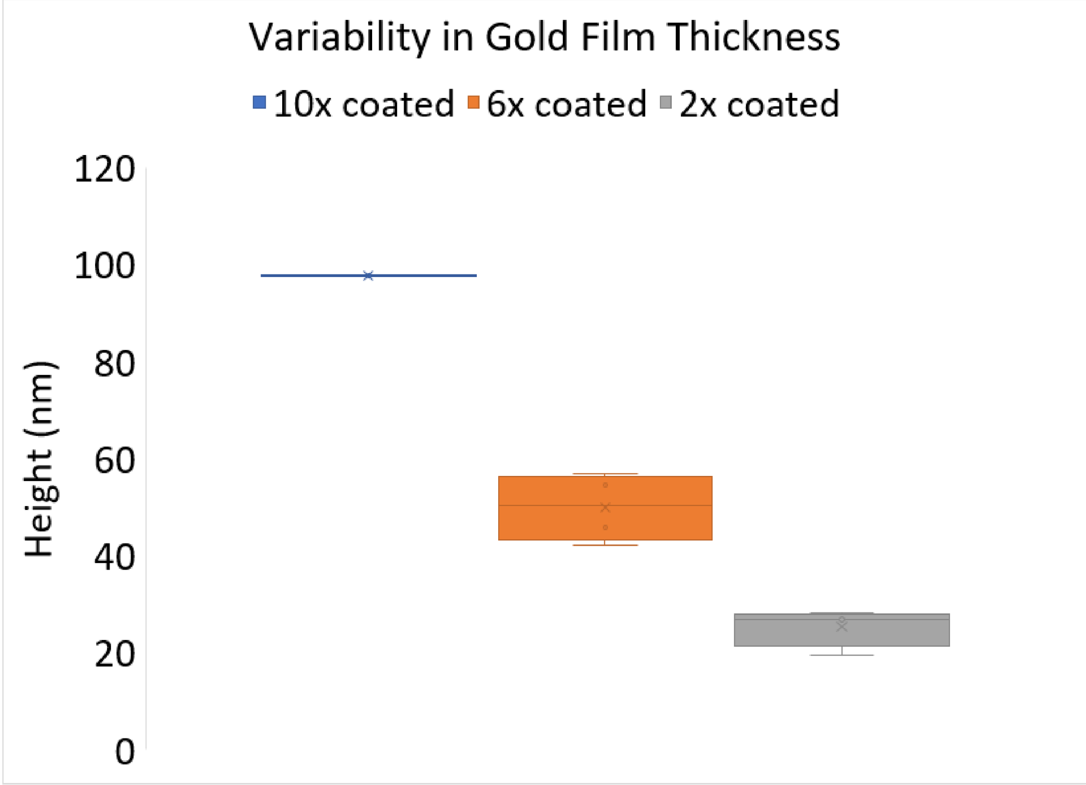


Figure 3: Boxplot of measured film thickness

Quantifying Resonance:

