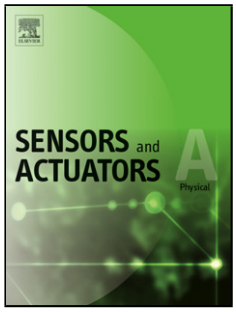

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Author: Jijo V. Ittiarah Siraj Sidhik Tarun Kumar Gangopadhyay

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Refractometry using evanescent field based fiber loop ringdown spectroscopy

Jijo V Ittiarah, Siraj Sidhik and Tarun Kumar Gangopadhyay*

CSIR- Central Glass & Ceramic Research Institute (CGCRI), Kolkata - 700032, India
**Corresponding author: tkg@cgcri.res.in*

An analysis of fiber loop ring down spectroscopy for refractive index sensing with side polished fiber has been carried out in this paper. Side polished fiber as an Evanescent field based sensor element has been fabricated with a low insertion loss of 0.2055 dB. In second part, a refractometric sensor using evanescent field based fiber loop ring down spectroscopy (FLRDS) has been implemented in which the output is represented in the form of a time constant. The detection sensitivity is increased manifold due to the multipass nature of the ringdown technique. Refractive index based detection of various concentration of Sodium Chloride and Glucose has been demonstrated with FLRDS technique using two fiber loops of length 5 m and 15 m. A sensitivity of 1.4×10^{-6} sec/RIU change is recorded and minimum RI change of 3.5×10^{-5} is detectable.
Key words: Side polished fiber, Refractometry, Chemical sensing, Fiber loop ringdown spectroscopy.

1. Introduction

For the past several years, a large variety of sensitive refractive index (RI) sensor has been reported. These sensors are based on index dependent Bragg wavelength shift of fiber Bragg grating (FBG) [1] or long period grating (LPG) [2], Fabry-Perot interferometry [3], single mode fiber (SMF) grating and photonic crystal fiber grating [4]. These index sensors have demonstrated a high sensitivity in terms of change in RI, Δn of the order of 10^{-6} [5]–[7]. But the major drawback of all these high sensitivity RI based sensors is high cost of fabrication and use of delicate fiber optic components. The use of evanescent field based RI sensor using SMF proves to be much simpler and less costly compared to other sensors. A variety of evanescent field based sensors have been fabricated which includes chemically etched SMF [8], biconically tapered optical fiber [9] and side polished fiber (SPF) [10]. Presently in this paper, the use of SPF as an evanescent field based RI sensor is discussed.

The method adopted is based on fiber loop ringdown technique which has gained much interest among the research world in recent years. Various sensing mechanism like FBG [11] and LPG [12] can be employed in the FLRDS detection scheme which is based on the ring down signal. One of the major advantages of this FLRDS scheme is the freedom from the limitation of optical light source fluctuation. Evanescent field sensing is the most adaptable sensing mechanism which is widely used in case of biological, chemical or gas detection. Tarsa et al. [13] first demonstrated the incorporation of evanescent field sensor in the FLRDS scheme for the detection of water absorption and single bimolecular cell scattering. In the present work, the use of evanescent field based FLRDS as RI based sensor using SPF as the sensor element is demonstrated.

2. Theory of FLRDS

Time domain method is usually based on determining the optical losses within the fiber loop by monitoring the decay lifetime of an optical pulse that is introduced into the fiber loop. This decay lifetime is depending on the absorption and scattering losses that is occurring inside the fiber loop and is independent of the intensity fluctuations and detector efficiency. The ringdown time (τ) is related to the round trip time of the loop (t_{RT}) and the transmission per round trip (T_{rt}) which is given by [14].

$$\tau = \frac{t_{RT}}{-\ln(T_{rt})} \tag{1}$$

$$t_{RT} = \frac{nL}{c} \tag{2}$$

where n is the effective RI of the fiber loop, L is the length of the fiber loop and c is the speed of the light in vacuum. The transmission per round trip time (T_{rt}) is governed by the losses within the fiber loop which includes the losses in the sensor element and the transmission loss. Hence, much elaborated version of the ringdown time is given by [14]: