Quartz Crystal Microbalance Gas Sensor Utilizing Graphene Oxide / TiO_2 Composite

P. S. Jayawardena [a], E.K.D.H.D. Siriwardena [b], A. Kubono [a,b], and M. Shimomura [a,b]

[a] GSIST, Shizuoka University, [b] GSST, Shizuoka University

E-mail: jayawardena.pramudi.savidya.15@shizuoka.ac.jp

Graphene oxide (GO) contain a range of reactive oxygen functional groups on the sheet surface, which provide a good candidate for supporting metal oxide particles and also may become an ideal sensing platform because of potential hydrogen bonding and π- π stacking interactions [1]. Titania (TiO_2) has been explored for advanced chemical gas sensors based upon different parameters to detect different gas species [2]. Our research deals with, studies concerning the construction of sensors based on a quartz crystal microbalance (QCM) containing a graphene oxide / TiO_2 composite sensor layers.

The oxidized graphite was obtained according to the modified Hummers method. TiO_2 particles were deposited in aqueous GO solution using liquid phase deposition (LPD) technique. The composite was deposited on the gold-coated QCM resonator (5 mm ø, 9 MHz) by spin coating method. Appropriate ethanol concentrations were obtained by injecting known volumes of gas via a gas tight syringe. N_2 gas was passed through the chamber until the frequency difference became stable. The instrumentation utilized consisted of driving circuits, a frequency counter and a computer. All experiments were carried out at room temperature.

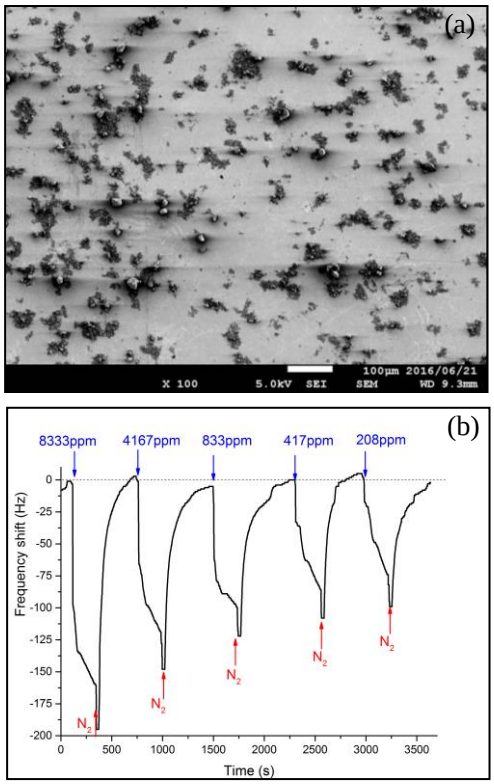

Fig 1. (a) SEM image of GO/TiO_2 composite on QCM surface (b) Plot of frequency shift vs time for various EtOH concentrations

Fig. 1(a) shows the SEM image of the GO/TiO_2 functionalized QCM surface. The sensing performance of functionalized QCM resonators were examined by changing EtOH concentration from 9000 ppm – 200 ppm. The GO/TiO_2 coating amount on the QCM resonator was 2.1 µg according to the Sauerbrey equation. When EtOH of 8333 ppm, 4167 ppm, 833 ppm, 417 ppm and 208 ppm were introduced respectively into the testing chamber, all responses obtained were similar in shape, and the response of QCM resonator decreased proportionally to the concentrations. The corresponding amount of EtOH present over the QCM resonator varied from 0.172 µg to 0.08 µg. This concludes that GO/TiO_2 composite has significant response to EtOH. However, the response and recovery speeds of the sensor are unsteady and need further optimization.

[1] M. Yang and J. He, Graphene oxide as quartz crystal microbalance sensing layers for detection of formaldehyde, Sens. Actuators B: Chem. 228 (2016) 486–490

[2] M. Procek, A. Stolarczyk, T. Pustelny and E. Maciak, Study of a QCM sensor based on TiO_2 nanostructures for the detection of NO_2 and explosives vapours in air, Sensors.15 (2015) 9563-9581