INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study	:	Ph.D.

Thesis Title: Ultrafast, highly sensitive optical fiber relative humidity sensor employing graphene-derived nanomaterials and other novel materials for potential applications in human breath monitoring and voice-print recognition

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SHORT ABSTRACT

This thesis focuses on developing an optical fiber relative humidity (RH) sensor that offers a linear response over a broad dynamic range with optimal sensitivity, ultrafast response times, high resolution, and exceptional repeatability. The goal is achieved using simplified optical fiber configurations and intensity modulation via evanescent-wave absorption. The research explores the feasibility of these sensors for real-time applications in human breath monitoring and voice print recognition. To achieve this, novel sensing materials such as GO-ZnO nanocomposite, GO-ZnO-Fe nanocomposite, rGO-TiO_2 nanocomposite, polyhydroxybutyrate (PHB), and ash derived from menthol plants are utilized for the first time in sensor fabrication. Comprehensive experimental studies are conducted to optimize parameters like chemical composition, reaction conditions, and film thickness, ensuring superior sensor performance. A sensor employing GO-doped silica sol-gel film demonstrates linearity across 15.0−95.3%RH, with a sensitivity of 0.1036 dB/%RH. Sensitivity is further enhanced to 56.3mV/%RH (0.1262 dB/%RH), with response/recovery times of 0.18 seconds, by incorporating reduced graphene oxide (rGO) into the silica film. Using graphene oxide quantum dots (GQDs), another sensor achieves a sensitivity of 0.2437 dB/%RH over a 3−70%RH range, with response/recovery times of 0.025 seconds. Further developments include sensors with GO-ZnO and GO-ZnO-Fe nanocomposite claddings. These demonstrate sensitivities of 33.6mV/%RH and 60.6mV/%RH over ranges of 17−91%RH and 17−80%RH, with response times of 0.33 seconds and 0.031 seconds, respectively. A rGO-TiO_2 nanocomposite-based sensor achieves an exceptional sensitivity of 103.5mV/%RH over 3−70%RH with response times of 0.025 seconds. The research culminates in the development of an ultrafast sensor employing GO-coated reduced-to-few-micron core-diameter (RFMCD) PCS fibers. This sensor achieves the widest linear dynamic range of 3−94%RH with a sensitivity of 0.0115%RH^{-1}, resolution of ±0.049%RH, and a

groundbreaking response time of 50 milliseconds. Further innovations include a biodegradable PHB-doped PVA sensor with a sensitivity of 66mV/%RH over 58−98%RH and response times of 0.0125 seconds. Additionally, a biowaste-based sensor using menthol plant ash achieves a linear range of 4−90%RH, sensitivity of 9.7mV/%RH, and response/recovery times of 0.013 and 0.014 seconds, respectively. The developed sensors exhibit exceptional reversibility, stability, and resolution, establishing benchmarks in optical fiber RH sensing. Their innovative configurations and rapid response times demonstrate transformative potential for real-time health monitoring and biometric applications. This research underscores the capability of evanescent-wave-based optical fiber sensors to meet modern sensing demands with unparalleled accuracy, speed, and reliability.