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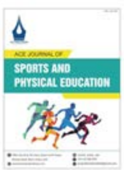

Modify TFBG Sensor Properties Using Surface Plasmon Resonance Technique for Refractive Index Sensing

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Surface plasmon resonance
refractive index,
TFBG sensor

Abstract: The present research the properties of the optical fiber type of Silica TFBG with a wavelength of 1550 nm were examined and improved, where the refractive index was sensing to different concentrations of sodium nitrate, then the thickness of the optical fiber was reduced by chemical treatment using hydrofluoride acid at a concentration of 10% and using SPR technique it was coated with gold film, where the results showed that there is a displacement in the wavelengths of both the transmitting and reflected light spectrum, as well as an increase in power and thus an increase in sensitivity.

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INTRODUCTION

Today, optical fiber sensors are used to measure various parameters such as pressure, temperature, humidity, changes in refractive index, concentration of chemical substances, biosensors, etc[1].

Optical fiber Bragg grating (FBG) are a simple and low-cost wavelength selective filter. This filter has wide applications that both improve the quality and reduce the cost of optical networks. An optical fiber Bragg grating is a section of a common single-mode fiber of several centimeters that is shaped into a Bragg grating. This Bragg grating is created by changing the refractive index of the core along the length of the optical fiber.

Surface plasmon resonance: Surface plasmon resonance or in short SPR is a widely available optical technique used to monitor the RI change of a sensing layer after target molecule binding[2]. The Plasmon resonance In the fiber is also identified by a dip in the transmission spectrum of the guided light. This configuration became a standard for the best fiber optic SPR sensors and is still used today[3-12].

Tilted fiber bragg grating theory: The periodic changes of the refractive index along the length of the fiber cause the coupling between the back and forth waves in the fiber. If the periodicity of the grating created in the fiber is equal to and its effective refractive index is equal to, the Bragg wavelength is obtained from the following equation[13]:

$$\lambda B = \frac{2n(eff)\wedge}{\cos\theta} \quad (1)$$

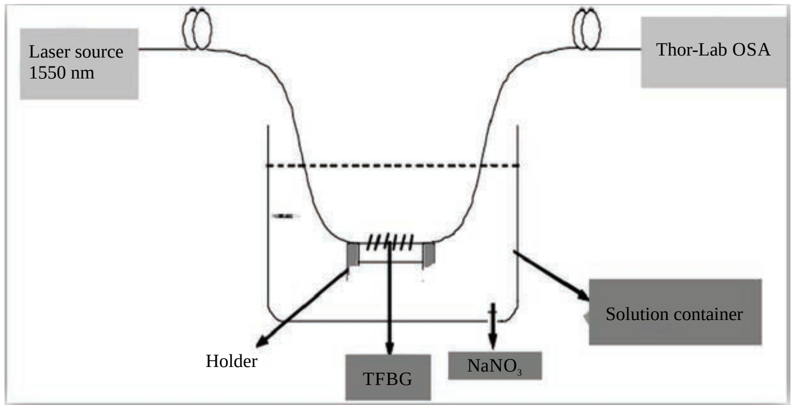


Fig. 1: Diagram of measurement setup for TFBG submerged in solutions with various RI transmission spectra

