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Abstract

Mass Sensitivity Analysis of a Newly Developed Quartz Crystal Microbalance with Ring-Dot Electrode Configuration and Reduced Mass Loading Area †

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Abstract: Quartz Crystal Microbalance (QCM) is used for detecting microgram level mass changes in gas and liquid phase. Conventional QCM design comprises a circular electrode configuration with an evenly distributed mass loading area. However, their mass sensitivity distribution is found to be non-uniform due to the inherent energy trapping effect. In this paper, the recently developed QCM with a ring electrode and a ring-dot electrode configuration are evaluated. It is shown that this new configuration offers the ability to achieve a uniform mass sensitivity distribution, while attaining a comparable mass sensitivity for a reduced mass loading area. Finite Element Analysis is used to design and evaluate the conventional circular electrode QCM, and the proposed ring electrode and ring-dot electrode QCM configurations, where the mass loading area is reduced by 25% compared with the conventional sensor. Simulations are conducted to determine the sensor's resonant frequency shifts for an added mass per unit area of 20 μg/mm². The results indicate that newly designed ring and ring-dot electrode configurations operate at a higher resonant frequency. The observed frequency shift for the designed circular electrode, ring electrode, and ring-dot electrode configurations on a 333 μm thick quartz substrate are 85 kHz, 84 kHz, and 82 kHz, respectively. It is shown that the ring electrode and new ring-dot electrode configurations achieve a higher resonant frequency and offer a comparable sensing performance despite comprising of over 25% reduced mass loading area, in comparison to the conventional circular electrode configuration.

Keywords: quartz crystal microbalance; ring-dot electrode; mass sensitivity; finite element analysis; frequency shift

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