Enhanced SPR Optical Fiber Biosensor using $Ti_3C_2T_x$ MXene/AuNPs for Label-Free and Sensitive Detection of Human IgG

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SUPPORTING INFORMATION

Content

1. Characterization of layers on fiber

Fig. S1 displays the SEM image of the fiber's surface and cross-section. When varying the immersion time (25 min, 80 min, 120 min, and 180 min), the $Ti_3C_2T_x$ MXene thickness was also observed to be successively 76 nm, 119 nm, 149 nm, and 170 nm.

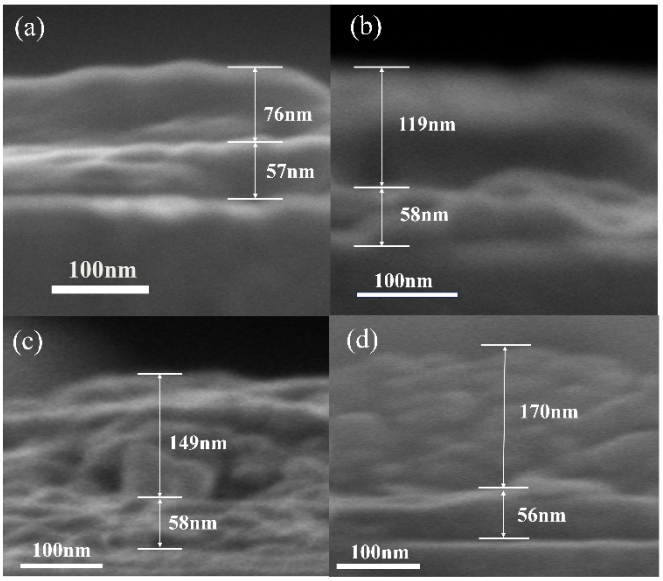

Fig. S1 SEM images of the $Ti_3C_2T_x$ MXene coated on the SPR-OFSs with the different immersion times (a) 25 min, (b) 80 min, (b)120 min, and (d)180 min.

2. Distribution of AuNPs size

To clarify the size of AuNPs, statistical analysis was conducted and their distribution was plotted in Fig. S2. It shows that most of the AuNPs exhibit a size of about 16.6 nm and their average particle size is about 16.7 nm, which closely matches the theoretically predicted 17 nm.

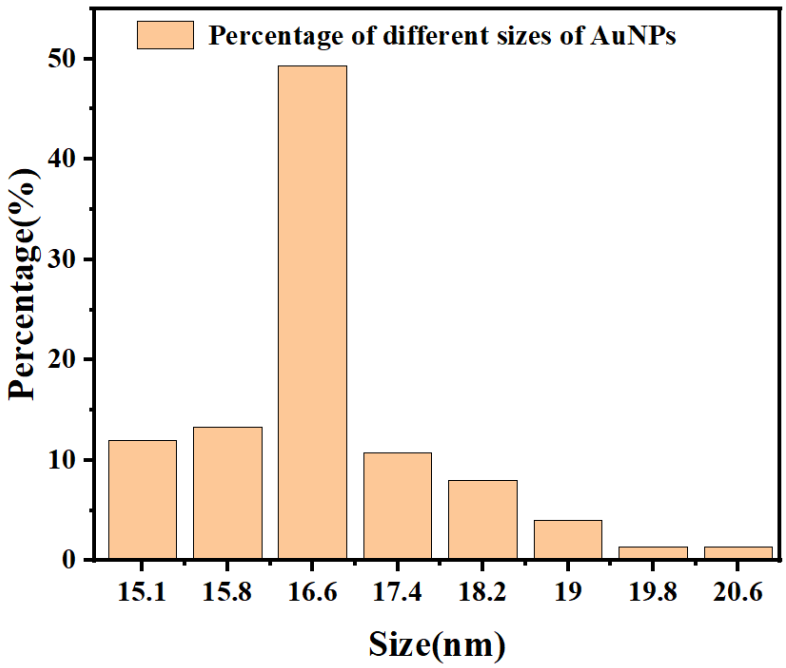

Fig.S2 The distribution of AuNPs on the fiber.

3. The FWHW and FOM as the function of immersion time in $Ti_3C_2T_x$ MXene solution (corresponding to the different thicknesses of $Ti_3C_2T_x$ MXene layer on the fiber)

The FWHM and FOM of the SPR-OFSs were obtained by measuring their SPR resonance spectrum and the experiments were repeated three times. Fig. S3 plotted the results that the maximum FOM (18.1 RIU^{-1}, 18.2 RIU^{-1}, and 18 RIU^{-1}) was measured repeatedly three times at the immersion time of 40 min.

