ANALYSIS OF ADHESIVE LAYER MATERIAL INFLUENCE ON TRANSMISSION CHARACTERISTICS OF PLASMONIC BASED BIOSENSOR WITH NANO-HOLE ARRAY

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Bio

Ilya Belyakov received Bachelor's Degree in specialty Electronics and Nanoelectronics from the Bauman Moscow State Technical University in 2016, working on functional thin films. From 2016 until 2018 was working in the industry as a manufacturing technologist with a special focus on manufacturing processes; in the summer of 2020 joined the research team at the University of Waterloo in Canada. Currently, a Master's student at the University of Waterloo, developing plasmonic-based biosensors.

Motivation

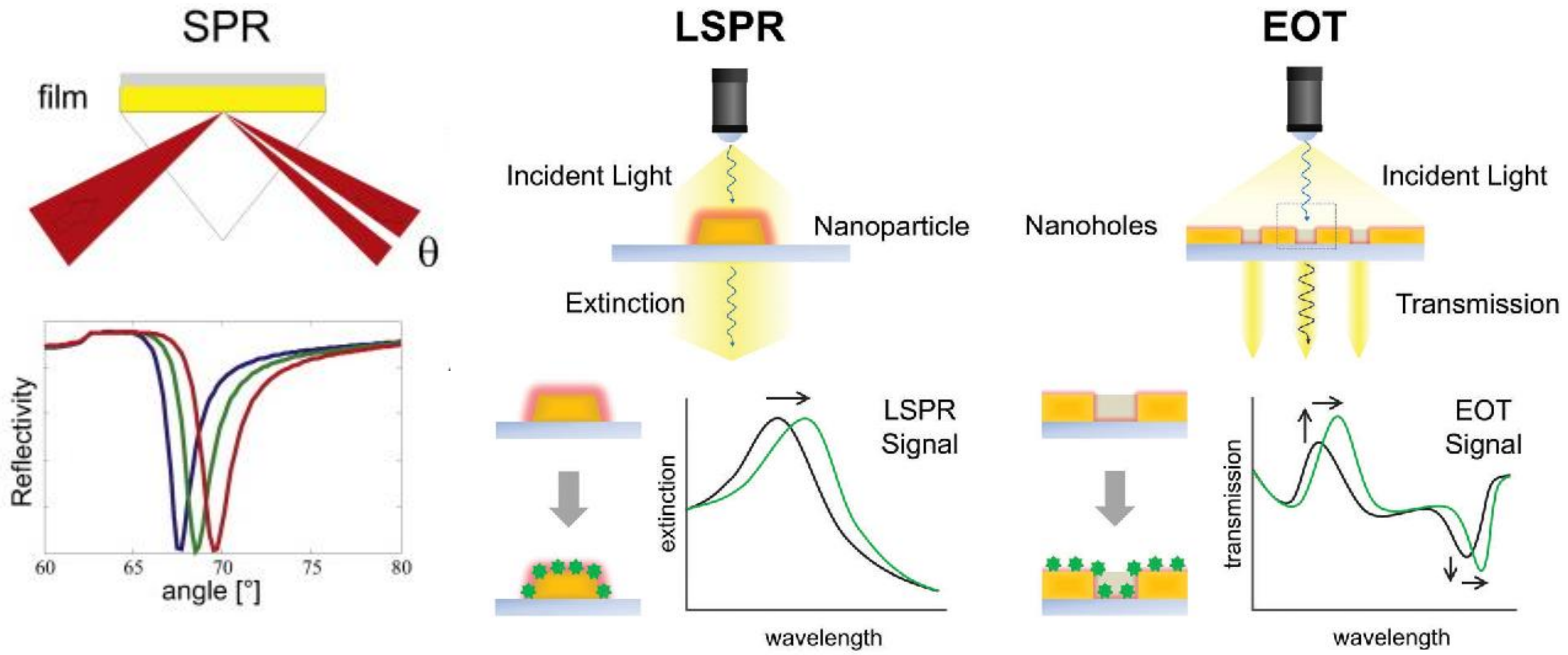
- Plasmonic biosensors are promising technology for molecular detection, which is under wide research nowadays;

- Noble metal thin films have good optical properties as is required for Surface Plasmon Resonance (SPR) biosensors;

- Not all plasmonic sensor applications are suitable for point-of-care use and require complex lab equipment because of poor performance/effect of the adhesion on the sensor performance

Extraordinary optical transmission (EOT)

Extraordinary optical transmission (EOT) is the phenomenon of greatly enhanced transmission of light through a subwavelength aperture in an otherwise opaque metallic film which has been patterned with a regularly repeating periodic structure.



