GOLD NANOPARTICLES (AuNPs) AS ACTIVE MATERIALS TO DETECT SARS-CoV-2 USING PLASMONIC COLORIMETRY METHODS AND FILTER-FREE WAVELENGTH SENSORS (FFWS) ON LOCALIZED SURFACE PLASMON RESONANCE (LSPR) PHENOMENON

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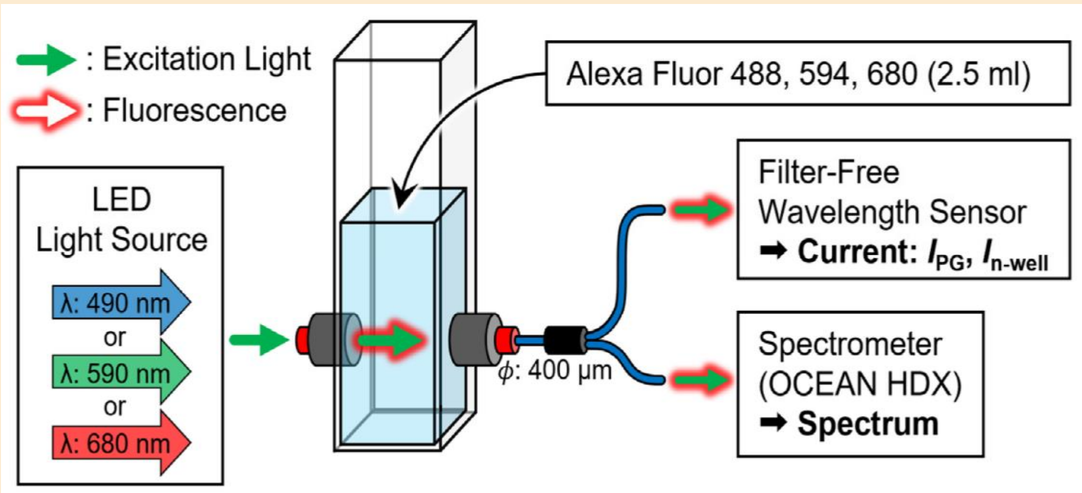
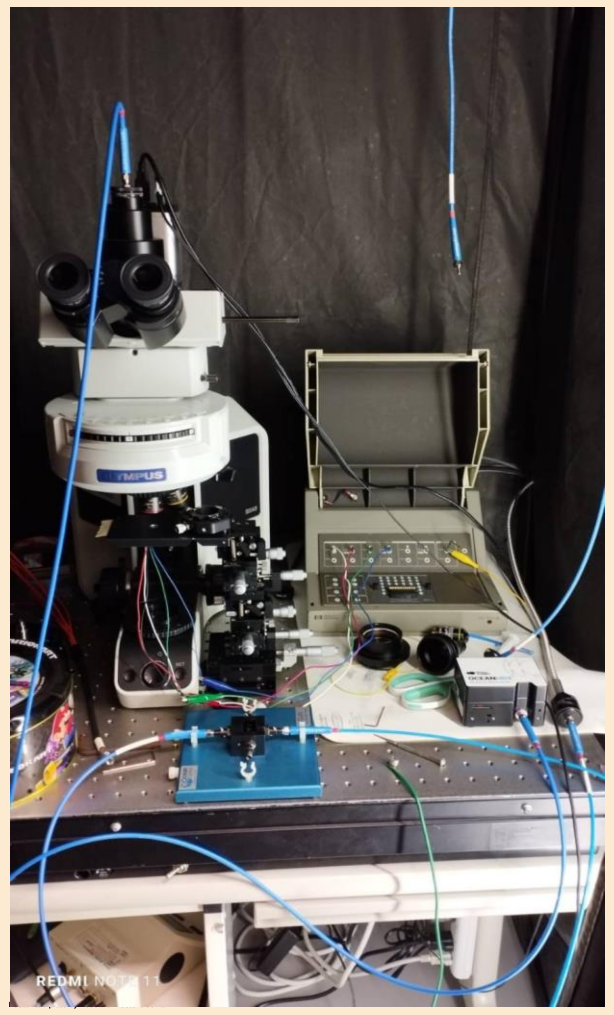
Introduction