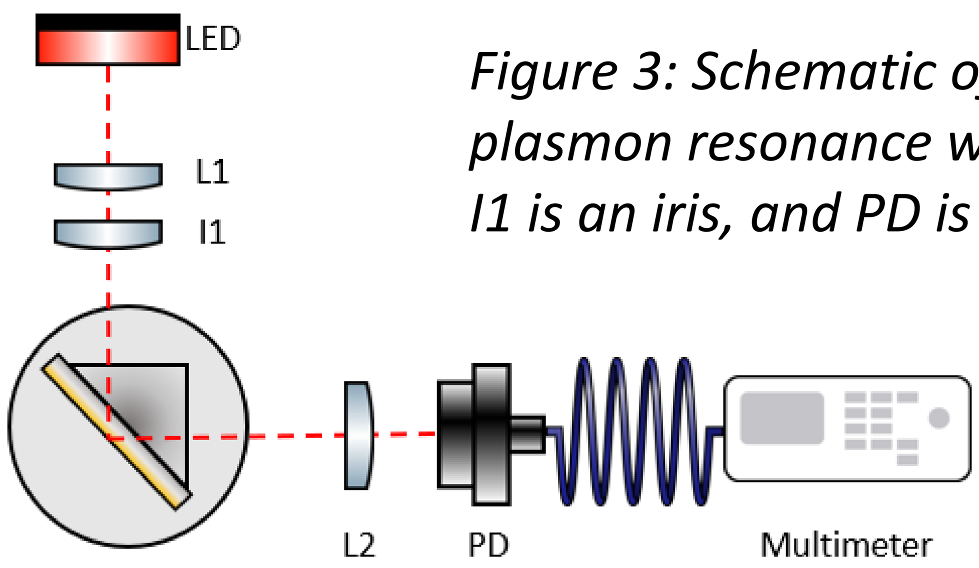
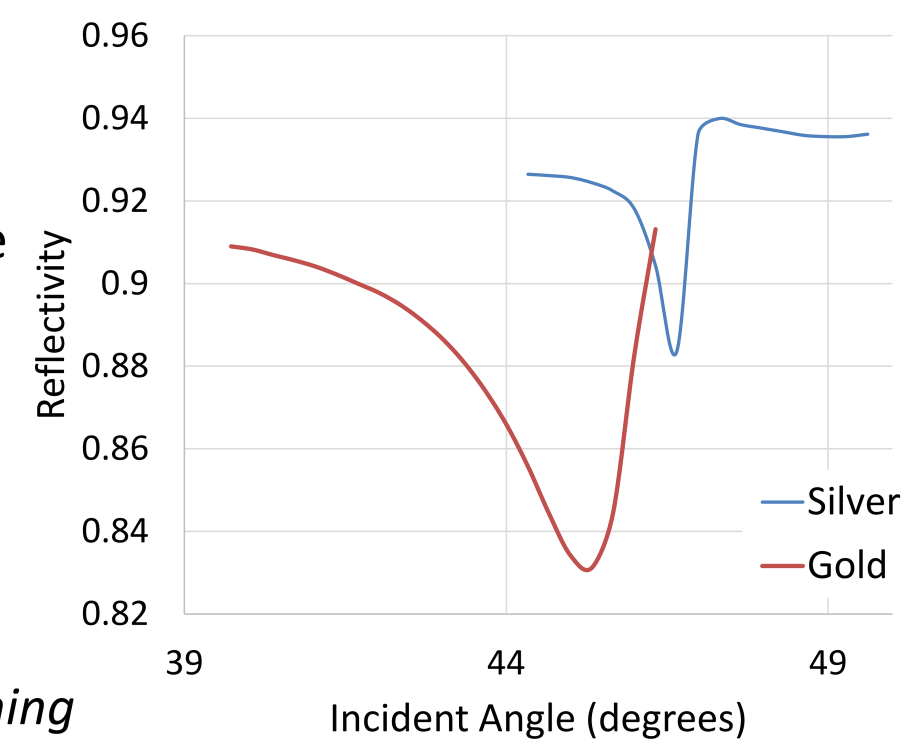


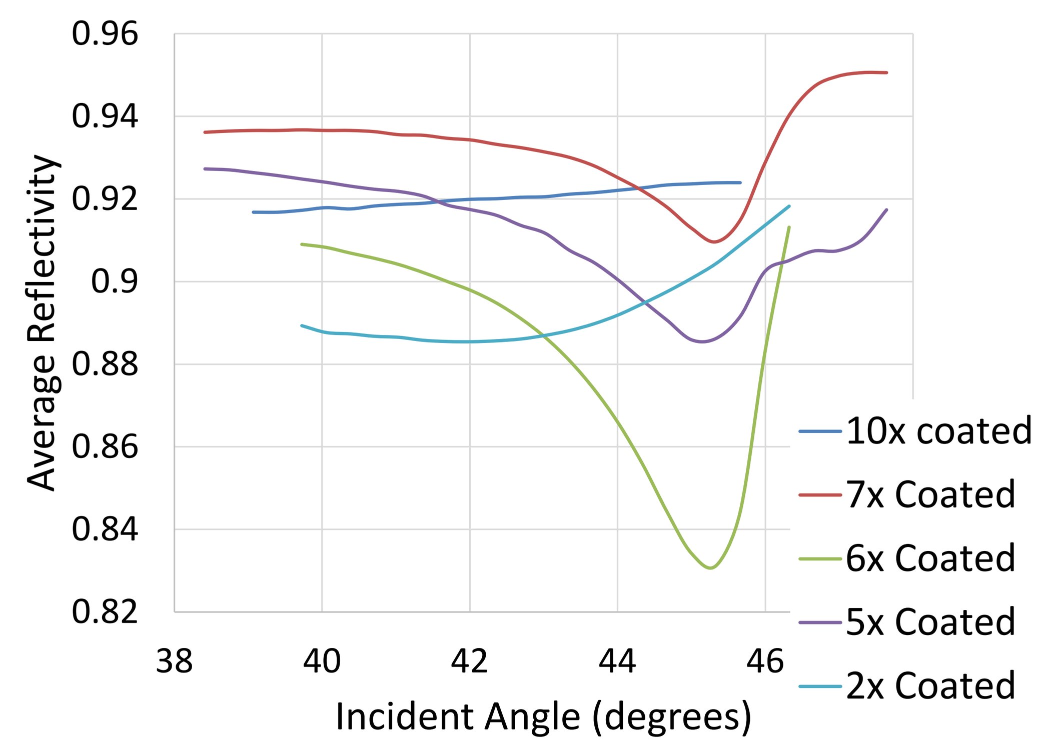
Figure 3: Schematic of setup used to quantify plasmon resonance where L1/L2 are lenses, I1 is an iris, and PD is the photodetector

