ABSTRACT

Humidity measurement ascertains the amount of water molecules available in the atmosphere and it is denoted mostly as relative humidity (RH). Humidity sensing and monitoring are quite important for today's advanced manufacturing as well as environmental monitoring. It finds extensive applications in semiconductor industry, pharmaceutical, agriculture, food processing, textile and biotechnology sectors. The types of techniques available for humidity measurement are capacitive, resistive, surface acoustic wave (SAW), quartz crystal microbalance (QCM), and mass spectrometry. Most of the commercially available humidity sensors are based on capacitive technique. However, such sensors suffer from instability for prolonged use and hysteresis due to the polymer dielectric layer. This apart, its fabrication is not cost-effective. In this respect, resistive humidity sensor is attractive because of its simple structure and easy to integrate with silicon technology.

A successful attempt has been made to develop chemically synthesized graphene oxide (GO) based resistive type low-cost humidity sensor. Afterwards, GO was functionalized in order to enhance humidity response. It was observed that metal oxide functionalized GO cannot give good response whereas Nafion® ionomer functionalized GO enhanced humidity response immensely. The sensing materials were characterized using optical microscope, scanning electron microscopy (SEM), atomic force microscopy (AFM), transmission electron microscopy (TEM), Raman spectroscopy, X-ray photoelectron spectroscopy (XPS), energy dispersive analysis of X-rays (EDAX) and fourier transform infrared (FTIR) spectroscopy. The sensor devices were fabricated by drop-casting of sensing materials on patterned gold electrodes on Si/SiO_2 substrate. Humidity sensing devices were exposed to six different relative humidity (RH %) and the response of humidity sensors were found to be excellent due to large proton conduction of GO and Nafion. The sensing mechanism is based on large proton conductivity (in presence of humidity) provided by GO, which follows Grotthuss mechanism. Apart from these, a FET based humidity sensor was also developed utilizing Nafion functionalized GO as its channel material. The humidity measurement was performed in custom-made humidity sensing setup coupled with semiconductor parameter analyzer (SPA) via test fixture. The developed humidity sensors showed ultrafast response and recovery (within few secs) with extremely good repeatability and stability. The GO/Nafion based resistive humidity sensor gave response as high as ~ 18000 times (88% RH). I believe realization of such humidity sensor will help in development of good performance low cost resistive humidity sensor.

***Key words**: Humidity, sensor, graphene oxide, proton conduction, Nafion, SnO_2, resistive, FET.*