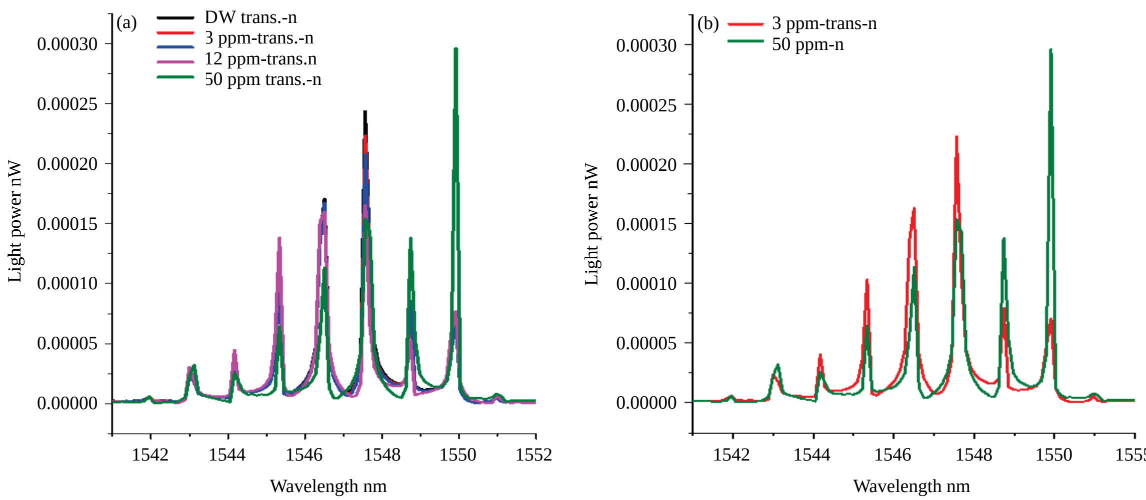


Fig. 2: Transmitting spectra for all concentrations in the left figure, while the right spectrum is for the highest and lowest concentrations witout coating sensor

Experimental setup: The experimental setup for the suggested refractive index sensor device is shown in Fig. 1. The 2 cm TFBG is submerged or incubated in several solutions with refractive indices ranging from 1.3333-1.3456. The transmission power detection experiment uses a laser source at wavelength 1550 nm was used to illuminate the TFBG, allowing for the observation of minute changes in the optical characteristics of the fiber transducer and an optical spectrometer an optical spectrum analyzer (OSA Thor-Lab), transmission spectra were measured with a resolution of 0.01 nm for spectrum monitoring. Use Five $NaNO_3$ salt in water solutions were made for this article's purposes. Refractive index of water solutions with $NaNO_3$ contents ranging from 0-10%.

Transmitted operating mode

Transmitted tilted fiber bragg grating sensor (TTFBGS) tip etching without coated: The spectra transmitted from the Bragg grating sensor when the refractive index of the solution changes with the change of concentrations can be seen in Fig. 2. The patterns of the spectra to the left represent all the concentrations of the solution, while the spectra curve between the highest and lowest concentrations appear to the left.

Transmitting spectra of different concentrations (a) for distilled water (b) 3 ppm (C) 6 ppm (d) 12 ppm (f) 50 ppm (Fig. 3).

Transmited tilted fiber bragg gratting sensor (TTFBGS) with nano gold coated film: The transmission spectrum of the gold-coated Bragg gratting fiber sensor with