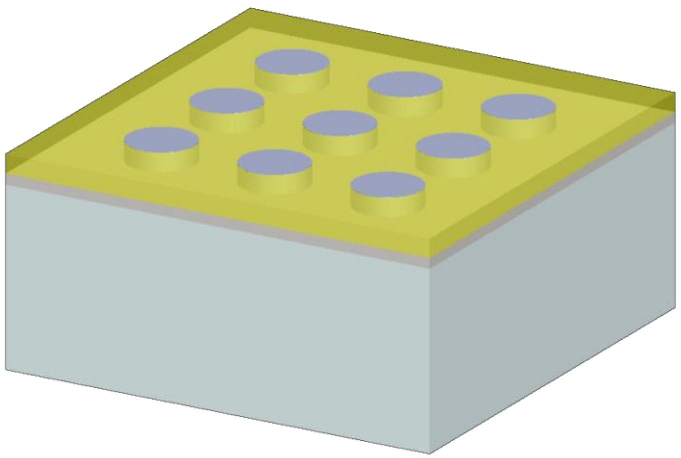
Numerical simulations

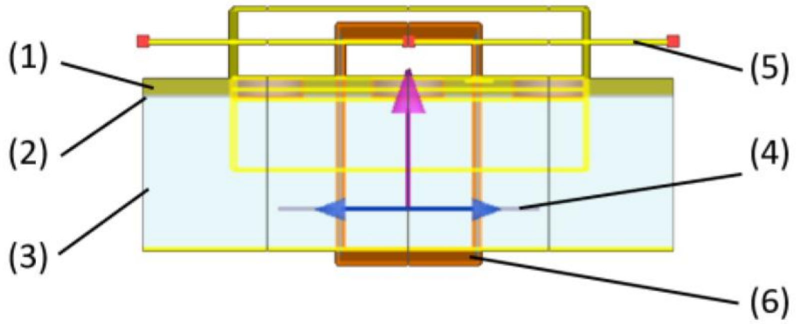
In this project, finite difference time domain (FDTD) were used to solve Maxwell's equations to study the interaction of an electromagnetic wave and surrounding medium and objects.

Among different type of sacrificial layer Aluminum, Titanium, Tantalum, Chromium, and Tungsten were tested in this study, base on their optical properties and adhesion between gold and glass.[1][2]

The transmission signal, peak level, peak width, and overall signal level were used as the primary analysis metrics.

[1] X. Fan et al., "Assembly of gold nanoparticles into aluminum nanobowl array", Scientific Reports, vol. 7, no. 1, 2017. Available: 10.1038/s41598-017-02552-z.
[2] J. Bhattarai, M. Maruf and K. Stine, "Plasmonic-Active Nanostructured Thin Films", Processes, vol. 8, no. 1, p. 115, 2020. Available: 10.3390/pr8010115.





Numerical analysis layout, (1) NHA structure, (2) sacrificial layer (3) substrate, (4) light source, (5) monitor, (6) analysis region

Usual Fabrication Scheme for Gold NHA Biosensor

Sample with Titanium sacrificial layer showed two peaks at 665 nm and 716 nm wavelengths

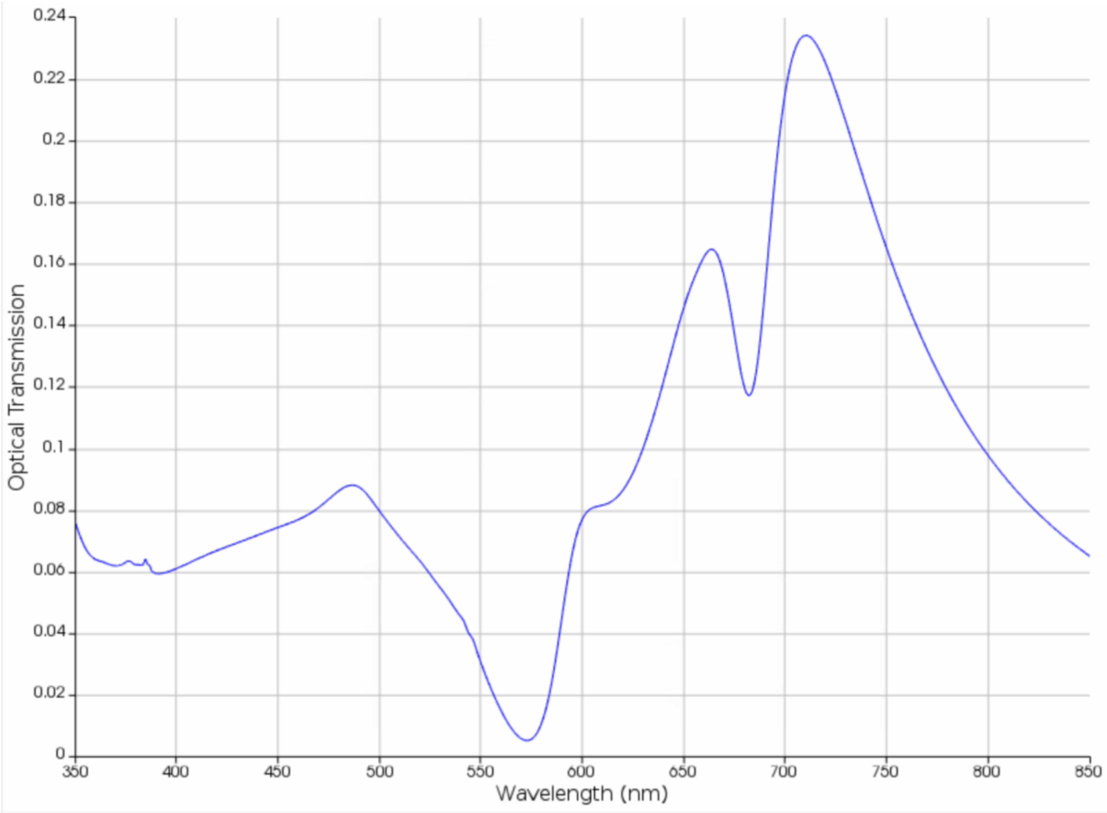
Highest transmission peak value is 24.03%, and lower peak value is 15.41%

