Abstract
Fiber-optic based localized surface plasmon sensor has been developed for the measurements of refractive index (RI). The RI sensitivity of 506 nm/RI unit was achieved.

I. INTRODUCTION
The surface plasmon resonance (SPR), localized near the boundary between a metal nanostructure and its surrounding dielectric, produces an enhanced electromagnetic field at the interface. This enhanced field can provide sensitive interaction at the metal-dielectric interface, forming a powerful basis for optical sensing [1]. Recently, a noble metal nanostructure has attracted considerable attention as a new class of plasmonic sensors, called the localized surface plasmon resonance (LSPR) sensor. Here, LSPR can be occurred even at the normal incidence of light by collective oscillation of conduction electrons in metallic nanoparticles. The average field penetration depth of LSPR sensors is typically tens of nanometers, so that its sensitivity for measuring bulk refractive index (RI) is lower than conventional SPR sensors. On the other hand, due to the short decay length of the field, LSPR sensor shows a comparable interfacial RI sensitivity, but less sensitivity to other disturbing fluctuations such as temperature variations [2]. In order to excite the resonance surface plasmon, most of the conventional SPR or LSPR sensors require special configuration geometry with a prism or glass substrate. However, for this reason, they have some unavoidable drawbacks such as bulkiness, complexity, and expressivity. In contrast, fiber-optic based SPR or LSPR sensors require special configuration geometry with a prism or glass substrate. However, for this reason, they have some unavoidable drawbacks such as bulkiness, complexity, and expressivity. In contrast, fiber-optic based SPR or LSPR sensors have been studied because they could overcome the above drawbacks [3-6]. However, there are additional drawbacks which possibly limit their functions and capabilities. For instance, the method using electron-beam lithography is time-consuming to form a large area of metallic nano-dots. The fabrication by the Turkevich method produces a non-uniform shape of metallic nano-dots, and SPR based fiber sensors mostly operate in the side sensing mode [3-6].

In this work, we propose a LSPR-based optical fiber sensor for the RI measurement. A layer of Au nanoparticles (NPs) for LSPR were formed with thermal evaporation of thin metal films on the fiber end-face and post-annealing. To demonstrate the feasibility of the fabricated sensor, resonance peak changes on the reflection spectra were measured with various RI matching liquids using all fiber-optic measurement system.

II. FABRICATION OF SENSOR AND EXPERIMENT
To fabricate the LSPR sensor, 8 nm thick Au film was deposited onto the fiber end-face using electron-beam evaporation after cleaning the fiber. Then, it was annealed for 1 minute at 600 °C to form Au NPs. The size and distribution of NPs could be carefully controlled through adjusting the film thickness and the annealing conditions. Figure 1 shows the SEM image of the fabricated LSPR sensor where Au NPs were formed on the fiber end-face.

Fig. 1. SEM image of the fabricated LSPR sensor (left) and. Inset shows the zoom-in image of Au NPs on the fiber end-face. The mean diameter of Au NPs was around 128 nm and area fraction ratio was 14.1% (right).

The mean diameter of Au NPs formed on the fiber end-face was 144.4 nm. The area fraction ratio, defined as the total NPs area divided by whole area of the SEM image, was 14.1 %. Figure 2 shows the schematic of the fiber-optic based reflection spectrum measurement system used to evaluate the performance of the fabricated LSPR sensor. A white light source (AQ- 4303B) was delivered to the LSPR sensing head through 1X2 optical fiber coupler (Fovice, LMSC0102-54555A1L4S). The back scattered light was detected with a spectrometer (Ocean Optics, USB4000) and the spectrum was analyzed. As known samples, a series of index matching liquids having...
RI from 1.3 to 1.45 were used. The reflection spectrum was measured for each index matching liquid. The reflection spectrum was measured for each index matching liquid.

![Diagram of the RI measurement system with the LSPR sensor. The inset indicates the LSPR sensing head where Au NPs could be randomly distributed.](image_url)

**III. EXPERIMENTAL RESULT AND DISCUSSION**

Figure 3 (a) shows the change in the overall LSPR band of Au NPs obtained with various RI matching liquids. In Fig. 3 (b), we can see that the resonance wavelength associated with the LSPR changes quite linearly as increasing the liquid RI.

![Graph showing the change in LSPR band of Au NPs upon immersion in RI matching liquid (1.3-1.45) and a plot depicting the linear relationship between the RI of matching liquid and the change in LSPR peak wavelength.](image_url)

In the case of adsorbate thickness much greater than the characteristic EM-field decay length, the LSPR spectral shift, \( \Delta \lambda_{\text{max}} \), in response to the change in the RI, \( \Delta n \) is simply described as:

\[
\Delta \lambda_{\text{max}} = m \Delta n
\]

Then the bulk RI sensitivity, \( m \) of 506 nm/RIU is achieved. It is worth noting that this LSPR sensor shows much larger sensitivity than previous LSPR sensor fabricated by electron beam lithography [5]. Furthermore due to advantages of fabrication method, the sensor’s performance is expected to be optimized by controlling the size and distribution of NPs properly.

**IV. CONCLUSIONS**

A fiber-optic based LSPR sensor and its RI measurement capability have been presented. Because of the fiber-optic based sensor configuration, it provides many advantages such as compactness, portability, sensing flexibility, and cost effectiveness. The sensor shows high sensitivity of 506 nm/RIU for detecting changes in the RIs. It is expected that the proposed LSPR sensor would be used for the surface enhanced Raman spectroscopy and fluorescence enhancement for biological and chemical applications.

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