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Fiber optic ammonia gas sensor utilizing surface plasmon resonance of reduced graphene oxide

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1. Introduction

Sensors based on surface plasmon resonance (SPR) have emerged as sensitive instruments for chemical and biological optical analysis. The SPR technique is widely accepted among the several sensing techniques due to its high sensitivity, efficient and reliable procedure.

The demand of ammonia sensor is due to its hazardous and toxic nature. Even a small concentration of ammonia is very harmful for human body. Due to this ammonia sensor is always active area of research.

Graphene has high aspect ratio, electrical conductivity and mechanical properties. These properties make graphene an ideal candidate for the ultrahigh sensitive detection of different gases existing in various environments. High levels of sensitivity in detection processes are important for different industrial, environmental, public safety and military applications.

2. Experimental

For the fabrication of the proposed SPR based fiber optic ammonia sensor we used 24 cm length of the multimode fiber of 600 µm core diameter and numerical aperture 0.4 and remove 1 cm length of the cladding in the middle portion of the fiber and cleaned it. After that we deposited the 40 nm thick copper film on the unclad portion of the fiber by thermal evaporation. After that we dip coated the copper coated fiber by reduced graphene oxide. Synthesis of the reduced graphene oxide (rGO) is given in ref. [1]. After dip coating the gas sensing mechanism follows from here [2].

3. Results and Discussion

Figure 1 shows the SEM image of the prepared reduced graphene oxide. Figure 2 (a) shows the SPR response of the fiber optic probe with Cu (40 nm) and reduced graphene oxide thin films with the change in the concentration of the ammonia gas from 10- 100 ppm. When ammonia gas comes in contact with the probe it reacts with the reduced graphene oxide and forms the complex matrix. Due to the formation of the complex matrix, the dielectric constant of the graphene layer changes.

Figure 2 (b) shows the variation of the resonance wavelength with the concentration of the ammonia gas around the probe. With the increase in the concentration of the ammonia gas (10-100 ppm) the resonance wavelength increases. The shift in the wavelength is due to the change in the real part of the dielectric constant of the reduced graphene oxide film. The shift in the resonance wavelength has been observed to be around 6 nm.

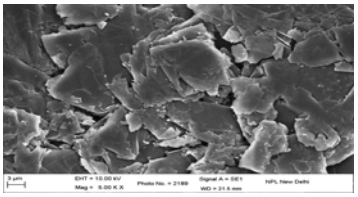

Figure.1: SEM image of reduced graphene oxide.

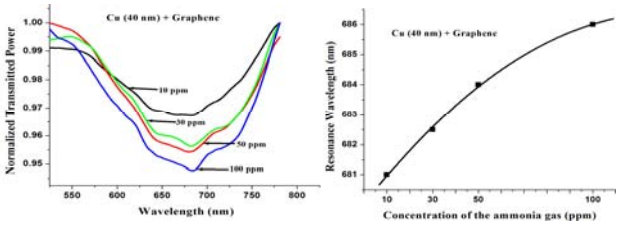

Figure 2 (a) Figure 2 (b)

Figure.2; (a) SPR spectra of fiber optic SPR probe for ammonia gas for different concentrations of the gas in the chamber and (b) Variation resonance wavelength with respect to the concentration of the ammonia gas.

4. Conclusion

We have fabricated and characterized a copper/rGO coated surface plasmon resonance based fiber optic ammonia gas sensor. The present sensor operates in wavelength modulation scheme. The sensor utilizes the reactivity of the ammonia gas with rGO, giving rise to changes in the dielectric constant of the rGO, which results in a change in the resonance wavelength.

Acknowledments

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References

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