Gold film thickness: 100 nm

Sacrificial layer thickness: 2nm

Light source bandwidth: 400-750 nm

Transmission Spectrum



Chromium Sacrificial Layer

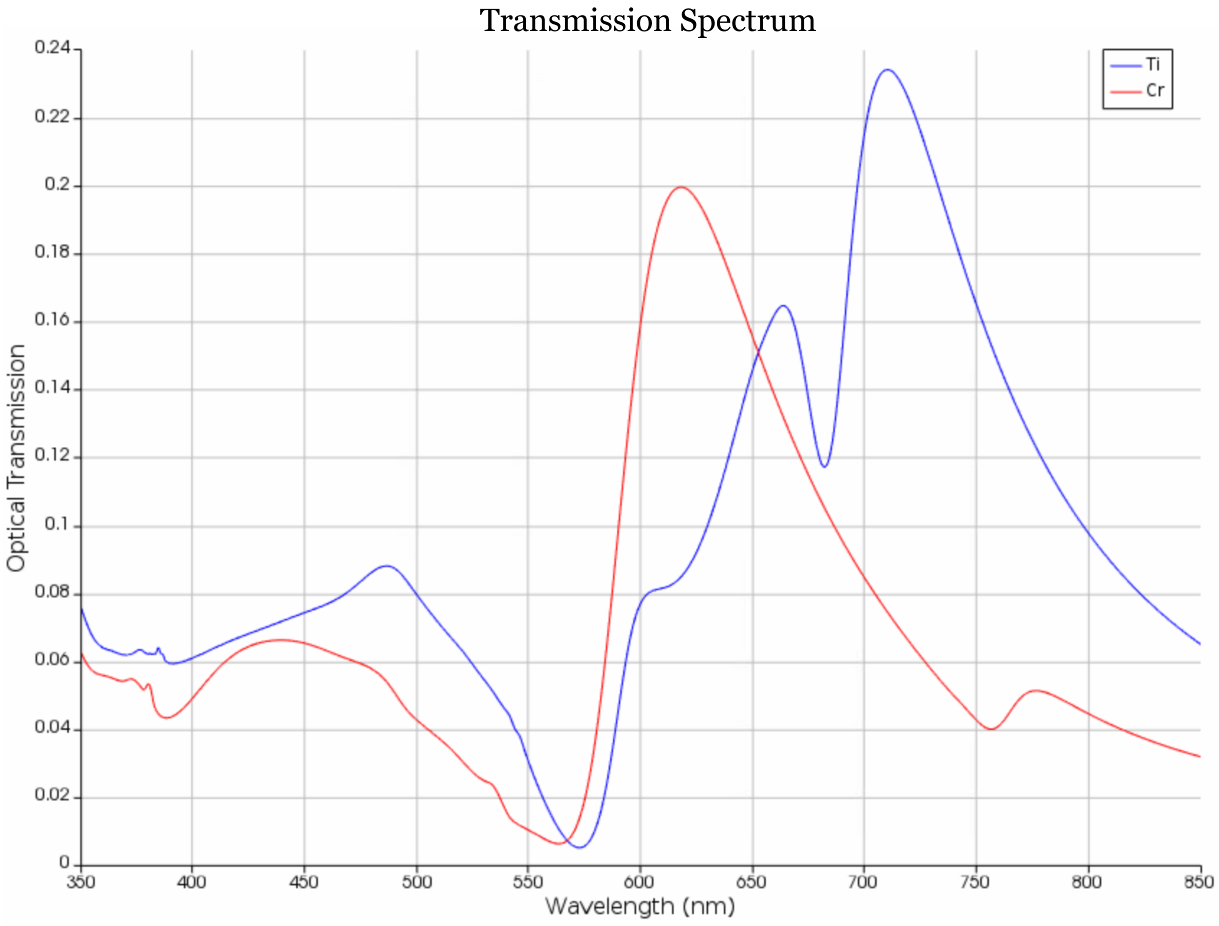
Sample with Chromium sacrificial layer showed one peak at 620 nm wavelength

