# A FIBER-BASED OPTICAL TRANSDUCER FOR WASH-FREE ANALYSIS OF BIOMARKERS

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## REQUIRMENT

Functional Requirement:

1. Complete removal of Cladding and Coating layer
2. Gold nanoparticles attached evenly onto the optical fiber
3. Stable etching platform

Non-functional Requirement:

1. Optimize the efficiency of optical fiber model
2. Optimize the efficiency of laser coupling experiment

## MOST RELEVANT STANDARDS

1. IEEE Standard for Sensor Performance Parameter Definitions
2. IEEE Guide for Installation Methods for Fiber-Optic Cables in Electric Power Generating Stations and in Industrial Facilities
3. IEEE Recommended Practice for Validation of Computational Electromagnetics Computer Modeling and Simulations

## ACKNOWLEDGEMENT

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## 1 INTRODUCTION

In this project, we aim to collect preliminary results by designing and fabricating a fiber-based optical wash-free transducer, which utilizes the evanescent wave occurred during the total internal reflection (TIR) within the fiber core to cause the light scattering in a target object near the fiber core surface. It has a high sensitivity and can be used to detect cancer biomarkers. The first step for us is to establish the integration of optical fiber and plasmonic nanoparticles. We investigated the near-field coupling between the optical fiber core and gold nanoparticles (AuNP) numerically and experimentally.

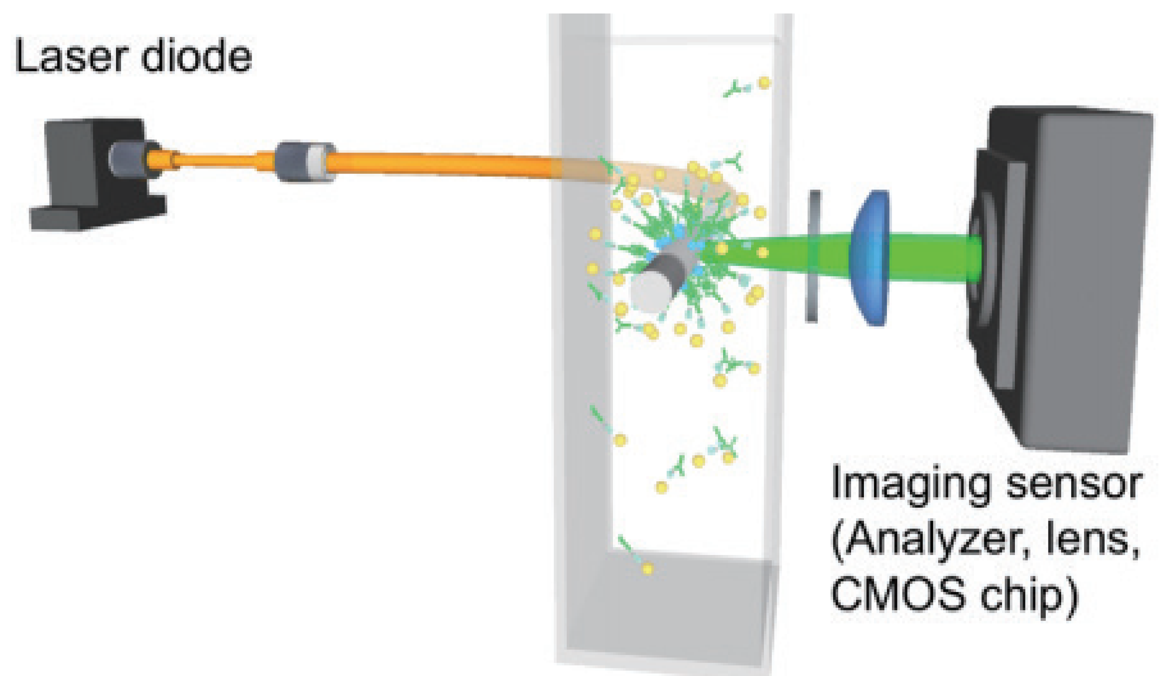


Fig.1 Schematics of the optical wash-free transducer. The fiber is coupled with a laser source and imaged by using a camera.

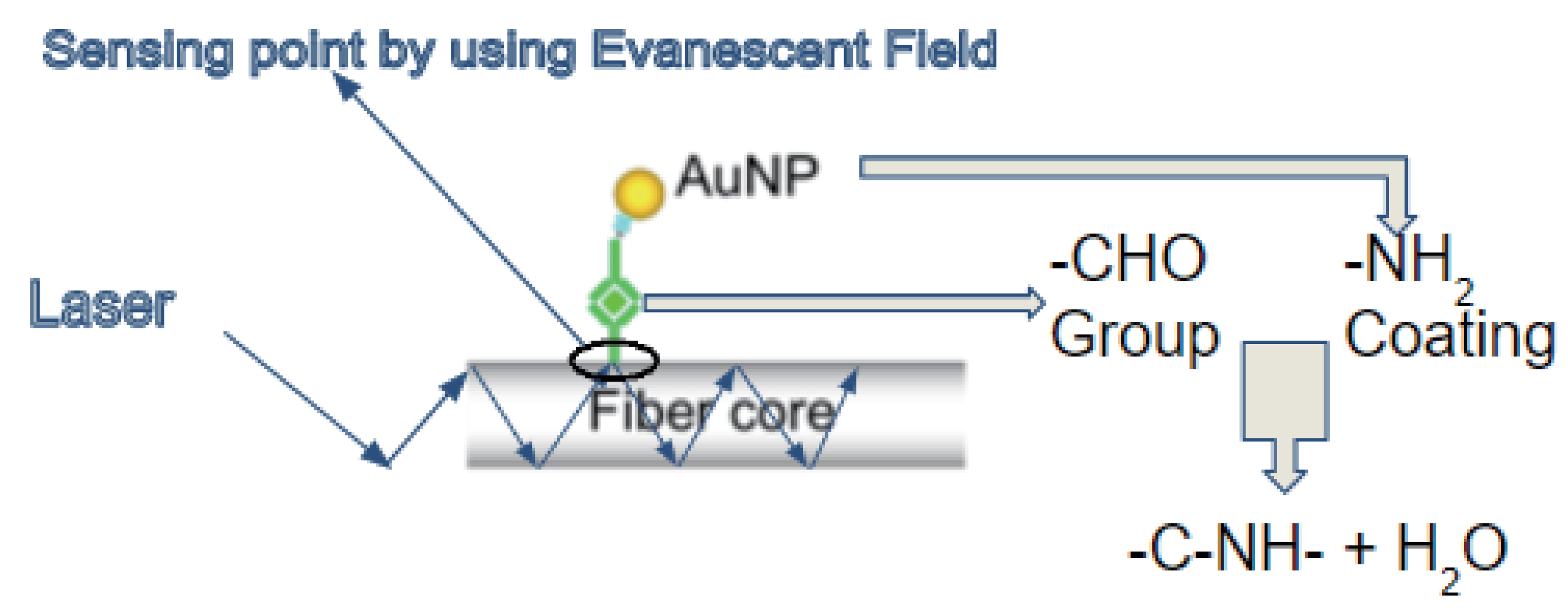


Fig. 3 Illustration of how we immobilize gold nanoparticles (AuNP). The AuNP we use has -NH2 coating. For growing -CHO group on the surface of the fiber core, the fiber core is immersed in 2% polyvinylamine (PVA) firstly, followed by being put into 20% Glutaraldehyde (GA). -CHO group and -NH2 group can have a chemical reaction to form -C-NH- bond.

