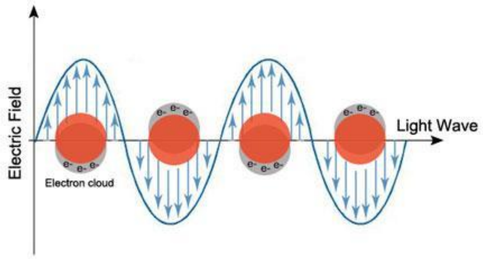
Optimizing Sensitivity of Nanodisk LSPR Sensors

Background

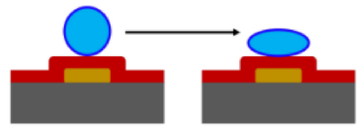
Gold and silver nanostructures much smaller than the wavelength of incident light exhibit LSPR (localized surface plasmon resonance). The specific wavelength that the nanostructures resonate with most strongly is sensitive to changes in local conditions such as the surrounding index of refraction.



This interaction makes LSPR structures particularly sensitive to small changes in the local refractive index such as the adsorption of vesicle onto the sensor surface.

Methodology

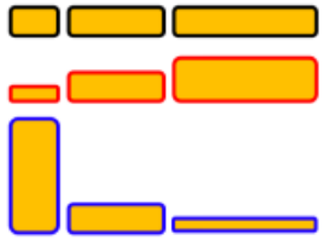
The Lumerical FDTD (finite-difference time-domain) Solutions package was used to solve for the absorbance of LSPR sensors supported on a glass substrate. Each disk is coated by a conformal film of silicon nitride.



Gold and silver sensors were compared. Also simulated was the effect of a shelled ellipse above the disk, emulating a vesicle absorbed onto the sensor.

Sensitivity was evaluated by looking at how much the peak resonant wavelength shifted with a change in the background index (n)

$$\text{Sensitivity} = \frac{\Delta\lambda_{\max}}{\Delta n}$$



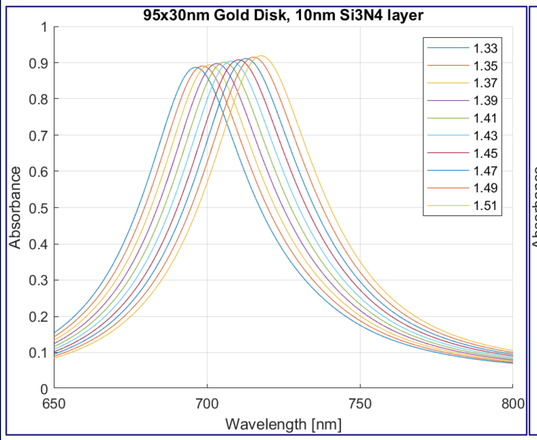
To investigate the disk shape's effect on the sensitivity, from a base setup of a 100nm diameter and 30nm tall disk, the diameter was changed in three different regimes: keeping height, aspect ratio, or volume constant. Sensitivity was evaluated at each diameter.

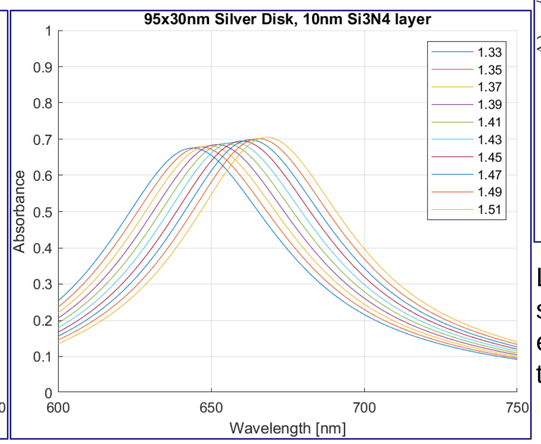
Results

Gold vs Silver:
Disk is 95nm in diameter 30nm tall

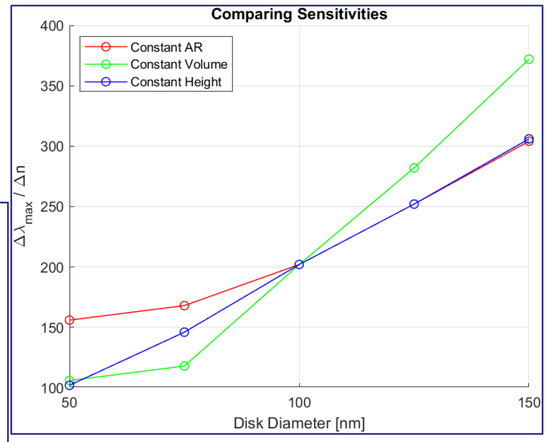
Gold and silver peak wavelengths shifted linearly with changing background index (1.33 – 1.51)

Silver is found to be ~13% more sensitive than gold



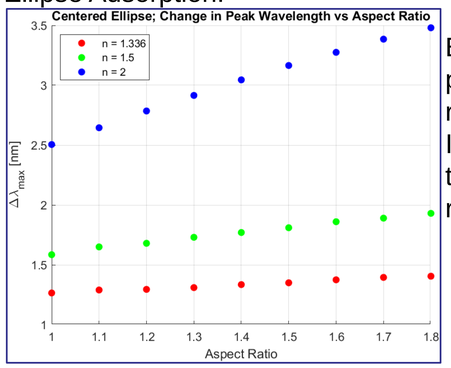


Disk Shape Sensitivity Comparison:

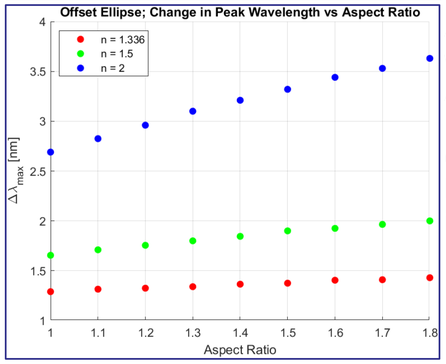


Larger nanodisks are found to be more sensitive to changes in local conditions, especially so when they are made to be thinner.

Ellipse Adsorption:



Both centered and offset ellipses present above the nanodisk resulted in very similar results. Increasing the aspect ratio of the ellipse led to a larger resonance peak shift.



Aspect ratio is the ratio of the width of the ellipse to the height. Aspect ratio was increased from 1 to 1.8 while maintaining constant volume of the ellipse beginning from a sphere 60nm in diameter