The transmission peak value is 19.98%

Gold film thickness: 100 nm

Sacrificial layer thickness: 14 nm

Light source bandwidth: 400-750 nm



Tantalum Sacrificial Layer

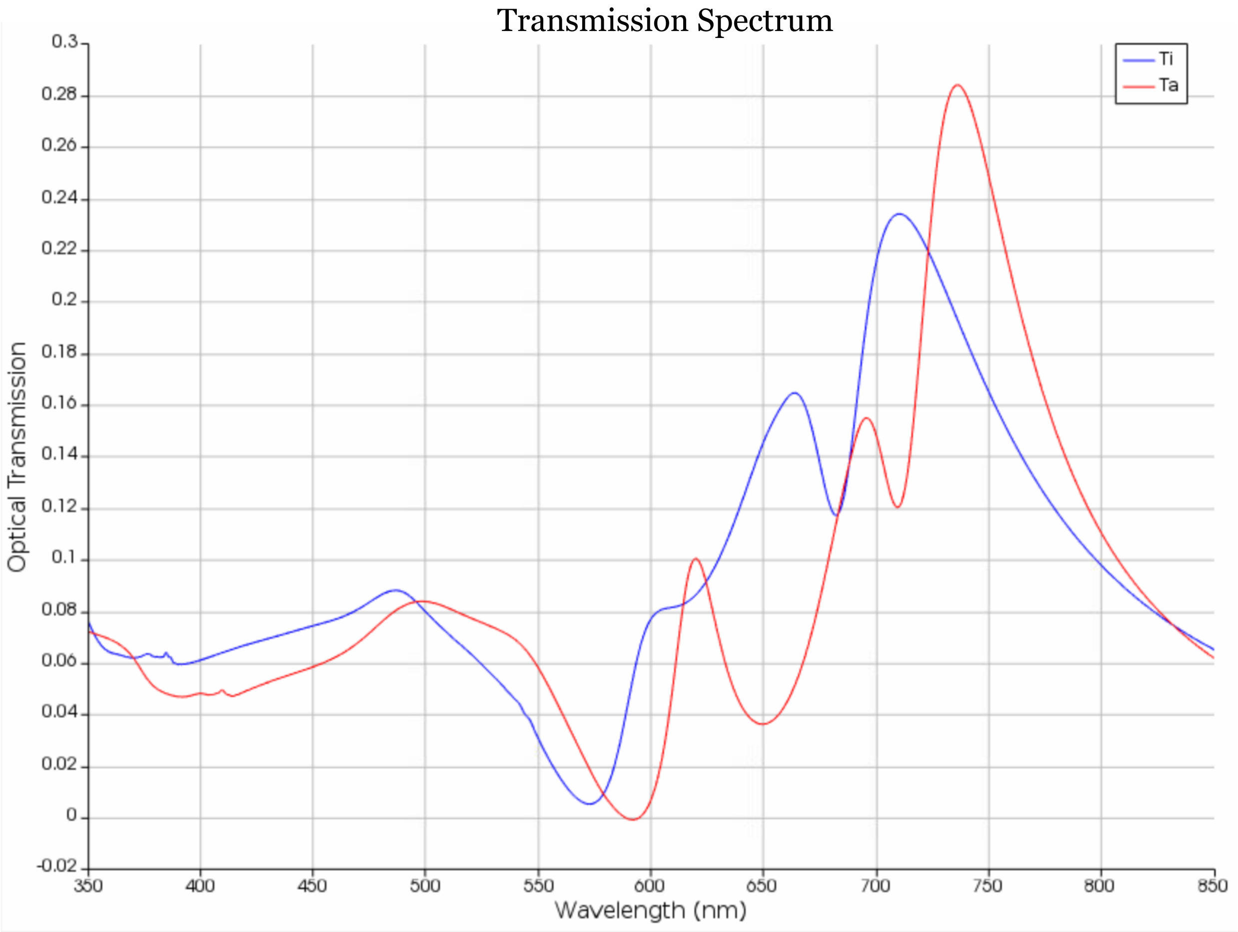
Sample with Titanium sacrificial layer showed two peaks at 618 nm and 737 nm wavelengths