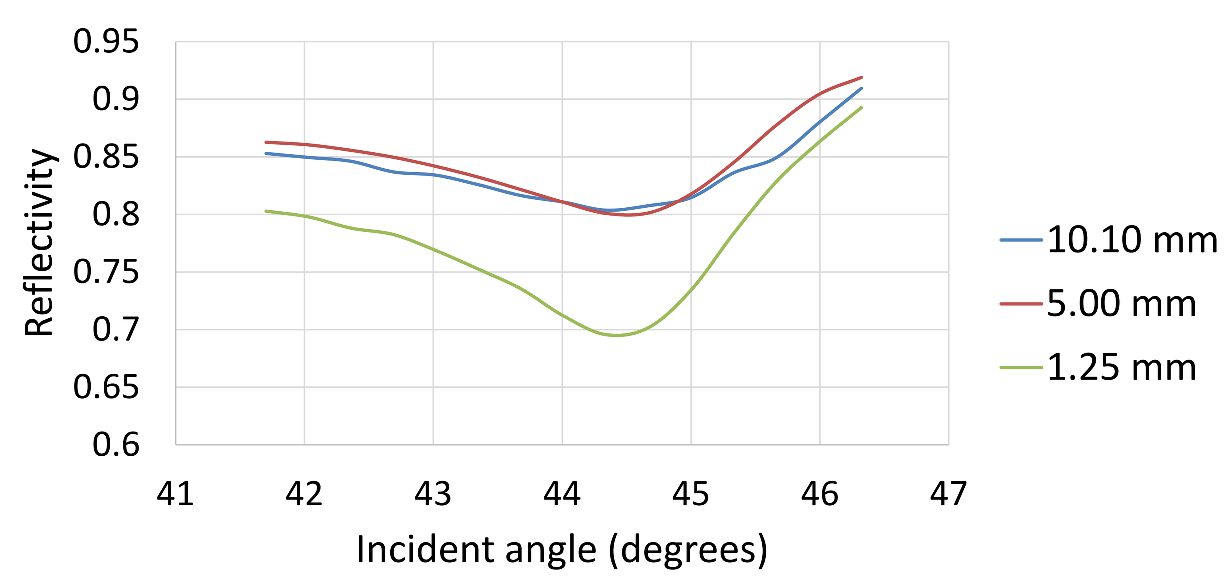
Procedure:

- Deposit thin gold film on glass slide and place on edge of prism
- A red LED (634 nm) is used as the incident light source is shined through the prism where it interacts with the electrons in the film
- As the incident angle changes, a photodetector collects the reflected light and reports it as voltage
- When the evanescent waves and surface plasmons have equal energies, the incident light dissipates resulting in a decrease in intensity
- A relationship between incident angle and reflectivity and how the curve is affected by film thickness, film type, and incident light intensity can be graphed:

Results:







Conclusions:

- The sputter coater lays ~10 nm film during each 'auto-cycle'
- Film material type changes the curve shape and incident angle where resonance occurs –> helpful for characterizing film
- The thickness of the film changes the intensity of the resonance
- An iris opening smaller than 5.00 mm will affect reflectivity

Acknowledgements:

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References:

1. Presentation, Kolomenski, A.; Surface Plasmons, Part 2, September 2012