This research describes an experimental study of SARS-CoV-2 detection using plasmonic gold nanoparticles, which overcomes the limitations of traditional detection techniques known for their time-consuming and a tendency to produce high false negative results. The transmission spectrum of gold nanoparticles (AuNPs) was recently estimated to be in filter-free wavelength sensors as a miniaturization detection system. Additionally, we demonstrate that wide-ranging absorption will manifest within the visible spectrum when the virus is partially coated with gold nanoparticles at a particular percentage of coverage. This extensive absorption can be harnessed to direct the advancement of a reliable and precise colorimetric plasmon sensor for the detection of COVID-19. The transmission value resulting from the gold nano seed is around 507-540 nm. In addition, plasmonic gold nanoparticles can detect SARS-CoV-2 well from the range of 100-1,000 ng/ml. We expect a miniaturization biosensor system with qualitative diagnosis to be realized by the development method.

Experimental Procedures





Stage 1 → Synthesis & Simulation of Gold Nanoparticles

Stage 2 → Surface Functionalization of Gold Nanoparticles

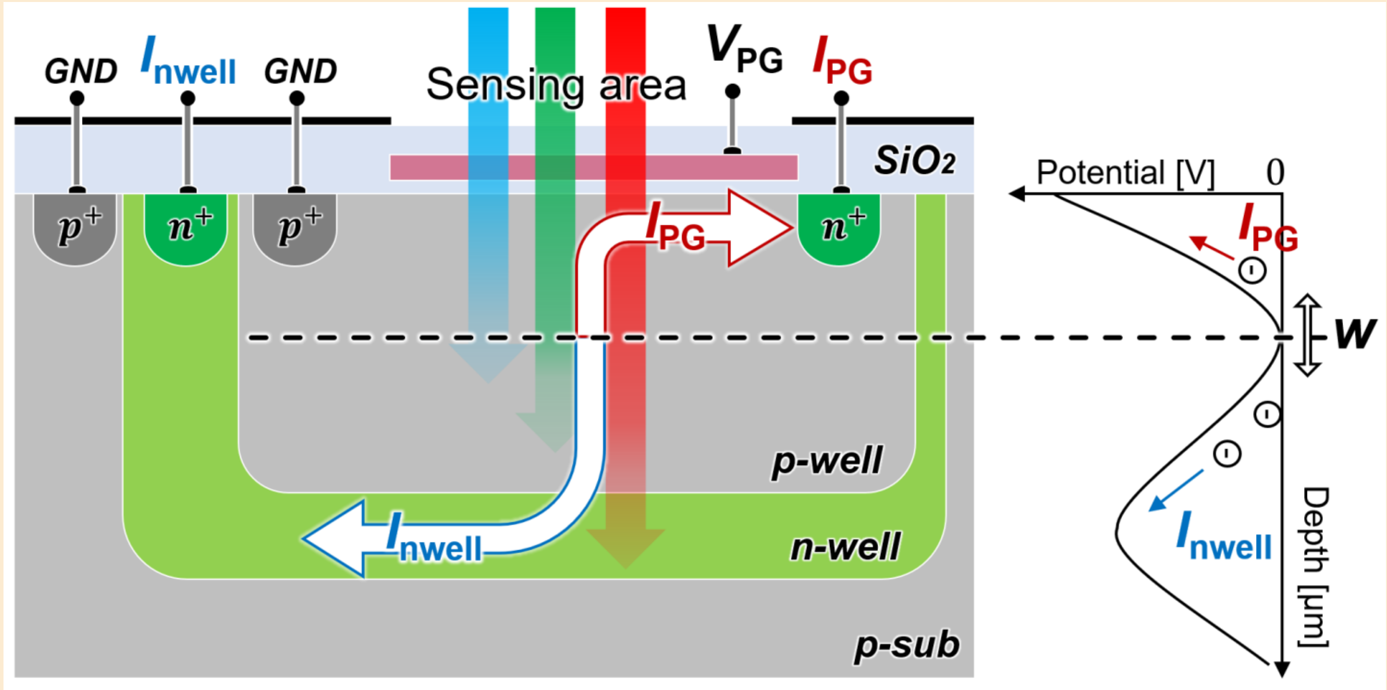
Stage 3 → Antigen-antibody coated Gold Nanoparticles synthesis