Highest transmission peak value is 29.12%, and lower peak value is 10.05%

Gold film thickness: 100 nm

Sacrificial layer thickness: 2nm

Light source bandwidth: 400-750 nm



Tungsten Sacrificial Layer

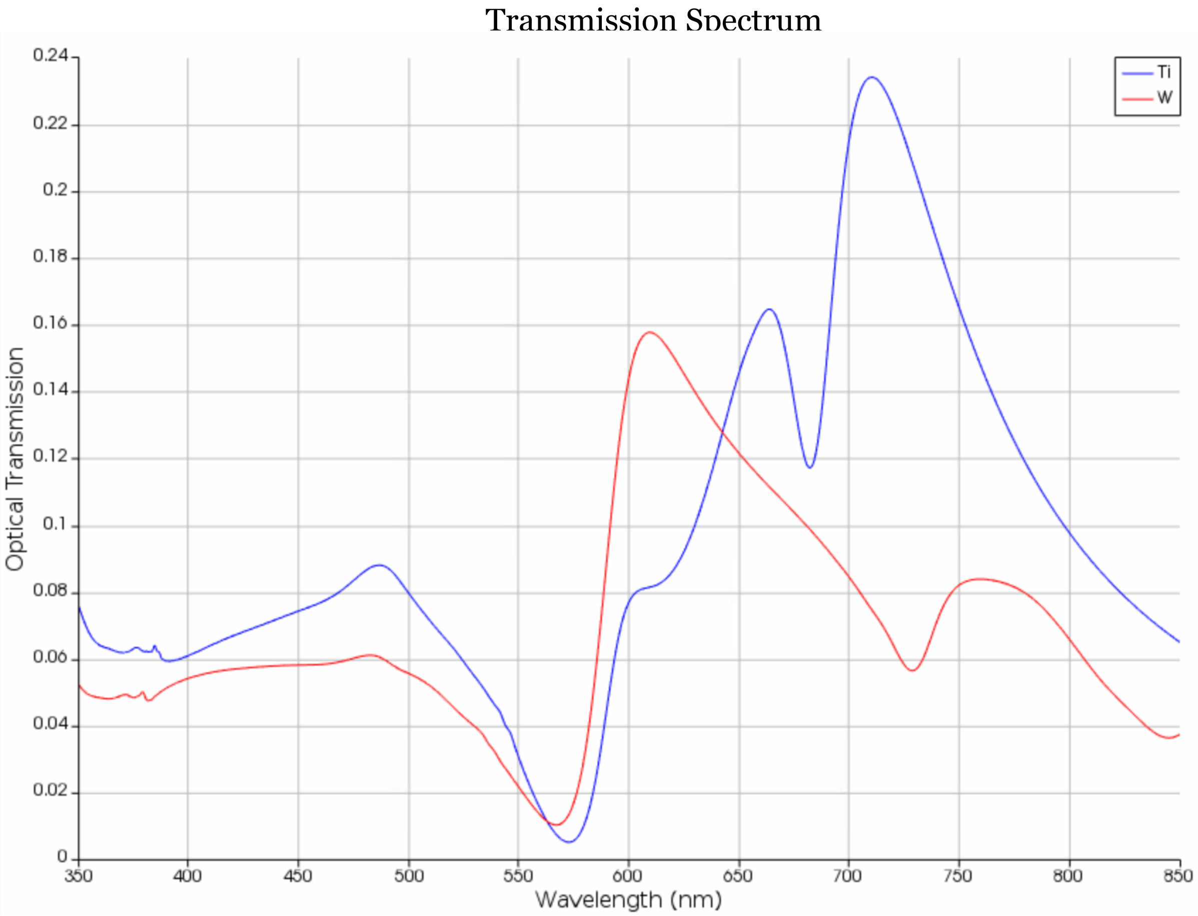
Sample with Tungsten sacrificial layer showed one peak at 607 nm wavelength