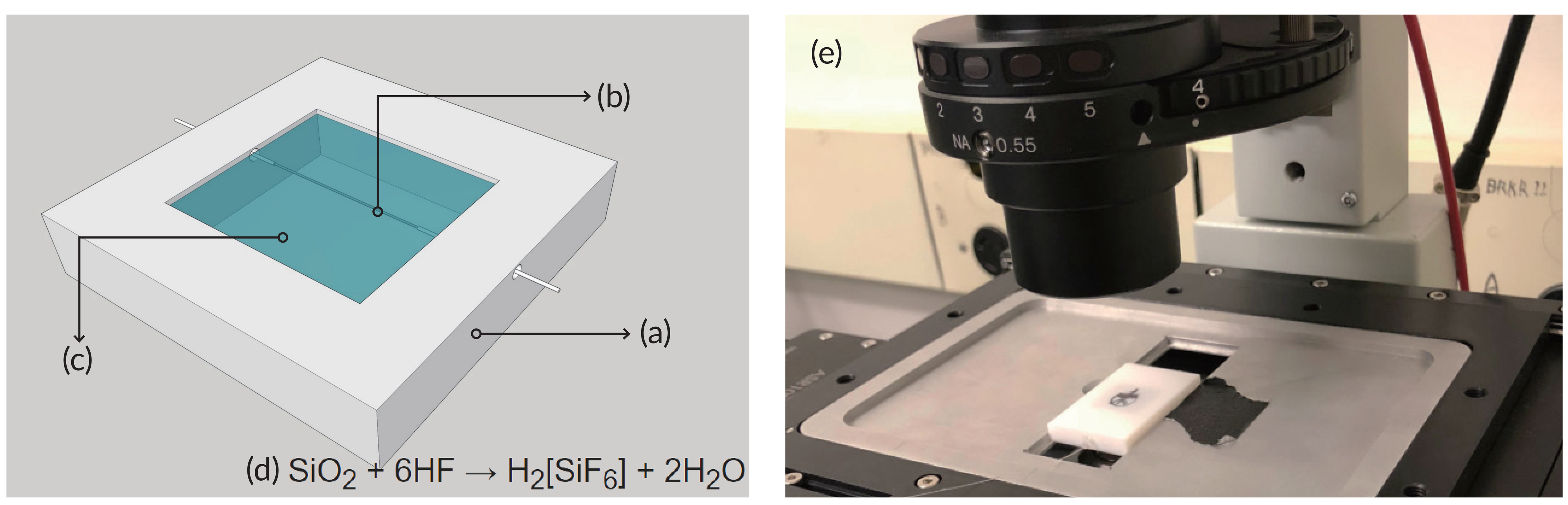


Fig. 2 Illustration of the holder used for fiber etching process and microscope observation. (a) The etching platform made by high density plastics; (b) The fiber component without coating; (c) 49% hydrofluoric acid (HF) + 1% acetic acid; (d) Chemical reaction formula for the etching process. (e) Image of the holder on the microscope we used for observing the light scattering by AuNP.

## 2 METHODS AND MATERIALS

The device we developed is optimized based on two results: Simulations and Experiments. Our simulation work was performed in FDTD. In our experiment work, the single mode optical fiber we used comes from Thorlabs. And the etching platform was designed in SolidWorks and fabricated by ETG in coover. The gold nanoparticles we purchased have a size of 40 nm. For knowing the intensity of the particle scattering, ImageJ was used.

## 3 RESULTS

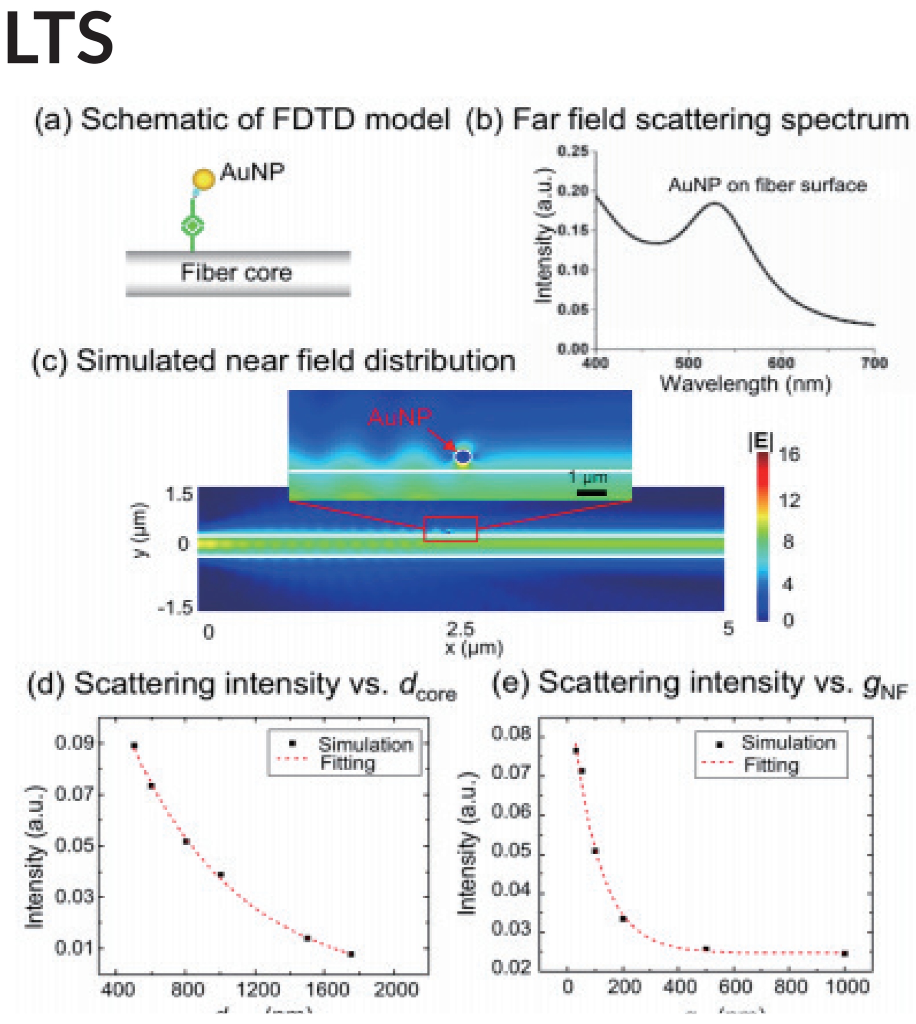


Fig. 4. Preliminary 2D FDTD simulation results of the fiber-nanoparticle interaction. The scattering characteristics of a single AuNP on fiber surface was modeled.