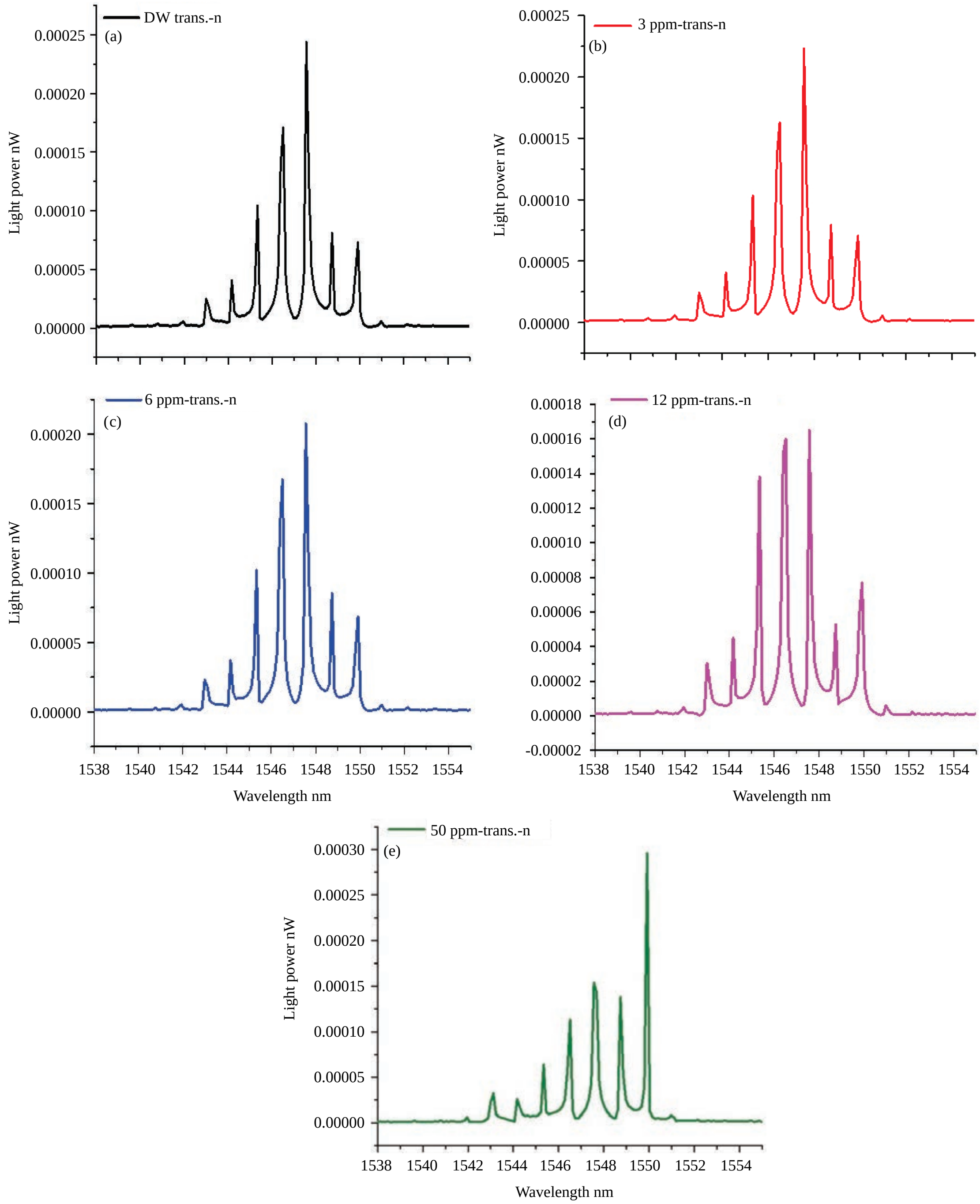


Fig. 3(a-e): Shows the available spectra from the Bragg grating fiber sensor when the refractive index of the solution changes with the change in concentrations (a) of distilled water (b) 3 ppm (c) 6 ppm (d) 12 ppm and (e) 50 ppm

different concentrations appears in Fig. 4. A spectrum to the right shows the relationship between the wavelength and the ability to transmit to the highest and lowest concentration. The effective spectra for each concentration of the pollutant, sodium nitrate, with a concentration of (a) Pure water, (b) 3 ppm, (c) 6 ppm, (d) 12 ppm and (e) 50 ppm.

A summary of the patterns resulting from the transmission spectrum of the Bragg grating sensor coated with a Nano-gold film when testing solutions of