The transmission peak value is 15.73%

Gold film thickness: 100 nm

Sacrificial layer thickness: 8 nm

Light source bandwidth: 400-750 nm



Aluminum Sacrificial Layer

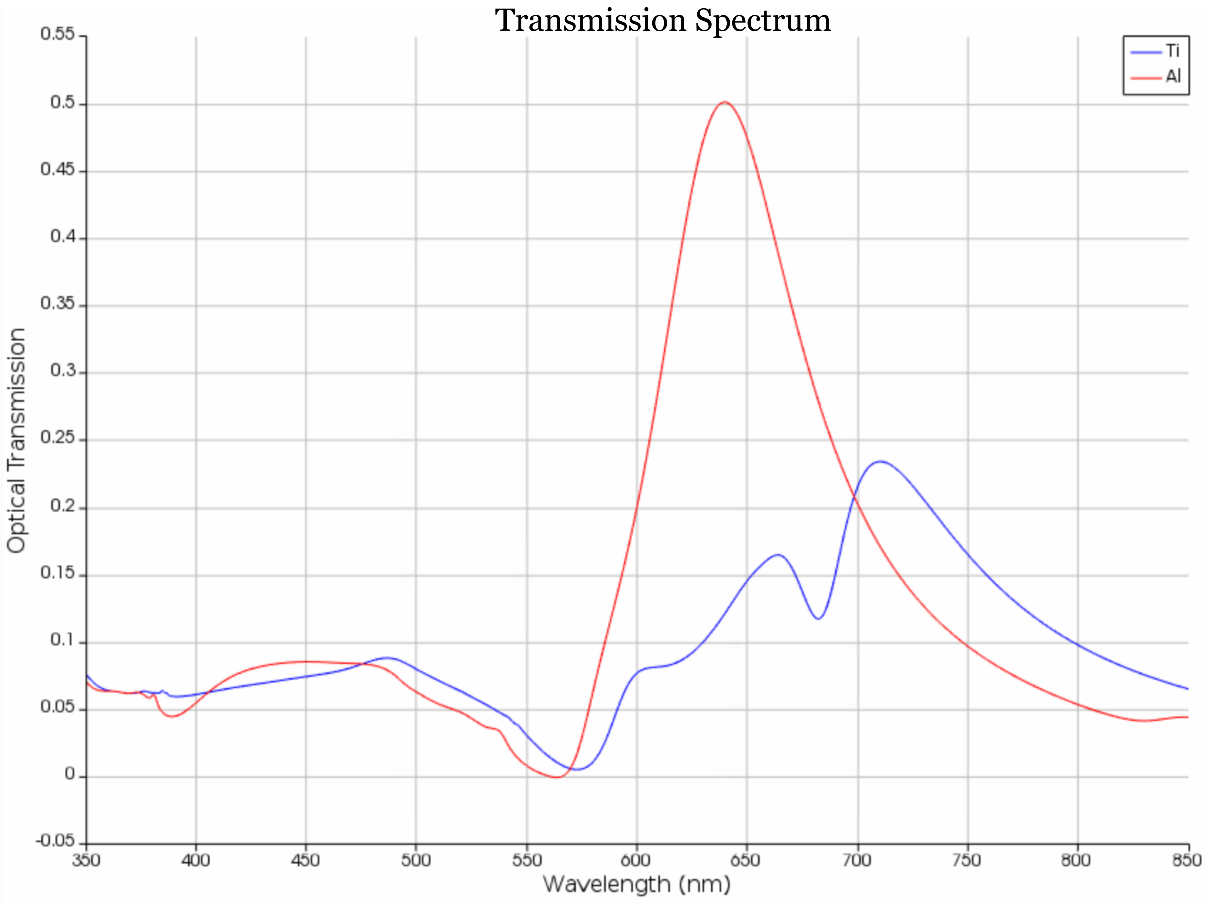
Sample with Aluminum sacrificial layer showed one strong peak at 637 wavelength.

The transmission peak value is 50.05%

Gold film thickness: 100 nm

Sacrificial layer thickness: 2 nm

Light source bandwidth: 400-750 nm



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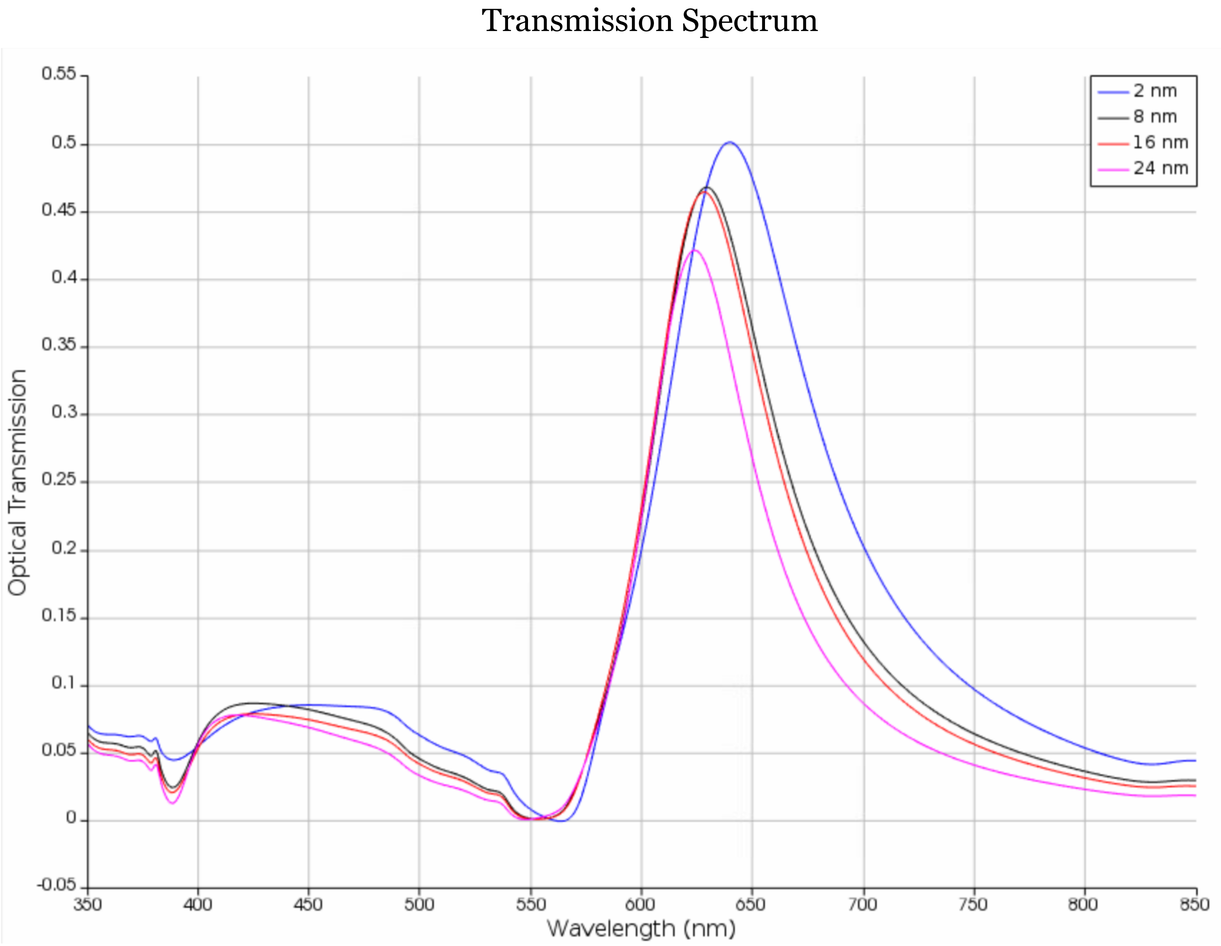
Aluminum Sacrificial Layer Thickness