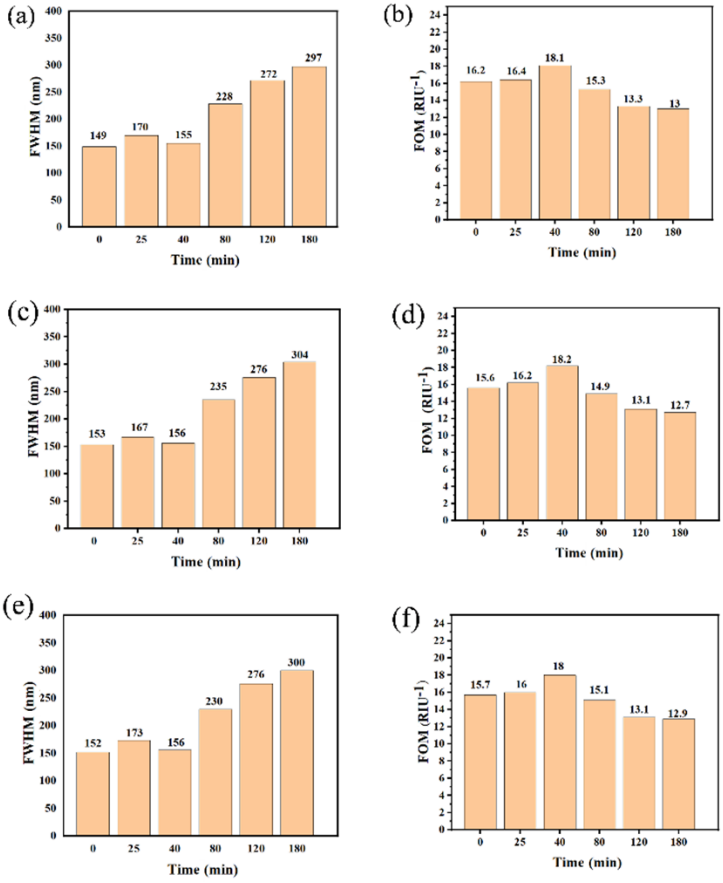

Fig. S3 The FWHM (a, c, e) and FOM (b, d, f) of SPR-OFS obtained at different $Ti_3C_2T_x$ MXene thicknesses.

4. The influence of the environmental temperature on detection

the SPR-OFS was placed in an electrothermal constant temperature blast drying oven (DHG-9123A) for 120 min to detect the human IgG solution sample of 10 μg/mL. Subsequently, the temperature was adjusted to 20°C, allowing the desiccator to equilibrate, and transmission spectra were recorded at 10 min intervals. The temperature was then incrementally increased by 10°C each time until reaching 50°C, with wavelength changes in the transmission spectrum plotted over temperature. The

same procedure was carried out using human IgG concentrations of 20 µg/mL and 30 µg/mL.

Fig. S4(a) shows that the SPR-OFS detects human IgG within a temperature range of 20 to 50°C, with wavelength changes stable at 17 nm, 34 nm, and 46 nm respectively. The maximum fluctuation is less than 0.3 nm. Fig. S4(b) displays the wavelength changes of SPR-OFS in detecting human IgG at room temperature (25°C) and 37°C. The results exhibit small differences, and it indicates that temperature has a negligible impact on the detection by using the proposed sensor here.

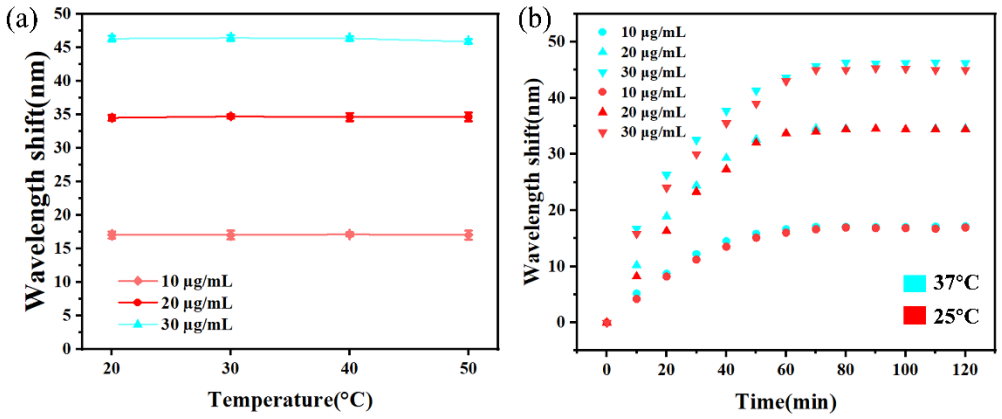

Fig. S4 (a) The wavelength shift of fiber optic SPR sensors when changing the testing temperature and the concentrations (10 µg/mL, 20 µg/mL, 30 µg/mL) of human IgG sample. (b) The detection at 37°C and room temperature (25°C).