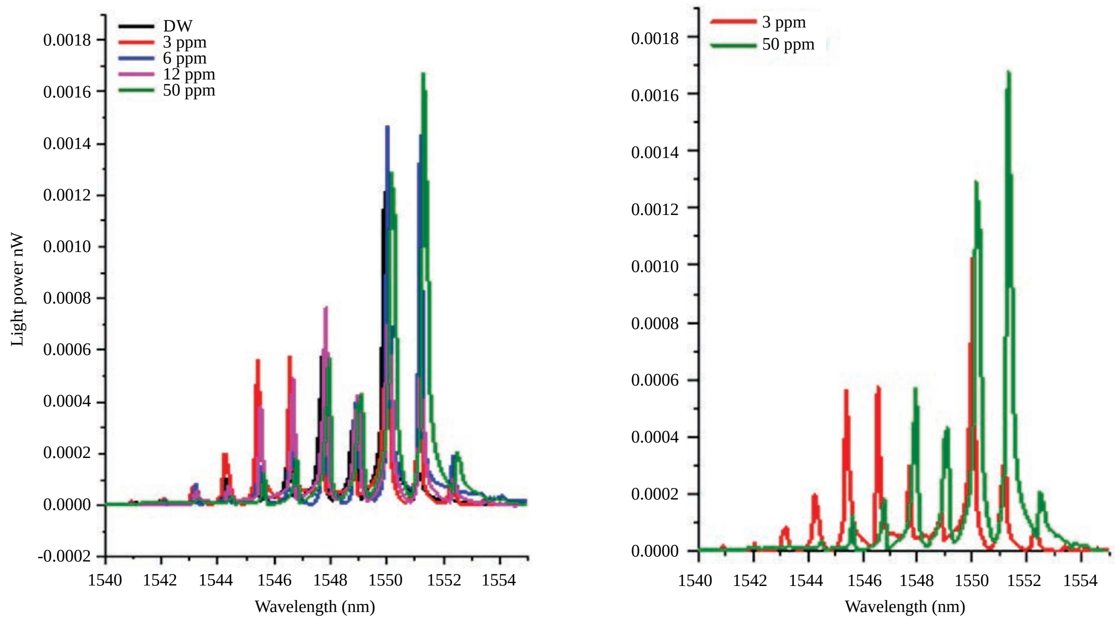


Fig. 4: Transmission spectrum of the gold-coated Bragg Grating fiber sensor with different concentrations