At Aluminum sacrificial layer thickness 2 - 7 nm highest peak value is in range 48-50%.

At 8 – 20 nm thickness peak value slightly drops to 44 – 46%, but peak signature is much sharper.

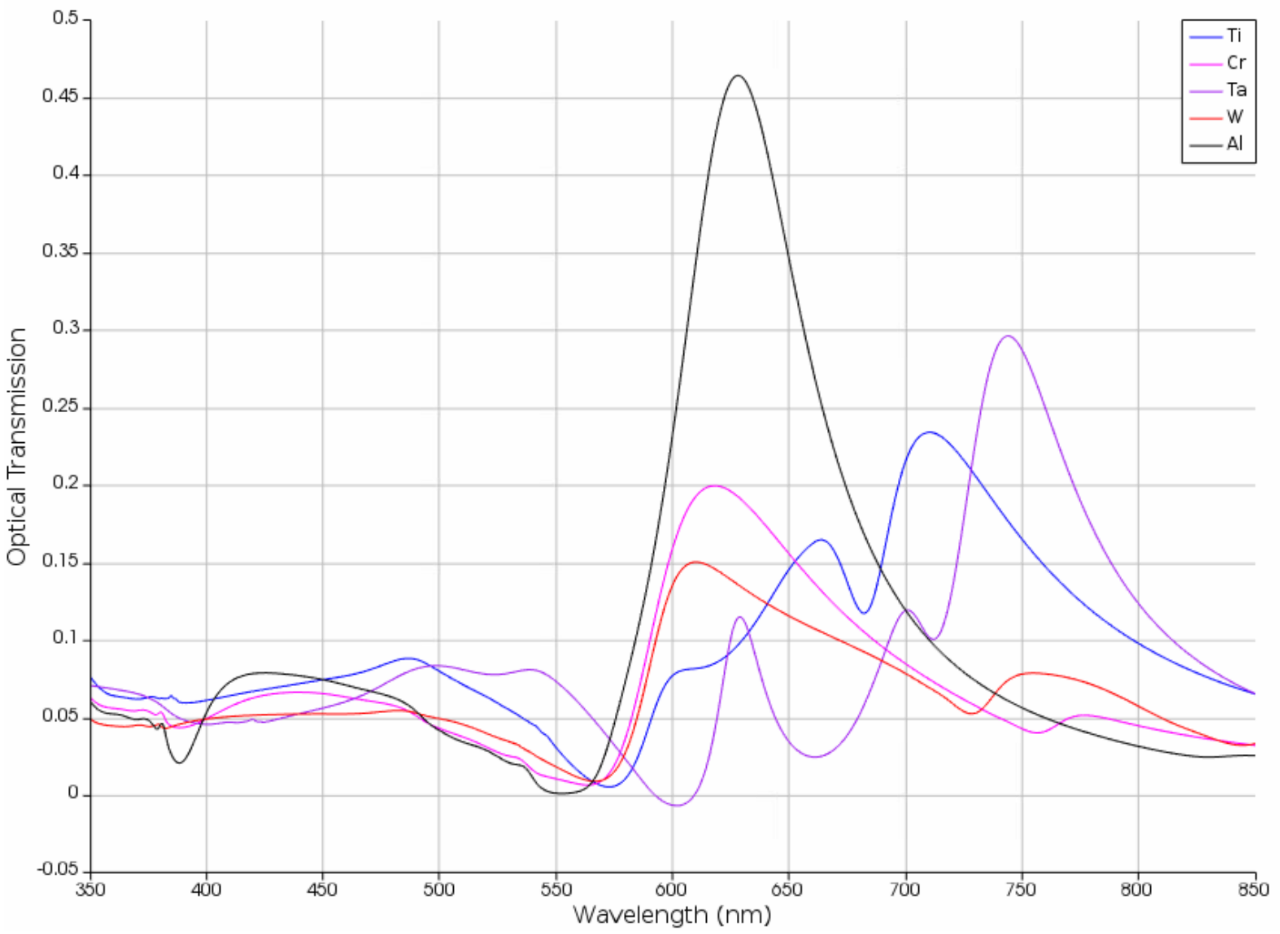
At 20+ nm thickness drops to 41% and decrees fast after incising thickness.

