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Graphene coated silica microfiber for highly sensitive magnesium sensor

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ABSTRACT

A high sensitivity and simple magnesium sensor based on an silica optical microfiber coated with graphene for the detection of different concentrations of magnesium in de-ionized water is developed and demonstrated. The silica microfiber probe is fabricated by flame brushing technique and it has a waist diameter of 6 μm with tapering length of 3 cm. The microfiber is coated with graphene, which functions as a sensing layer using drop coating method. It is observed that the output power from the probe decreases as the magnesium concentration increases. Without the graphene coating, the sensor has a sensitivity of 12.1 dB/% with slope linearity of more than 98.31% and resolution of 0.0102%. However, the sensitivity of the sensor is significantly improved to 19.63 dBm/% with better slope linearity of 99.25% and resolution of 0.0038% as the graphene is coated onto the silica microfiber probe. The resonant peak also shifts to a longer wavelength as the concentration of magnesium solution increased.

1. Introduction

Magnesium is an essential mineral in human body for improving health and controlling diseases. It is found within our cell, where it is being co-factors for over 300 enzymatic reaction involving nucleic acid for use in synthesis protein and energy metabolism. High level of magnesium is also considered as a risk factor for atherosclerosis, myocardial infarction, hypertension, kidney stones and cancer [1]. In order to avoid various diseases like cardiac arrhythmias, hypocalcemia, hypomagnesemia, premenstrual syndrome and psychiatric disorders, the monitoring of magnesium level is essential [2]. Therefore, the research interest on magnesium biosensors is increasing. So far, many chemical sensors have been proposed to detect magnesium based on various approaches including electrochemical conductivity [3], fluorescence [4], selective ion electrode and ion channel [5], voltammetry [6] and capillary zone electrophoresis (CZE) [7]. Among these sensors, fluorescence device presents many advantages since luminescence measurement are usually very sensitive and low cost. However, this detection method has several technical difficulties.

Recently, graphene has attracted much interest due to its unique characteristics such as high surface area, fast electron mobility and excellent electrical conductivity [8–10]. It also has attractive properties such as zero band gap, high electron mobility, ballistic transport, low electrical noise, and low resistivity [11]. The ongoing exploration on electrical, physical, chemical and mechanical properties contributes to a development of a wide range of new applications for graphene such as sensors, optoelectronic devices and nanocomposite material. For instance, the electrical properties of graphene, which are extremely sensitive to chemical doping and charge transfer effects by various molecules can be applied for sensing applications. It is reported that the graphene has a great potential to be used as sensing elements and tools for biochemical analysis as well as sensor for gases, biochemical sensing, and relative humidity [12–14]. Graphene has been used in the development of magnesium rechargeable battery where graphene based electrode has been employed in the study [15]. Owing to large surface area per unit volume, the electrical conductivity of graphene sheets changes upon exposure and subsequent adsorption of targeted chemical [16]. In Ref. [17], the absorption of MgO nanoclusters on Graphene layers were investigated and their finding shows that there are a significant charge transfer from graphene to the MgO flakes. Inspired by recent studies, we apply graphene as coating material in our fabricated microfiber to further study