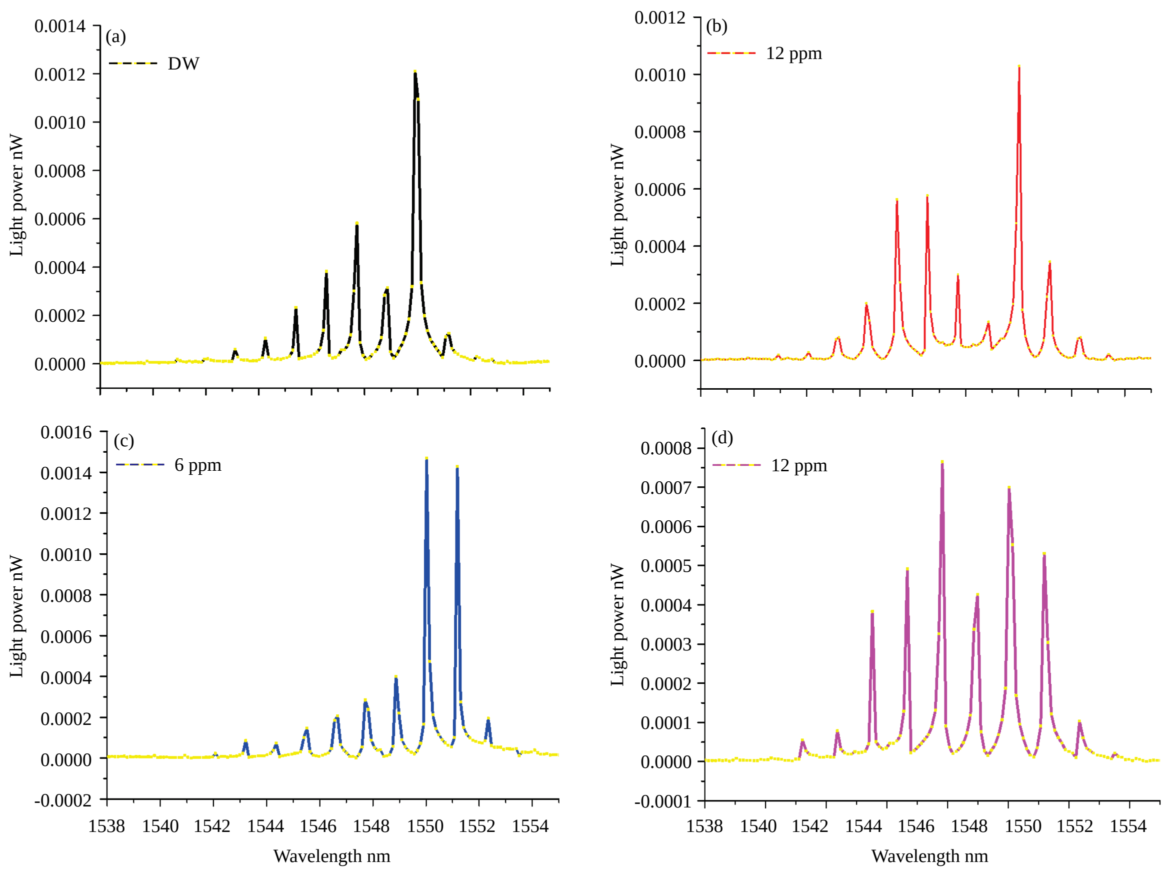


Fig. 5(a-d): Continued

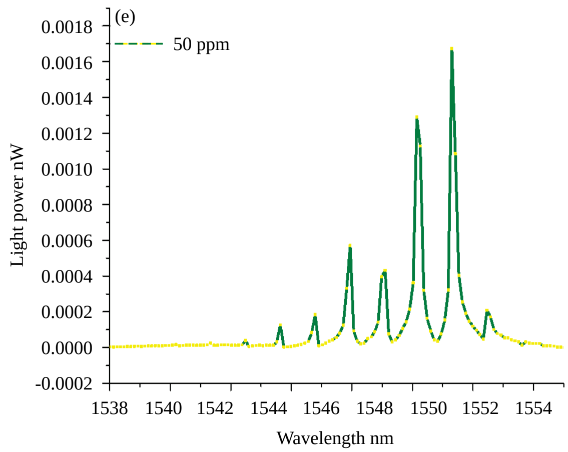


Fig. 5(a-d): The transmission spectrum of the gold-coated Bragg gratting fiber sensor showing the transmission spectra