Stage 4 → Characterizations (TEM, AFM, UV-Vis, Filter-free wavelength sensor)

Stage 5 → Naked eye colorimetric diagnosis of SARS-CoV-2

Principle and Design

Filter-free wavelength sensor is a miniature sensor capable of distinguishing wavelength information in a single pixel without using optical components. Usually, information about the wavelength in the excitation light is required to obtain the fluorescence intensity, making it impossible to detect an intensity of unknown fluorescence. An unknown wavelength can be detected using a filter-free wavelength sensor with a photogate structure



The principle is based on a p-type silicon substrate in a double-well structure. The sensor has a three-layer structure in which a deep n-well and p-well are formed on the p-sub silicon structure to measure electrons generated by light passing through a potential depth W. This allows us to measure light passing through it by a potential depth W with a photocurrent. The photocurrents by the incident light were divided into the surface side as an I_{PG} and the substrate side as an $I_{n\text{-well}}$ based on the potential depth W and identified the wavelength from the current ratio ($I_{n\text{-well}}/I_{PG}$).

Mathematically, the currents I_{PG}, $I_{n\text{-well}}$, and a current ratio of this miniature sensor can be written as follows:

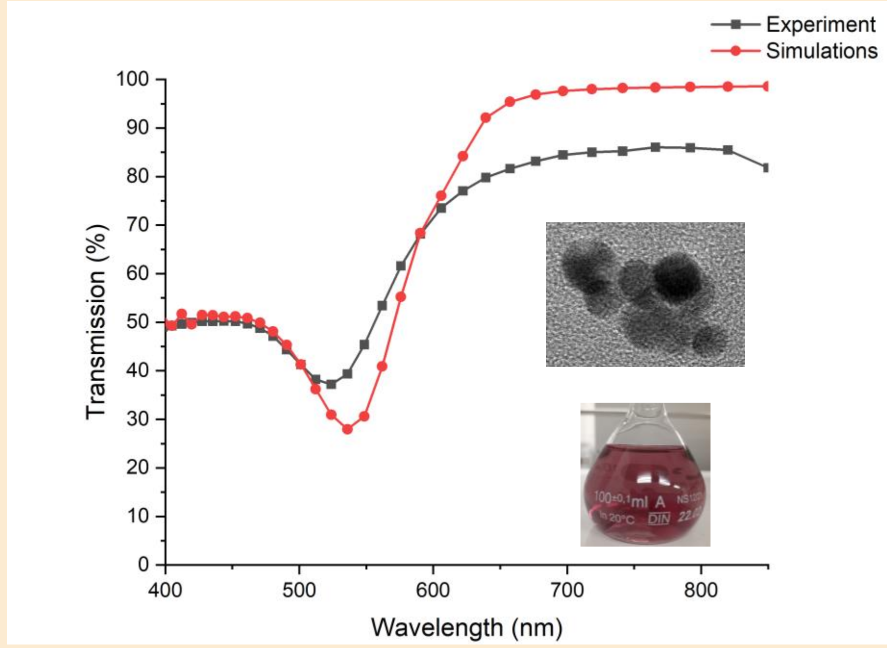
$$I_{PG} = -\frac{qS\lambda}{hc}(1 - e^{-\alpha W_x})\phi_0$$

$$I_{n-well} = -\frac{qS\lambda}{hc}(e^{-\alpha W_x} - e^{-\alpha W_{n-well}})\phi_0$$

$$\frac{I_{n-well}}{I_{PG}} = \frac{e^{-\alpha W} - e^{-\alpha W_{pn}}}{1 - e^{-\alpha W}}$$

Where $\phi_0$is the intensity of light, q is the amount of charge, S is the area of irradiation, λ is a wavelength, h is the Plank constant, c is the speed of light, α is the absorption coefficient, and W is the potential depth.

Experimental and Simulation Results



Bipyramid has better performance than sphere.

Ratio $I_{n\text{-well}}/I_{PG}$=0.23 and color changed from dark red to purple.

Ratio $I_{n\text{-well}}/I_{PG}$ of gold nanosphere = 0.013

LoD = 100 ng/ml in the reagent.