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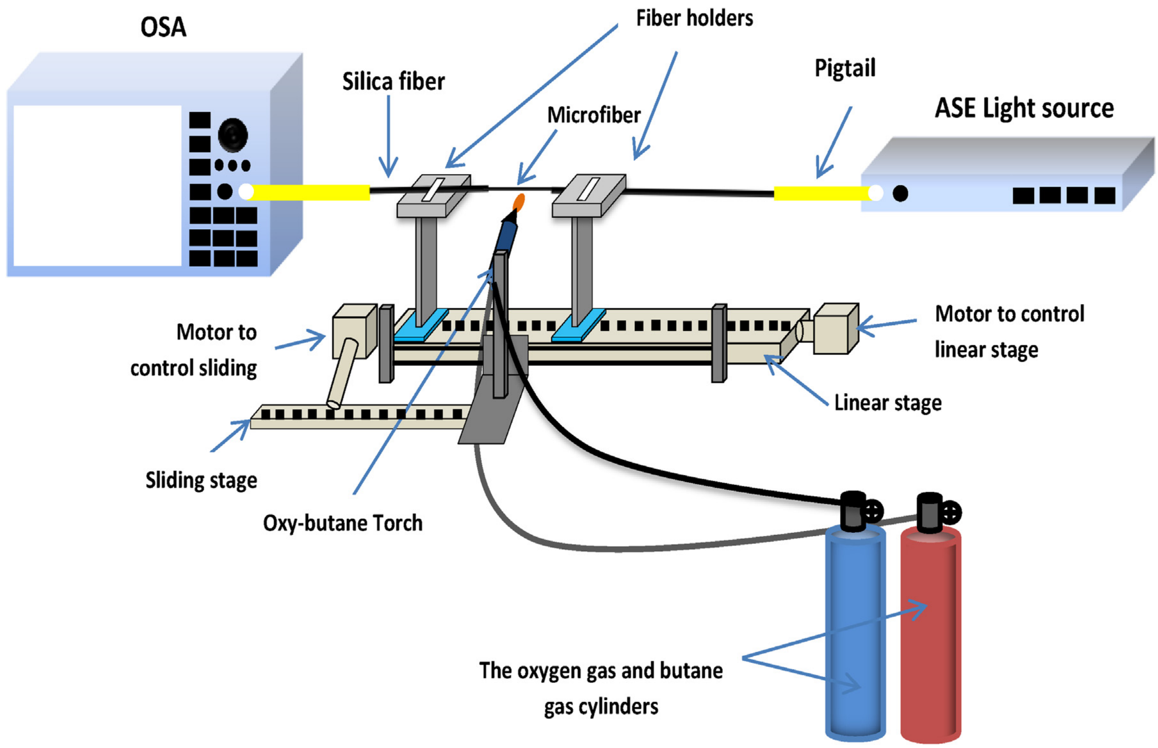

Fig. 1. Schematic diagram of the fabrication setup for the silica microfiber using a flame brushing technique.

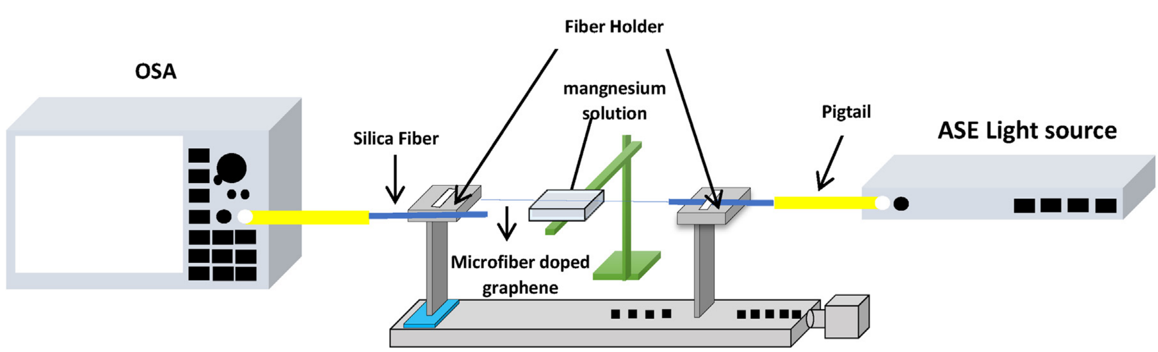

Fig. 2. Experimental setup for the magnesium detection system using a silica fiber coated with a graphene.

(a) (b)

Fig. 3. Microscopic image of (a) silica microfiber (with diameter 6 μm), (b) silica microfiber coated with graphene layer at the taper waist.