for each concentration of the pollutant sodium nitrate, with a concentration of (a) pure water (b) 3 ppm (C) 6 ppm (d) 12 ppm (d) 50 ppm

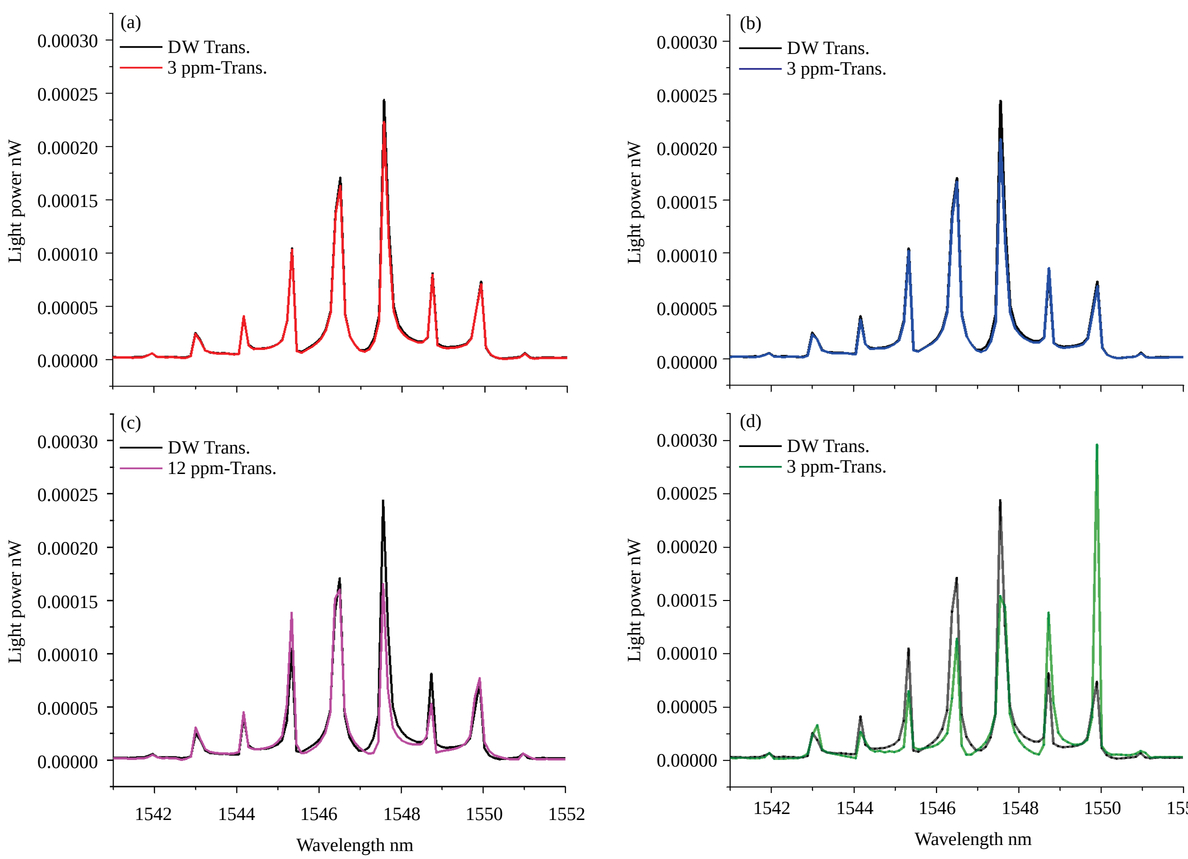
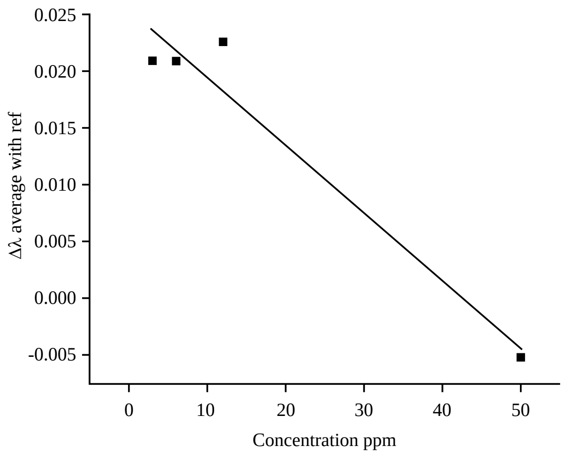