Optimal thickness: 16 nm.

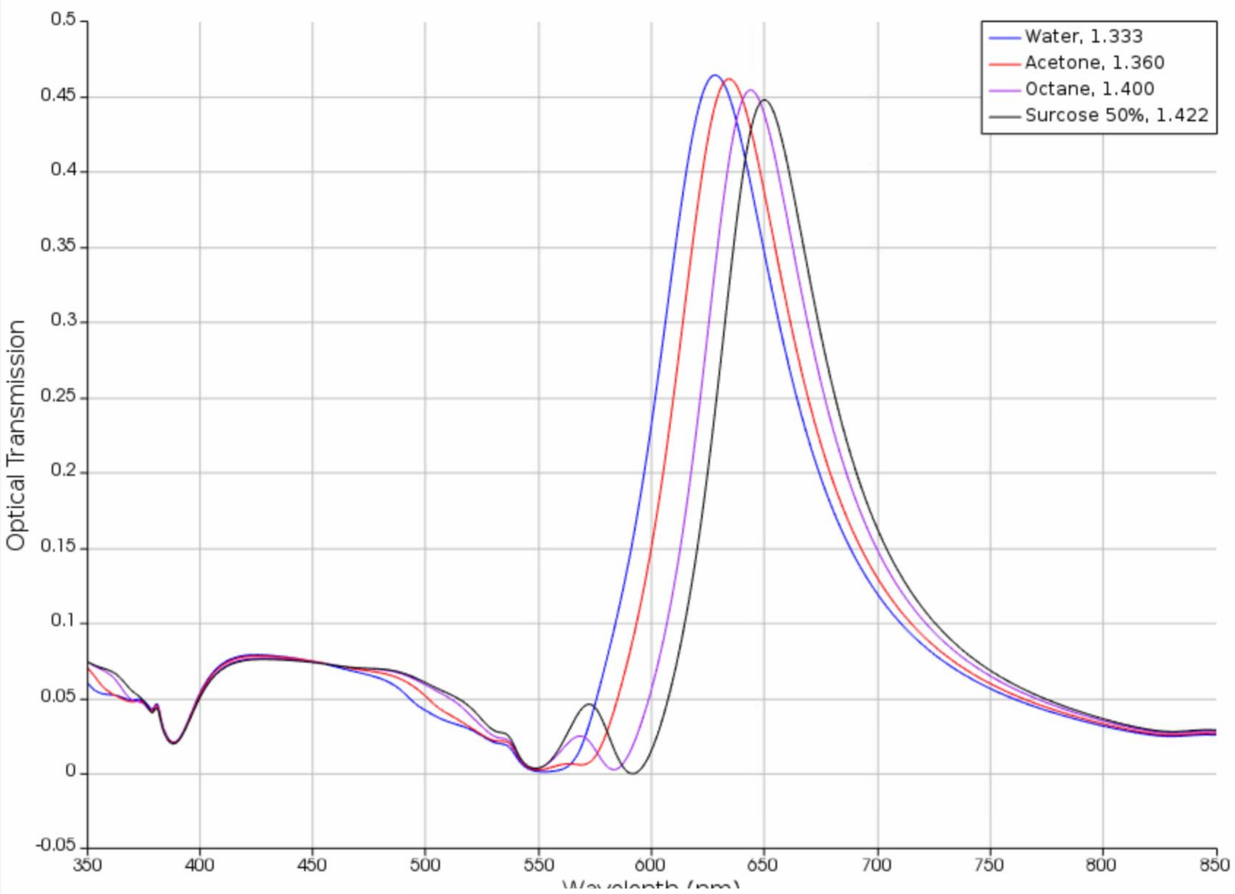


Results and conclusion

Transmission Spectrum of Various Sacrificial Layers



Aluminum Sample Transmission Spectrum Shift



Future work

- Study in depth influence of sensor geometry on transmission signal;

- Preparation of sensor recipe and test sample manufacture;

- Comparative analysis of theoretical simulation data with a real sample.

Thank you for listening!

Questions?