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Integrated Multichannel Electrochemical-Quartz Crystal Microbalance Sensors for Liquid Sensing (Article) (Open Access)

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Abstract

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This paper highlights the design, simulation and fabrication of an array of twelve integrated electrochemical - quartz crystal microbalance (IEQCM) sensors on a single substrate for liquid sensing. Integration of both measurement techniques is made possible by combining the three electrode electrochemical device with the top and bottom electrodes for the microbalance. Important design parameters such as the working electrode radius and gap spacing, were studied using both theoretical calculations and COMSOL Multiphysics® finite element simulations. The sensor's working electrode radius affects the magnitude of the frequency response while the gap affects the capacitance and current density which are important for electrochemical measurements. It was found that the best values for the working electrode radius was 2 mm and gap spacing was 0.5 mm. The sensors were fabricated using microfabrication techniques for the gold electrode and screen printing techniques for the reference electrode. Water contact angle, atomic force microscopy, and scanning electron microscope were utilized to study the surface roughness of the IEQCM sensor. IEQCM has a low contact angle of 53.0 ± 1° and low surface roughness of 1.92nm. For liquid sensing, an array of circular chambers were fabricated using polydimethylsiloxane (PDMS) and placed on top of the quartz substrate for liquid testing. Electrochemical measurements and cyclic voltammetry were performed using the sensor in ferri-ferrocyanide and phosphate buffered saline solution to study the function of scan rates on the peak current with respect to the potential difference. For mass sensing measurements, liquid water droplets of 1uL - 10 uL were placed onto the sensing surface and the change in resonance frequencies of the sensors were measured. These resonance frequency changes can be converted in mass change/area in accordance to the advanced Sauerbrey equation. The multichannel IEQCM sensor shows good potential as a parallel sensor for both biosensing and environmental applications. © 2013 IEEE.

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