Fig. 6(a-d): Transmission spectra of TFBGS without coated for solutions of different concentrations compared to the spectrum of distilled water (a) at a concentration of 3 ppm (b) at a concentration of 6 ppm (c) at a concentration of 12 ppm and (d) at a concentration of 50 ppm



Equation	y = a+b*x
Plot	B
Weight	No weighting
Intercept	0.02532±0.00254
Slop	-5.94085E-4±9.78214E-4
Residual sum of squares	2.73435E-5
Pearson's r	-0.97394
R-square (COD)	0.94856
Adj. R-square	0.92285

Fig. 7: Sensitivity of the Tilted Bragg Fiber Grating sensor

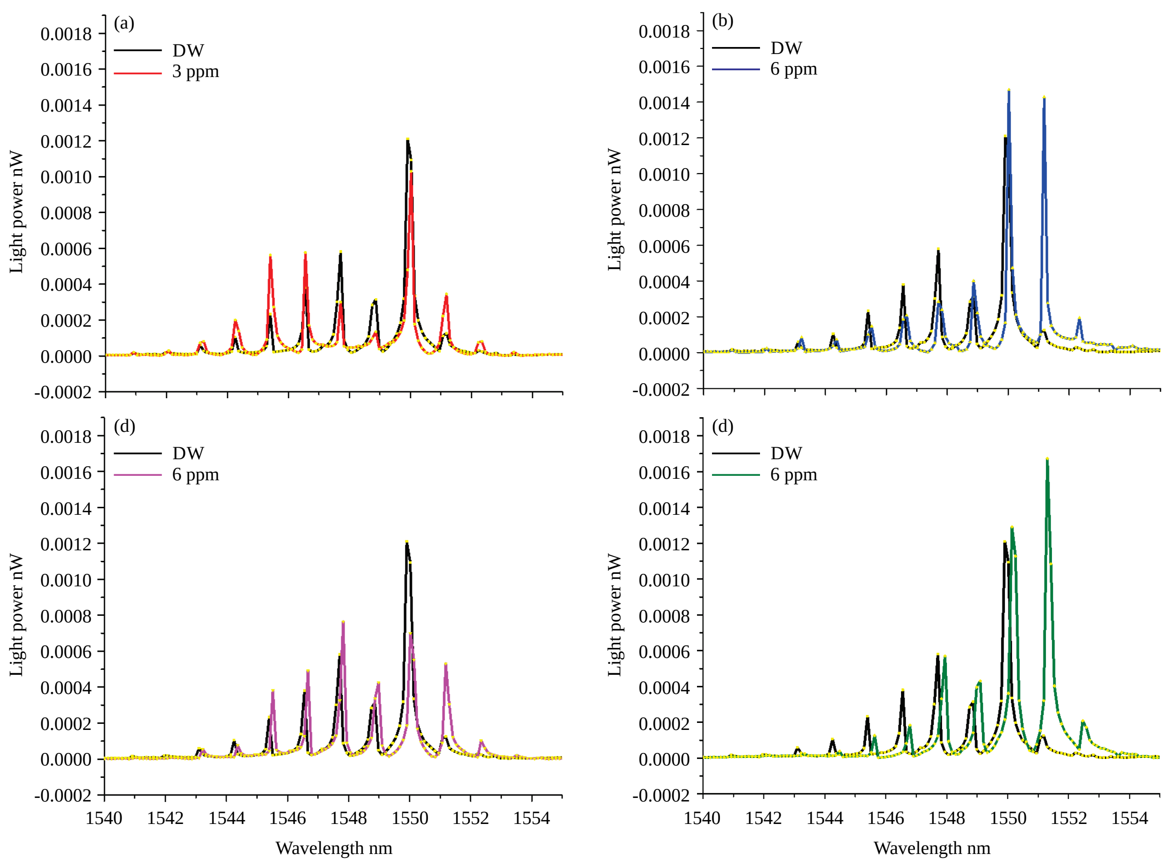
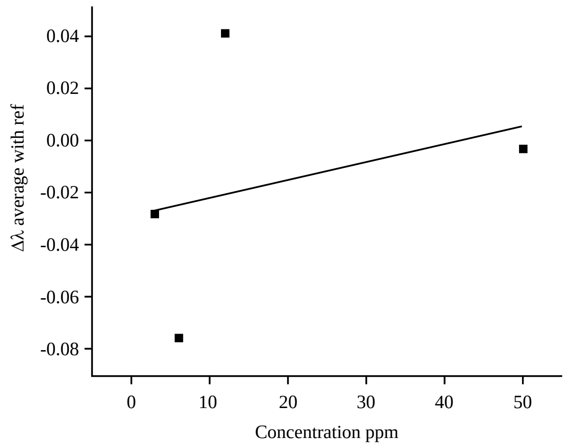


Fig. 7: Transmission spectra of TFBGS without coated for solutions of different concentrations compared to the spectrum of distilled water (a) at a concentration of 3 ppm, 6 ppm and (c) 12 ppm concentration of 50 ppm

different concentrations, in other words, variable refractive index. It was observed that the first and second patterns disappeared for a concentration of 50 ppm. The sixth pattern disappeared for concentrations 50-12 ppm. As for distilled water and 3 and 6 ppm, the seventh pattern disappeared. The tenth pattern did not appear in distilled water and concentration 3 ppm. All of this description is documented.



Equation	y = a+b*x
Plot	B
Weight	No weighting
Intercept	-0.02849±0.03879
Slop	6.74889E-4±0.001
Residual sum of squares	0.0064
Pearson's r	0.30391
R-square (COD)	0.09236
Adj. R-square	-0.36146

Fig. 9: Sensitivity of the tilted bragg fiber grating sensor

FBG Bragg-Transition sensor under the effect of refractive index of analyst medium based on shift with Distill water: Figure 6 and 7 show that the transmission spectrum of the Tilted Bragg Fiber Grating sensor was compared in the normal condition without coating and Fig. 8 and 9 show the case of the sensor coated with Nano-gold and for different concentrations. which in general shows a higher value of the transmittance power of the gold-coated sensor much more than the uncoated sensor. we get the sensitivity of the sensor, which is represented by the slope of the straight line increase, which It reached 6.74889E-4 nm C^{-1}.

CONCLUSION

The transmission spectra of the Bragg sensor of reflective index appear for some concentrations and to show the patterns more clearly. The obtained shift rate for the patterns that are affected by the change in concentration. The sensitivity of transmitted spectrum increasing after coated the TFBG sensor by Nano-Au film.

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