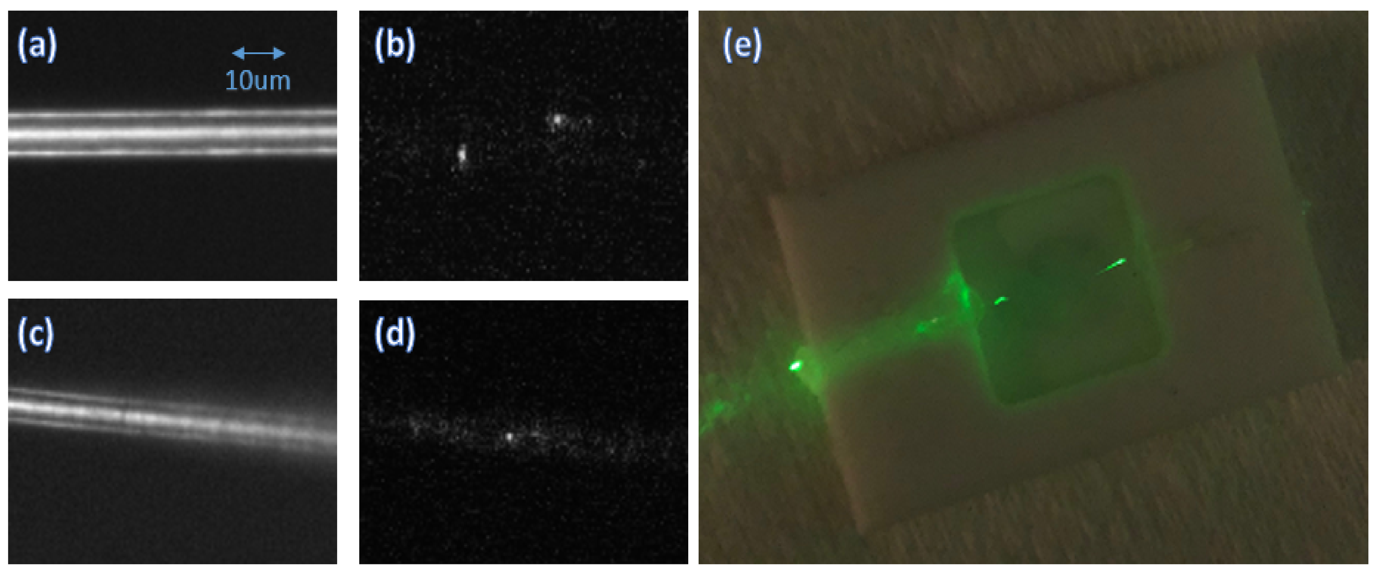


Fig. 5 Experimental results of the near-field coupling between the optical fiber core and gold nanoparticles by using the AuNP solution with the concentration of about 0.25 ug/ml. For (a) to (d), the objective used is 20x. (b) and (d) have the gain of 200 and exposure of 5 ms. (a) The image of the fiber core with about 10 um diameter from the center part. (b) The image of (a) without the light source. The intensity of the light scattering by AuNP is 3010. (c) The image of the fiber core with about 6 um diameter away from the center. (d) The image of (c) without the light source. The intensity of the light scattering by AuNP is 5526. (e) The coupling between a laser with wavelength of 532 nm and our optical transducer.

## 4 CONCLUSIONS AND DISCUSSIONS

In this project, we demonstrated the near-field coupling between the optical fiber core and gold nanoparticles. The results showed that the optical transducer we developed can detect a very low concentration of AuNP. From the results, we believe that the optical wash-free can be used for cancer biomarker detection. Therefore, the primary intended users of our product should be the researchers who work on the biomarker analysis. what's more, the results also proved that reducing the diameter of the fiber core can increases the scattering light intensity. Working on reducing the diameter to below 1 um and trying to make the etching more uniform by using a new etching platform will be our next step. After that, we will move to demonstrate fiber-based proximity assays for cardiac biomarker by using our optical transducer.